Abstract: The development of a country is directly proportioned to its growing infrastructure needs. One of the most needed infrastructure in Indonesia is medical facility. The construction of public hospital especially in its tendering phase needs to refer to the stated presidential decree that includes a specific rule and policy. The tender process needs to be done carefully to ensure the most beneficial offer is selected. This research will utilize e-tendering method to select the right construction partner. The criteria for the tender requirement will be chosen with the Analytical Hierarchy Process (AHP) which finally would be evaluated to determine the tender winner. AHP should help to elaborate the problem into multiple complex criteria, forming a hierarchy. The AHP implementation requires primary data from questionnaire and secondary data from existing research and policies. AHP calculation process is then used to process the data in the form of scores from the distributed questionnaire. The result of the AHP calculation was used to evaluate each offer from the goods and services providers, while finally done using the method of knockout by passing grade. The dominant factors that influenced the final decision making includes financial power (30.79%), Materials and equipments (8.55%), health and safety (4.59%), technical competence (8.91%), and experience (2.9%). AHP was proven to be very effective when utilized to evaluate e-tendering offer documents.

Index Terms: AHP, e-tendering, knockout by passing grade system, tender evaluation

I. INTRODUCTION

The development of a country is directly proportioned to its growing infrastructure needs. One of the most needed infrastructure in Indonesia is medical facility. Medical facility is one of the basic need of every citizen. In Indonesia, the construction of hospitals is divided to 5 regions. The province of Banten is included in region 1, whereas the construction of hospitals in Banten compared to the available hospital beds per 100,000 citizens could be observed[1]. in figure 1.

Meanwhile, the public funding for the medical sector have not reached 5% of the state budget even though the hospital requirements of Indonesia in 2017 have reached 11.57%. The growth of the requirement is directly proportioned to the construction activities, especially tendering [3][2]. The data of the amount of hospitals have included government hospitals and public hospitals. The growing number of the citizens of Banten have pushed the need to have more hospitals available. The regional police force of Banten have constructed their own medical facilities to accommodate the medical needs of their members, with another new addition. The construction of this newest police hospital in Banten had to go through a series of procurement procedure in accordance to the presidential decree no. 54/2010 from the tendering phase to the construction phase. This research will utilize e-tendering method to select the right construction partner. The criteria for the tender requirement will be chosen with the Analytical Hierarchy Process (AHP) which finally would be evaluated to determine the tender winner[4]. The contractor selection process is done with a decision making on the middle management level to give opinions and inputs to the top management, in which case the general manager is entitled to determine the contractor that would finish the construction work[5]. The offer evaluation using elimination system with passing grade is a prime process if the decision making method used is Analytic Hierarchy Process (AHP) due to its ability to select the criteria and weight of every scoring element which will be used.
Analytical Hierarchy Process (AHP) Implementation in Determining Document Evaluation Criteria of Post Qualification E-Tendering Knockout Phase

The score of each goods and services provider would be done with a scale, and the result will be significant enough with the correct specification [6].

II. AHP AND OFFER EVALUATION

A. Analytic Hierarchy Process (AHP)

A decision making process that involves a system or an organization should not be done just using intuition. The decision making process should have utilized a more complex decision making process that could cover more aspects involved. The decision making method that will be used in this research is AHP. This process should help to elaborate the problem into multiple complex criteria, forming a hierarchy. Utilizing the hierarchy, the criteria regarding the problem should be more structured [7][4].

As the outcome of AHP, the resulting hierarchy could ease the decision makers in considering the various decisions involved by graphically describing them in sequence based on their subjective scores[8].

B. Basic Principles of AHP

While utilized as a problem solving method, there are several principles that needs to be followed that includes [9]
1. Hierarchy construction

A complex system could be made simpler by breaking it into supporting elements and combining them in a hierarchy.

![Figure 2. Structur AHP](source:8).

2. Criteria and alternatives valuation.

The valuation of the criteria and alternatives are done in pairs. According [10], scaling them 1 to 9 is the most viable option in expressing opinions. The score and qualitative opinion could be measured by utilizing the data provided in figure 3

![Figure 3. Pair Comparative Rating Scale](source:11).

3. Synthesis Of Priority

For every criteria and alternative, pair wise comparisons are needed. The relative comparison scores from all of the criteria and alternatives could be adjusted with the pre-determined judgment to produce weight and priority. The weight and priority could be calculated by manipulating the matrices or by solving them mathematically.

4. Logical Consistency

The consistency involves two things, which are the categorization of similar objects according to their uniformity and relevance, and connecting the relation level between object based on certain criteria.

C. E-Tendering

According the presidential decree no.54/2010 and its addition of chapter 39, e-tendering is a method of selection for goods or services providers which is done openly and could be participated by all of the goods and services provider that is listed in the procurement system electronically. The e-tendering is participated by conveying one offer in the given time frame. The tendering process includes the phases of qualification, announcement and/or invitation, registration and documentation, briefing, offer document delivery, offer document evaluation, and winner confirmation[12][2].

D. Offer Evaluation

The presidential decree no.54/2010 and its changes in chapter 79 verse 1 stated that in doing an offer evaluation, the procurement officials must refer to the procedures or criteria that is stated on the procurement document. The procurement officials and the goods and services provider are forbidden to do a post bidding[13][14].

III. AHP IMPLEMENTATION AND RESULT

The AHP implementation requires primary and secondary data. The secondary data for this research was acquired from previous research and decrees/policies. Meanwhile, the primary data was acquired from questionnaires and FGD[15][16].

| Intensity | Information |
|-----------|-------------|
| 1         | Both elements are equally important |
| 3         | One element is a little more important than the other elements |
| 5         | One element is more important than the other elements |
| 7         | One element is clearly more important than the other elements |
| 9         | One element is absolutely important than the other elements |
| 2,4,6,8   | The values between two consideration values are close together |
| The opposite | If element i has one of the numbers from a comparison scale of 1 to 9 that has been set by Saaty when compared to the element j, then j has the opposite when compared to the element i |
A. Research Instruments

Based on the identification of criteria, sub criteria, and alternatives from previous related studies, a questionnaire was made and spread to the experts in related fields. The identification process itself was done by focus group discussion of 5 government procurement experts with the goal of distinguishing the most exact elements to be included in the questionnaire.

B. Evaluation of offers with AHP

The steps of offer evaluation using AHP could be observed in figure 4.

![Flow Chart Evaluation of offers with AHP](Source: Processed Alone)

Figure 4. Flow Chart Evaluation of offers with AHP (Source: Processed Alone)
A. AHP Calculation Phases

The process of processing the results of the questionnaire by utilizing AHP is described in figure 4.

- START
- Criteria Priority Scale
- Calculating the Normalization of the Decision Matrix
- Calculate the Eigen Value, Priority Weight and Total Amount of the Paired Matrix
- Calculating the Distribution of Each Column, Weight of Synthesis and Max Eigen (X)
- Calculate max λ (max max)
- Calculating CI (Consistency Index)
- Calculating CR (Consistency Ratio) CR≤ 0.1

Yes
- Weight of eligible criteria
- Finish

No

The data from the questionnaire result that was acquired by AHP calculations and criteria comparisons are then used to calculate the Eigen Value with the following equation:

\[ \text{Eign Maks} = \frac{\text{Baris bobot sintesa}}{\text{Bobot prioritas}} \quad \text{(4)} \]

The process is then continued by calculating the value of lambda max with the equation of:

\[ \lambda \text{ maks} = \frac{\text{Total Eign Maks (X)}}{N \text{ (Jml Kriteria)}} \quad \text{(5)} \]

After finding out the value of the lambda max, then the score of the consistency index could be calculated with the following equation:

\[ \text{CI} = \frac{\lambda \text{ maks}}{N \text{ (Number of Criteria) - 1}} \quad \text{(6)} \]

The final step of the AHP calculation consists of the operation to calculate the consistency ratio score with the equation of:

\[ \text{CR} = \frac{\text{CI}}{\text{IR}} \quad \text{(7)} \]

IR was gained from the table of random indexes with the amount of the used criteria. If the score of CR < 0.1, then the value is consistent[19].

B. AHP Calculation Results

In accordance to the phases described in figure 4, the offer evaluation by AHP utilization was done. Every phases resulted in the recapitulation of the criteria, sub criteria, and alternative calculations for the category of administration, technical, cost, and qualification. The result of this calculations could be observed in table 2-5.

Table 2. Recapitulation of criteria calculation using AHP method

| NO | CRITERIA | Eigen Value | Priority Weight | Sintesa Weight | Eign Maks (X) | CI (Consistency Index) | CR Consistency Ratio | Information |
|----|----------|-------------|-----------------|---------------|---------------|------------------------|----------------------|-------------|
| 1  | ADMINISTRATION | 1.0456 | 0.3483 | 1.0157 | 2.9160 | 0.0013 | 0.0022 | KONSISTEN < 0.1 |
| 2  | TECHNICAL | 1.5462 | 0.5568 | 1.0931 | 2.9822 | 0.0020 | 0.0008 | KONSISTEN < 0.1 |
| 3  | COST | 0.9999 | 0.3331 | 0.9999 | 3.0026 | 0.0005 | 0.0002 | KONSISTEN < 0.1 |
| 4  | QUALIFICATION | 0.6648 | 0.3331 | 0.6648 | 3.6611 | -0.0363 | 0.0157 | KONSISTEN < 0.1 |

Table 3. Recapitulation of the Administration criteria calculation with the AHP method

| No | Subcriteria | Eigen Value | Priority Weight | Sintesa Weight | Eign Maks (X) | CI (Consistency Index) | CR Consistency Ratio | Information |
|----|-------------|-------------|-----------------|---------------|---------------|------------------------|----------------------|-------------|
| 1  | Offering letter | 0.9566 | 0.3106 | 0.9844 | 3.0097 | 0.0013 | 0.0022 | KONSISTEN < 0.1 |
| 2  | Offer Period | 1.0456 | 0.3483 | 1.0931 | 2.9822 | 0.0020 | 0.0008 | KONSISTEN < 0.1 |
| 3  | Bid Security | 0.9999 | 0.3331 | 0.9999 | 3.0026 | 0.0005 | 0.0002 | KONSISTEN < 0.1 |

Table 4. Recapitulation of technical subcriteria calculations using the AHP method

The number of columns. The results are then used to calculate the synthetic weight by adding up the value of each row, while finally doing the operation for the eigen max with the following equation:

\[ \text{Eign Maks} = \frac{\text{Baris bobot sintesa}}{\text{Bobot prioritas}} \quad \text{(4)} \]

Before executing the calculation for the synthetic weight and the eigen max, the criteria scores must first be divided to
### Table 5. Recapitulation of cost subcategory calculations using the AHP method

| No | Subcriteria | Eigen Value | Priority weight | Status Weight | Eigen Value (%) | CI (Consistency Index) | CR (Consistency Ratio) | Information |
|----|-------------|-------------|-----------------|---------------|-----------------|-----------------------|------------------------|-------------|
| 1  | Low price   | 0.357       | 0.037           | 1.457         | 0.5023          | 0.0168                | 0.005                  | KONSISTEN <0.1 |
| 2  | Bid         | 0.083       | 0.008           | 0.351         | 0.1429          | 0.0588                | 0.008                  | KONSISTEN <0.1 |
| 3  | Unit price  | 0.081       | 0.005           | 0.348         | 0.1370          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 4  | The price of the job | 0.086   | 0.005           | 0.344         | 0.1370          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 5  | The price of non-critical work | 0.084 | 0.005           | 0.348         | 0.1370          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 6  | Total Price Offer for Total Value of BPS | 0.083 | 0.008           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 7  | Not balanced price with BPS | 0.080 | 0.008           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |

### Table 5. Recapitulation of calculation of qualification subcategories with the AHP method

| No | Subcriteria | Eigen Value | Priority weight | Status Weight | Eigen Value (%) | CI (Consistency Index) | CR (Consistency Ratio) | Information |
|----|-------------|-------------|-----------------|---------------|-----------------|-----------------------|------------------------|-------------|
| 1  | Business Entity | 0.298       | 0.005           | 0.351         | 0.1370          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 2  | Partnership / KSO | 0.084       | 0.005           | 0.348         | 0.1370          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 3  | Fulfilling the Obligation to Pay Taxes | 0.082 | 0.005           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 4  | Qualification Form | 0.084       | 0.005           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 5  | submit a written statement / acknowledgment that the company in question is not under the supervision of the client, does not go bankrupt and is not being terminated | 0.320 | 0.005           | 1.457         | 0.5023          | 0.0168                | 0.005                  | KONSISTEN <0.1 |
| 6  | Not blacklisted | 0.085       | 0.005           | 0.351         | 0.1429          | 0.0588                | 0.008                  | KONSISTEN <0.1 |
| 7  | Have an ID | 0.083       | 0.005           | 0.348         | 0.1370          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 8  | Ongoing work for at least 1 period of 4 years | 0.084       | 0.005           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 9  | Have the ability in the appropriate field of work | 0.084       | 0.005           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |
| 10 | Have an ISO/Quality Management Certification | 0.084       | 0.005           | 0.349         | 0.1371          | 0.0477                | 0.006                  | KONSISTEN <0.1 |

### IV. CONCLUSION

1. The knockout by passing grade evaluation was done by evaluating the administration document, while the cost and qualification was done without weight value. The technical document evaluation was done by evaluating the weight of the criteria, sub-criteria and alternatives.

2. The dominant factors that influenced the passing grade of the technical offer documents in determining the winning provider by utilizing AHP includes the sub-criteria of financial power (30.79%), materials and equipments (21.81%), labour competence qualification (14.07%), time management (8.55%), health and safety (4.59%), technical competence (8.91%), and experience (2.9%).

3. AHP was proven to be very effective when utilized to evaluate e-tendering offer documents.

### REFERENCES

1. S. Kabupaten and J. Tahun, “Evaluasi penawaran,” vol. 1, pp. 1–12, 2013.
2. A. E. Huisin and P. D. Wibowo, “Winning ratio improvement of tender in hospital building construction project by definitive technique based on java utilization,” pp. 1–5, 2018.
3. P. D. Wibowo, A. Amran, Z. Citra, and Adriansyah, “ANALISIS MARK UP DAN ESTIMASI DEFINITIVE TECHNIQUE PADA PROSES TENDER PROYEK RUMAH SAKIT,” vol. 7, no. 2, pp. 81–89, 2018.
4. P. Taylor, W. Wang, W. Yu, I. Yang, C. Lin, and M. Lee, “Applying the AHP to support the best-value contractor selection – lessons learned from two case studies in Taiwan,” no. October 2014, pp. 37–41, 2013.
5. S. Fransiska, “Model Penilaian Kontraktor Pada Pelaksanaan Proyek Konstruksi Dengan Metode AHP (Analytic Hierarchy Process) Studi Kasus : Proyek Perumahan Developer Pt. Xyz,” pp. 1–8, 2015.
6. Hartono, L. Nurhidayah, and Sugiyarto, “Pemilihan Rekanan Jasa Konstruksi / Kontraktor Dengan Metode AHP (Studi Kasus Pengadaan Di Universitas Sebelas Maret (UNS),” Matriks Tek. Sipil, vol. IV, no. 1, pp. 8–16, 2016.
7. A. Priyono, “Penerapan Metode Analytical Hierarchy Process (AHP) pada Aplikasi Pendukung Keputusan Seleksi Karyawan Unsurcharm Indonesia,” Justis Unj, vol. 6, no. 3, pp. 21–26, 2017.
8. E. Plebankiewicz and D. Kubek, “Multicriteria Selection of the Building Material Supplier Using AHP and Fuzzy AHP,”
9. S. Dhimas Prabowo and E. budi setiawan, “Jurnal Ilmiah Komputer dan Informatika (KOMPUTA) GAME SHOPPING TIME,” vol. 2, no. April, 2013.
10. T. L. Saaty and G. Hu, “Ranking by eigenvector versus other methods in the analytic hierarchy process,” Appl. Math. Lett., vol. 11, no. 4, pp. 121–125, 1998.
11. E. Tristantphyllou and S. H. Mann, “Using the Analytic Hierarchy Process for Decision Making in Engineering Applications : Some Challenges,” Inter’l J. Ind. Eng. Appl. Pract., vol. 2, no. 1, pp. 35–44, 1995.
12. M. Ruspawan, I. K. Sudarsana, and M. Nadiasia, “Analisis Faktor Yang Mempengaruhi Partisipasi Dan Nilai Penawaran Peserta Lelang Elektronik (E-Procurement) Jasa Konstruksi Di Kabupaten Buleleng,” J. Spectrurn, 2017.
13. Z. Arifin, “STUDI HARGA PENAWARAN DAN FAKTOR PENENTU PEMENANG TENDER Jurusan Teknik Sipil Universitas Islam Indonesia , Yogyakarta , Indonesia , Email : zaenal_pag@yahoo.com Jurusan Teknik Sipil , Universitas Islam Indonesia , Yogyakarta , Indonesia 3. METODE PENE,” vol. 7, no. KoNTekS 7, pp. 24–26, 2013.
Analytical Hierarchy Process (AHP) Implementation in Determining Document Evaluation Criteria of Post Qualification E-Tendering Knockout Phase

14. D. Puri and S. Tiwari, “Evaluating The Criteria for Contractors’ Selection and Bid Evaluation,” Int. J. Eng. Sci. Invent. ISSN (Online), vol. 3, no. 7, pp. 2319–6734, 2014.

15. K. Kanaprio et al., “PEMILIHAN KONTRAKTOR DI PROYEK KONSTRUKSIPT . X DENGAN METODE ANALYTIC NETWORK PROCESS,” pp. 1–12, 2014.

16. P. G. Akbar, H. Hennaidi, and E. Amrina, “Usulan Indikator Evaluasi Pemasok dalam Penetapan Bidder List: Studi Kasus Pengadaan Jasa PT. Semen Padang,” J. Optimasi Sist. Ind., vol. 14, no. 1, p. 39, 2017.

17. Syaifullah, “Pengenalan Metode AHP (Analytical Hierarchy Process),” Wordpress, pp. 1–11, 2010.

18. B. E. Widodo and U. Ciptomulyono, “SELECTION OF CONTRACTORS FOR CONSTRUCTION SERVICES,” pp. 1–8, 2012.

19. B. Columbia, “Procurement Process: Decision by Exclusion and Pairwise Comparisons,” vol. 20, no. 5, pp. 705–712, 1992.