Application of BLOCPLAN algorithm as liquified natural gas (LNG) regasification terminal design method

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Abstract. In the layout design of buildings using applications, such as in the fields of civil engineering, shipping, architecture, there are many design algorithm systems that have been developed. Design algorithm is an approaching method in design where the computer system has been processed with several formulas to produce designs automatically and efficiently. In this paper the researcher try to use one of the design algorithm to designing the LNG terminal layout, called BLOCPLAN algorithm. The BLOCPLAN algorithm is used to improve the efficiency of space utilization and facility placement. BLOCPLAN works by generating several terminal layouts with a direct appraisal system. A most efficient design will be selected from generated designs after re-analysis process. By using the BLOCPLAN algorithm the pipe length used in terminal will be less so it will be more cost-effective. In determining the main terminal facilities, Excel Solver is also used to choose the best scenario with low investment capital. Design algorithm system can effectively support the recommendation process of a more comprehensive layout design. This research is expected to facilitate the designers work because by using this method the designer no longer need to carry out complex processes from the initial stage of design.

1. Introduction

In initiating the LNG terminal layout design process, designers often use diagrams and sketches to produce an initial layout design. In making diagrams, the designer draws a proximity diagram between facility, the results is known as topological patterns of the layout. In sketching, the designer draws the area of the facility and their respective geometric shapes based on the topology pattern, so that the designer combines the topology and geometric shapes of the layout. Thus, if the existing design algorithm is used directly as an initial solution for the new design process, two benefits are obtained [1]: The task of the designer to create a new layout design is reduced, and designers can utilize a combination of patterns topology and geometric shapes using existing algorithms.

The purpose of the formulation of a design algorithm is to minimize the total cost of production between departments where related costs will relate to the distance between departments [2]. Design algorithm itself has become an inseparable part of the field of operations research where its application has been carried out in a multi-disciplinary manner from industry to architecture. This study aims as an initial step in the research of layout optimization applications in the LNG regasification terminal. In this study the method development was carried out at an early stage by using Excel solver to choose the best investment scenario followed by the use of a previously created design algorithm without developing a
new method. The algorithm used in this study is the BLOCPLAN algorithm. BLOCPLAN algorithm has the ability to produce multiple layout designs along with appraisal system for the efficiency of each layout.

2. Methodology

This study using Excel Solver to choose the best investment scenario for the construction of a new LNG terminal. Three initial scenarios will be made based on the size of the ship lng carrier used. After the main facility has been selected, the area for each facility is calculated to be used as input to the BLOCPLAN algorithm. 3D design is created using the layout design generated by the BLOCPLAN algorithm to visually depict the shape of the terminal and to calculate the total length of the pipe used. In general there are 4 stages used in this research.

2.1. Supply and demand modelling

Supply and demand modeling is based on existing data. Modeling is carried out to describe the condition of future gas balance to determine the specifications of the main LNG terminal facilities. From the modeling it is obtained the amount of LNG demand in a certain area and the level of daily LNG gas consumption.

2.2. Determine the main specifications of the terminal

In determining the main specifications of the terminal, the solver feature in Excel applications is used to simplify and speed up the process of determining the main specifications. Several scenarios are made to compare. The parameter used to determine the best scenario is the initial investment capital of the terminal construction. Excel Solver can determine the number and type of facilities needed with minimal capital cost while still meeting the design requirements.

2.3. Design layout making

Layout production facility is an overall shape and placement of facilities needed in the production process [3]. After the main dimensions of the terminal are obtained, the process continues to make the layout of the terminal itself. Creating a terminal layout using the BLOCPLAN algorithm is done by inputting area datas and proximity relationships for each facility. Then the algorithm will produce several layout designs and assessment scores for each type of layout. The advantage of the BLOCPLAN algorithm is that it already has the ability to score the levels of efficiency, closeness, and several other assessments. So the designer doesn’t need to test the results again but rather directly assess the resulting score to determine which layout type is the most efficient for the terminal to be designed. At this stage there are several processes that must be carried out in order to obtain the desired results. To get the value of the relationship between each of the facilities available at the terminal, an approaching method called systematic layout planning is used. Systematic layout planning (SLP) is a prominent procedural approach and is widely used in layout design for various small and medium enterprises [4]. This approach is based on a qualitative assessment of the researcher. The steps using the SLP procedure are as follows:

2.3.1. Activity relationship chart calculation. The activity relationship chart (ARC) calculates the relations between facilities based on the degree of activity relationships that are often expressed in qualitative assessments and tend to be based on subjective considerations. The assessment is taken from the analysis results of the existing terminal design.

2.3.2. Activity relationship diagram. The next step is the preparation of an activity relationship diagram (ARD). Activity relationship diagram is a method that uses tubular means to display the ranking of relations among all existing facilities. in general there are six closeness ratings used namely "A, I, U, E, O and X". where each rating has a special meaning attached to it.
2.3.3. Blocplan analysis. Blocplan analysis is performed at each major facility that has a direct work order with the calculation of the relation-distance value [5]. The value of closeness between each facility can be obtained by the following formula:

\[
\text{Proximity value} = \frac{\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} R_{ij} D_{ij}}{\sum_{i=1}^{n} \sum_{j=i+1}^{n} R_{ij}}
\]

(1)

And for the R-score values obtained from the equation:

\[
R\text{-score} = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} d_{ij} R_{ij}
\]

(2)

Next Blocplan calculates the upper limit, the lower limit and determines the normalized value of the rel-dist called the R-score as in the equation:

\[
R\text{-score} = 1 - \frac{\text{(nilai jarak relatif - batas bawah)}}{\text{(batas atas - batas bawah)}}
\]

(3)

R-score shows optimal results when the value is close to 1, but otherwise the results are said to be not optimal when approaching 0 (0 < R-score < 1).

3. Calculation and result

3.1. Supply and demand modelling

Supply and demand modeling is carried out to determine the amount of gas surpluses and deficits in a particular region. In this research the area taken as a target supply sample is Region II Indonesia (central Sumatra, southern Sumatra, Riau islands and western Java). Natural gas demand data in region II is shown in table 1 and the estimated data on natural gas supply in region II Indonesia is shown in table 2.

| Description                     | 2018   | 2022   | 2027   |
|---------------------------------|--------|--------|--------|
| Petrolium lifting               | 180.95 | 140.95 | 113.30 |
| Government program              |        |        |        |
| transportation                  | 23.99  | 29.16  | 37.22  |
| household                       | 4.36   | 5.3    | 6.76   |
| Fertilizer and petrochemicals   | 343    | 330    | 300    |
| Electricity                     | 689.8  | 773.9  | 1,009.3|
| Industry                        |        |        |        |
| retail industry                 | 967.03 | 1,175.43| 1,500.18|
| non-retail industry             | 159.5  | 251.5  | 371.5  |
| LNG export/commitment           | 926.9  | 895.9  | 215.3  |
| Total demand                    | 3,295.53| 3,602.14| 3,553.56|
Table 2. Estimated natural gas needs for region II. [6]

|       | 2018     | 2019     | 2020     | 2021     | 2022     | 2023     | 2024     | 2025     | 2026     | 2027     |
|-------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Needs | 2832.66  | 3088.09  | 3144.13  | 2946.05  | 2714.02  | 2400.72  | 2055.96  | 1889.72  | 1658.54  | 2433.20  |

In this study, the natural gas balance data used is the data in 2027. Based on natural gas balance data, it can be concluded that region II has a natural gas deficit of 1,120.36 MMSCFD annually. Assuming the gas needs are relatively the same every day, the daily gas demand for the region II is 9.7358 MMSCFD. The regasification terminal to be built is at the point of 5° 24'45.16" S 105° 49'11.82" E. Precisely at Bandar Negeri, Labuhan Maringgai, East Lampung, Lampung. The site selection takes into account the distance of the most relatively close locations to the Sumatra-Java gas pipeline. This site selection analysis does not consider the ambient conditions at the site because the design is only a modeling approach to apply the BLOCPLAN algorithm to streamline the layout of terminal facilities.

3.2. Ship selection
In the process of selecting ships, there are 3 LNG carrier ships being compared. Specific data from the three ships are shown in the table 3.

Table 3. LNG carrier specifications.

| Data                        | WSD50 5K | WSD50 7.5K | AP460 |
|-----------------------------|----------|------------|-------|
| LOA [m]                     | 99.99    | 115.1      | 90    |
| LPP [m]                     | 94.5     | 110.6      | 86.8  |
| B [m]                       | 12.2     | 18.6       | 15.7  |
| H [m]                       | 9.3      | 10.15      | 9.4   |
| T [m]                       | 5.2      | 6          | 4.72  |
| DWT [tons]                  | 3,350    | 4,100      | 2,820 |
| Vs [knots]                  | 14       | 13.5       | 12.5  |
| Cargo capacity [m³]         | 5,100    | 7,500      | 4,080 |
| Endurancea [nm]             | 3,350    | 8,000      | 1,200 |
| GT                          | 5,580    | 6,850      | 3,870 |
| Main engine [kW]            | 4,000    | 3,000      | 3,200 |
| Ship crew [persons]         | 18       | 18         | 12    |
| Cargo pump cap. [m³/h]      | 800³     | 1,000³     | 900⁴  |
| MDO capacity (fuel) [m³]    | 180      | 400        | -     |
| MDO consumption [tons/day]   | 15.8     | 10.4       | 14.65 |
| Ship cost [USD]             | 40,000,000 | 50,000,000 | 35,000,000 |

³Using MDO as ship’s fuel
³² x 400 m³/h. one each tank
³² x 500 m³/h. one each tank
³² x 450 m³/h. one each tank
³The price of the vessel is not the actual price, but the average price of a similar vessel

The three ships are compared based on the initial investment capital value needed for each type of ship. The objective is to choose the type of ship with the lowest investment cost while still meeting the terminal requirements. General data used for the calculation are shown in the table 4.

There is some data that is assumed due to the difficulty of getting authentic data, including insurance premium costs, port tax fees, and the cost of building a jetty. Using existing data, the initial investment
costs can be calculated for each type of LNG carrier. Costs calculated for comparison are insurance costs, port tax fees, ship bunkering costs when operating, and jetty construction costs for the vessel's berth. All of these calculations are carried out assuming there are no additional costs incurred at any time caused by certain factors that cannot be controlled.

**Table 4. General data.**

| Description                          | Amount      |
|--------------------------------------|-------------|
| Ship operational days                | 340         |
| Distance from origin [nm]            | 907         |
| Demand must be fulfilled per year [m³]| 42,907.40   |
| Insurance premium cost [USD/ton]     | 5           |
| LNGρ [ton/m³]                        | 0.47        |
| MDO cost [USD/ton]                   | 250         |
| Port tax fees [USD/ton]              | 4.24        |

**Table 5. Ship’s capital cost investment calculation.**

| Description                          | WSD50 5K | WSD50 7.5K | AP460 |
|--------------------------------------|----------|------------|-------|
| **Round trip duration/year**         |          |            |       |
| Sea time [hour]                      | 129.6    | 134.4      | 145.1 |
| Port time [hour]                     | 12.8     | 15         | 9.1   |
| Min. round trip per year             | 8.41     | 5.72       | 10.52 |
| Round trip duration/year [hour]      | 1197.4   | 854.5      | 1621.5|
| **Status**                           | Accept   | Accept     | Accept|
| **Insurance cost [USD]**             | 100,832  | 100,832    | 100,832|
| **Port tax cost [USD]**              | 181,927  | 181,927    | 181,927|
| **Bunkering cost**                   |          |            |       |
| MDO consumption at sea time [USD]    | 179,414.35| 83,279.21  | 232,897.99|
| MDO consumption at port time [USD]   | 3,530.92 | 1,859.32   | 2,910.15|
| Bunkering cost [USD]                 | 182,945  | 85,139     | 235,808|
| **Jetty construction cost [USD]**    | 2,000,000| 2,300,000  | 1,900,000|
| **Total investment [USD]**           | 42,465,705| 52,667,898 | 37,518,568|

*aRound trip duration/year must not exceed maximum ship operations duration in a year [340 days/8160 hours]*

3.3. **Tank selection**

For comparison to find the least amount of investment capital, it used four types of tanks of different sizes. Data from the four tanks is shown in the table 6.

**Table 6. Tank specification data.**

| Description                          | EN 13458 | VT 108 | LC 200V38 | LC 318V42 |
|--------------------------------------|----------|--------|-----------|-----------|
| Gross vol. [m³]                      | 95       | 107.57 | 200       | 318       |
| Net cap. (95%) [m³]                  | 90.25    | 102.192| 190       | 302.1     |
| Daily rate eva. [%/d]                | 0.1      | 0.09   | 0.083     | 0.078     |
| LNG cap [ton]                        | 42.4175  | 48.03024| 89.3      | 141.987   |
| Max. working pressure [bar]          | 5        | 11     | 5         | 5         |
| Width [m]                            | 3.35     | 3      | 3.81      | 4.21      |
| Gas ρ [ton/m³]                       | 0.0008   |        |           |           |
With the existing tank specification data, investment values for each type of tank can be found according to the type of vessel used. Calculation data for each scenario, starting from using the WSD50 5K, WSD50 7.5K, and AP460 vessels, are shown in tables 7, table 8, and table 9, respectively. The constraint used in the Solver program is the total capacity that can be accommodated by the terminal. The terminal must be able to accommodate all LNG carried by LNG carriers. Furthermore, the number of tanks needed can be calculated.

The choice of tank type is carried out with the objective of minimizing the cost of constructing the terminal. This is done by multiplying the cost of purchasing the tank and the amount of land needed for the construction of the tank for each type of tank. After that the total cost compared each other between the four types of tanks used. The tank with the lowest initial investment capital is considered the most optimum result.

**Table 7.** Tank calculation for using WSD50 5K ship as LNG carrier

| Description                  | EN 13458 | VT 108 | LC 200V38 | LC 318V42 |
|------------------------------|----------|--------|-----------|-----------|
| Capacity [m³]                | 90.25    | 102.19 | 190       | 302.1     |
| Tank cost [USD]              | 100,000  | 170,000| 200,000   | 265,000   |
| Land area [m²]               | 14.8225  | 10.7584| 14.5161   | 17.7241   |
| Land cost [USD/m²]           |          |        |           | 50        |
| Terminal capacity            | 0        | 0      | 0         | 5,136     |
| Total terminal capacity [m³] |          |        |           | ≥         |
| Ship capacity [m³]           |          |        |           | 5,100     |
| Output                       | Total tank | 0      | 0         | 0         | 17        |
| Objective Function           | Total Investment [USD] | 4,520,065 |

**Table 8.** Tank calculation for using WSD50 7.5K ship as LNG carrier

| Description                  | EN 13458 | VT 108 | LC 200V38 | LC 318V42 |
|------------------------------|----------|--------|-----------|-----------|
| Capacity [m³]                | 90.25    | 102.19 | 190       | 302.1     |
| Tank cost [USD]              | 100,000  | 170,000| 200,000   | 265,000   |
| Land area [m²]               | 14.8225  | 10.7584| 14.5161   | 17.7241   |
| Land cost [USD/m²]           |          |        |           | 50        |
| Terminal capacity            | 0        | 0      | 0         | 7,552.5   |
| Total terminal capacity [m³] |          |        |           | ≥         |
| Ship capacity [m³]           |          |        |           | 7,500     |
| Output                       | Total tank | 0      | 0         | 0         | 25        |
| Objective Function           | Total Investment [USD] | 6,647,155 |
Table 9. Tank calculation for using AP460 ship as LNG carrier

| Description                  | Tank model | EN 13458 | VT 108 | LC 200V38 | LC 318V42 |
|------------------------------|------------|----------|--------|-----------|-----------|
| Capacity [m³]                |            | 90.25    | 102.19 | 190       | 302.1     |
| Tank cost [USD]              |            | 100,000  | 170,000| 200,000   | 265,000   |
| Land area [m²]              |            | 14.8225  | 10.7584| 14.5161   | 17.7241   |
| Land cost [USD/m²]          |            |          |        |           | 50        |
| Terminal capacity            |            | 0        | 0      | 0         | 4,229     |
| Total terminal capacity [m³]|            |          |        |           | ≥ 4,229   |
| Ship capacity [m³]           |            |          |        |           | 4,080     |
| Total tank                  |            | 0        | 0      | 0         | 14        |
| Total Investment [USD]       |            |          |        |           | 3,722,407 |

Using the investment results for ships and storage tanks, total investment value is calculated to choose the cheapest investment scenario. The data is shown in table 10.

Table 10. Investment value for each scenario.

| Scenario   | Ships investment | Tanks investment | Total investment for ship and tanks |
|------------|------------------|------------------|------------------------------------|
| I WSD50 5K | $42,465,705      | $4,520,065       | $46,985,771                        |
| II WSD50 7.5K | $52,667,898 | $6,647,155       | $59,315,053                        |
| III AP460  | $37,518,568      | $3,722,407       | $41,240,975                        |

Ships and tanks are the largest investment value in a terminal, therefore taking into account these two facilities alone can represent the investment value of all facilities to choose the best investment scenario. From the results listed in table 10, scenario III investments using AP460 as the LNG carrier is the cheapest scenario with an investment value for ships and tanks of $41,240,975. Then all other supporting facilities for terminal needs are selected based on the specifications of the third scenario.

3.4. Evaporator, compressor, pump selection, and BOG liquefaction plant

3.4.1. Evaporator selection. In choosing a vaporizer, the daily level of LNG consumption from the end user is considered as the minimum capacity of the evaporator. The level of LNG consumption per day from region II is 9.7358 or equal to 15.536 m³/h.

Table 11. Selected evaporator specification.

| Description               | Value |
|---------------------------|-------|
| Type                      | L40-4F3-HQ      |
| Max working pressure [bar]| 40    |
| Dimension [m]             | D: 0.52, W: 0.8, H: 3.836 |
| Nominal capacity [Nm³/h]  | 40    |
| Actual output [%]         | 0.972 |
| Actual output [Nm³/h]     | 38.88 |
| Number of evaporator      | 2     |
| Operational time [hour]   | 12    |
3.4.2. Compressor selection. The minimum compression level of the compressor must adjust the level of BOG produced by the storage tank. With an evaporation rate of 0.078%/day, the LC 318V42 tank produces a BOG of around 3.3 m$^3$/LNG/day or equivalent to 1,938.123 m$^3$/NG/day (80.755 m$^3$/NG/hour). The compressor chosen to serve terminal operations is shown in table 12. The number selected is two, one compressor is used for stand-by mode if at any time the main compressor has a problem.

Table 12. Selected compressor specification.

| Description                  | Value          |
|------------------------------|----------------|
| Type                         | TS2/130-E2     |
| Capacity [m$^3$/h]           | 160            |
| Inlet pressure [bar]         | 1.08           |
| Outlet pressure [bar]        | 7              |
| Number of stroke             | 2              |
| RPM                          | 490            |
| Installed power [kW]         | 11             |
| Number of compressor         | 2              |

3.4.3. Low pressure and high pressure pump selection. Selected pump must meet the minimum capacity of the terminal operating system. This capacity is adjusted to the level of daily LNG consumption from the enduser (15.536 m$^3$/h) and also need to consider the pressure of the operating system.

Table 13. Selected low pressure pump specification.

| Description                  | Value          |
|------------------------------|----------------|
| Model                        | DSM 185        |
| Power installed [kW]         | 5.5            |
| Max Operating speed [rpm]    | 2,950          |
| Max suction pressure [bar]   | 6              |
| Max working pressure [bar]   | 23             |
| Max head [m]                 | 50             |
| Max flow rate [m$^3$/h]      | 18             |
| Land area [m$^2$]            | 0.48           |
| Number of pump               | 2              |

Table 14. Selected high pressure pump specification.

| Description                  | Value          |
|------------------------------|----------------|
| Model                        | SGM 160        |
| Power installed [kW]         | 11             |
| Max Operating speed [rpm]    | 7,310          |
| Max suction pressure [bar]   | 6              |
| Max working pressure [bar]   | 30             |
| Max head [m]                 | 225            |
| Max flow rate [m$^3$/h]      | 31.2           |
| Land area [m$^2$]            | 0.95           |
| Number of pump               | 2              |
3.4.4. **BOG reliquefaction plant.** The selection of plant reliquefaction is done by considering the normal rate of BOG produced by the tank, which is 80,755 m$^3$/hour or equivalent to 0.065 ton/hour of gas. The selected BOG reliquefaction plant specification data is shown in table 15.

| Description               | Value  |
|---------------------------|--------|
| Name                      | TBF-175|
| Reliquefaction range [t/h]| 0.2    |
| Electrical consumption [kW]| 195    |
| L [m]                     | 9.5    |
| W [m]                     | 1.7    |
| H [m]                     | 3      |

3.5. **Layout making**

The process of making layouts in this study using the BLOCPLAN algorithm. The data used to create a layout using BLOCPLAN are the area of each facility and the proximity relationship between each facility. The area for each facility data is shown in table 16. The area for each facility is calculated based on Chapter 6 Plant Layout NFPA 59A [7], which regulates the minimum distance between facilities contained in the LNG terminal.

| Description               | Storage tank | Vaporizer | Compressor | Pump | Recondenser | Flare |
|---------------------------|--------------|-----------|------------|------|-------------|-------|
| Components area [m$^2$]   | 265.86       | 0.54      | 2          | 1.23 | 16.15       | 16    |
| Space between the          | 156.93       | 0.78      | 1.5        | 5.82 | -           | -     |
| components area [m$^2$]   |              |           |            |      |             |       |
| Between facilities area [m$^2$] | 865.2 | 270.9     | 285        | 348.63 | 393 | 329 |
| Total area [m$^2$]        | 1287.99      | 272.22    | 288.5      | 355.68 | 409.15 | 345 |

In order to process the existing area data, the proximity relationship parameters for each facility are also needed, the data is shown in table 17. In this study the proximity relationship between facilities is inputted based on the subjectivity of the designer. The objective of closeness rate is to bring operations-related facilities closer together so as to minimize the use of pipes in order to produce cost-effective designs.

| Facility                  | Vaporizer | Compressor | Pump | BOG reliquefaction | Flare |
|---------------------------|-----------|------------|------|---------------------|-------|
| Storage tank              | U         | A          | E    | U                   | X     |
| Vaporizer                 | U         | A          | U    | U                   | U     |
| Compressor                | U         | A          | E    |                     |       |
| Pump                      | E         | U          | U    |                     |       |
| BOG reliquefaction        |           |            |      |                     | U     |

There are 6 levels of value indicators used in the proximity relationship between facilities, namely absolutely essential (A), essential (E), important (I), ordinary closeness (O), unimportant (U), and undesirable (X). Each of the indicators has a score of A = 10, E = 5, I = 2, O = 1, U = 0, and X = -10. By using land area data and proximity relationship between facilities, 15 layout designs were produced.
with each score as listed in table 18. In the generating process, three suggestions are given to the algorithm. The first is storage tank location must be in the north because it considers the jetty position in the north. Second suggestion is the vaporizer position located in the south-east because it considers the distribution path to the end user which is closer from that direction. The third suggestion is the land ratio for the construction of the LNG terminal is 1:1.

| Layout | Adjacency Score | R. score | Rel-dist score | Prod. movement |
|--------|-----------------|----------|----------------|----------------|
| 1      | 0.89            | 0.73     | 812            | 0              |
| 2      | 1               | 0.78     | 737            | 0              |
| 3      | 1               | 0.77     | 686            | 0              |
| 4      | 0.89            | 0.73     | 812            | 0              |
| 5      | 0.78            | 0.65     | 908            | 0              |
| 6      | 0.89            | 0.73     | 812            | 0              |
| 7      | 0.78            | 0.61     | 984            | 0              |
| 8      | 0.78            | 0.69     | 775            | 0              |
| 9      | 0.78            | 0.59     | 1034           | 0              |
| 10     | 0.89            | 0.73     | 812            | 0              |
| 11     | 0.78            | 0.74     | 694            | 0              |
| 12     | 1               | 0.78     | 737            | 0              |
| 13     | 0.67            | 0.63     | 1033           | 0              |
| 14     | 0.67            | 0.61     | 991            | 0              |
| 15     | 1               | 0.81     | 698            | 0              |

The best layout design is one that has high adjacency score, high r.score, and the low rel-dist score. According to table 18, the best layout design is layout 15 with adj.score = 1, r.score = 0.81, and rel-dist score = 698. The top view of layout 15 is shown in figure 1 and the specific data from each main facility position are shown in table 19.

![Top view of layout 15](image.png)

**Figure 1.** Top view of layout 15.
Table 19. Layout 15 specific data.

| Facility                      | Centroids X | Centroids Y | Length | Width | L/W |
|-------------------------------|-------------|-------------|--------|-------|-----|
| Storage tank                  | 27.2        | 42.55       | 54.4   | 23.7  | 2.3 |
| Vaporizer                     | 42.4        | 5.67        | 24     | 11.3  | 2.1 |
| Compressor                    | 7.45        | 21.03       | 14.9   | 19.4  | 0.8 |
| Pump house                    | 45.21       | 21.03       | 18.4   | 19.4  | 0.9 |
| BOG reliquefaction plant      | 25.46       | 21.03       | 21.1   | 19.4  | 1.1 |
| Flare                         | 15.2        | 5.67        | 30.4   | 11.3  | 2.7 |

### 3.6. 3D terminal design

3D terminal design is done to visually see the relationship between each facility. There are two 3D designs created, the first is a 3D design based on the terminal layout produced by the BLOCPLAN algorithm and the second is a conventionally designed 3D design. From both designs the pipe length is used for the entire terminal. Minimal use of the pipe indicates a good utilization of space and the placement of facilities. The results are predicted to be more cost effective designs that use the BLOCPLAN generated layout.

### 4. Conclusion

Blocplan algorithm has a pretty good ability in making design layouts. This has been proven in previous studies in different industries. However, this research tries to provide a new approach. The BLOCPLAN algorithm combined with Excel solver is used to create a LNG terminal design layout. The method used in this research is very good to be used in designing simple terminals. Pipe length parameters are used to prove the effectiveness of BLOCPLAN in making the design of the LNG terminal. Not only using BLOCPLAN to make effective use of pipelines, Excel solver is also used to make investment capital more effectively. Several similar scenarios are made based on several main types of facilities and Excel can help calculate to choose the best scenario with the lowest investment capital.

### References

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