Design and development of biogas system for small village

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Abstract. Pasirmulya Village Bandung has a wastewater treatment plant that can be developed to serve as an alternative fuel for the biogas digester. Biogas has a great attracted by researchers in developing a renewable energy source to be used for residential. This process is designed to produce alternative energy to reduce the impact of fossil fuel uses. The design of biogas system is to utilize the use of wastewater treatment in current condition. Critical path method is used to identify the critical activities in this project. The Biogas works using 16 components with critical paths or activities that must be done first. The project shows the critical path method preparation for bill of material – material purchases – Cutting 0.75-inch PVC pipe – piece of pipe assembly – plant the pipe at the land – pipe assembly with elbow PVC – cover and pipe assembly – stave assembly – biogas stove testing - quality check – project reporting and documentation with 8 hours total time activity in one day. This community service project was implemented and found the potential of using biogas system for residential purposes.

Keywords: Biogas system, design, village, wastewater treatment plant

1. Introduction
The increasing population of the Indonesian population affects the carrying capacity of the environment. JuliantoWitjaksono, Deputy for Family Planning and Reproductive Health at the National Population and Family Planning Agency, JuliantoWitjaksono, said that Indonesia's population is projected to be 281.5 million in 2025 and 330 million in 2050. Indonesia's population will explode and become a burden to the economy. Much of the state budget will be absorbed for the provision of food and education and health services. The increasing in energy demand caused by population growth and depletion of world oil reserves as well as the problem of emissions from fossil fuels put pressure on every country to immediately produce and use renewable energy [1].

Indonesian still depend on energy sources that are commonly traded and traded, for example: fuel, firewood, LPG, kerosene, which are increasingly expensive and scarce. This situation makes the economic conditions of the Indonesian even more difficult, especially for those who live in villages, who generally live at a weak economic level. Local initiatives are needed to form an independent society, which is capable of being independent without having to wait for assistance from the government [1].

Biogas technology is also able to reduce Chemical Oxygen Demand (COD) by 90% from the initial material conditions and the Biological Oxygen Demand / Chemical Oxygen Demand (BOD /
COD) ratio of 0.37 is smaller than normal conditions of liquid waste BOD / COD = 0.5. Utilization of biogas technology will also be able to reduce CO$_2$, CH4 and N$_2$O [2].

The biogas digester installation in Pasirmulya Village processes human waste to turn it into biogas by using human waste contained in the wastewater treatment tank with a size of 15 meters x 5 meters x 7 meters, where the wastewater treatment tank accommodates waste in the range of 50-100 houses. This is very possible to be used as alternative energy that can be used. Based on these problems, there are opportunities in the utilization of human waste through socialization/counseling activities regarding the use of human waste to be used as biogas and about handling waste so as not to pollute the environment and the installation of biogas digester devices [3].

Biomass is an alternative energy that is most readily processed into a large amount of energy that is around us and is environmentally friendly. Plants, organic waste and animal and human waste can produce biogas which can be used as an energy source to replace oil, gas, firewood and coal. Biogas is a renewable energy source so there is no need to worry about the depletion of energy sources [4]. This process is a great opportunity to produce alternative energy so that it will reduce the impact of using fossil fuels.

In year 2020, most of research have been studied the biogas system in the particular countries in order to capture the global market profile. The biogas systems standard was introduced in China to adopt industry transformation and market needs [5]. In Sweden, the institutional capacity building theory is introduced to guide involvements with public and private person to enable the development of local biogas systems [6]. A system dynamics model was established in Brazil to evaluate biogas return over a 30-year period since public waste, feedstock, vinasse and wastewater routes [7]. Last in Indonesia, the authors described the potential development of small-scale biogas systems to use used in rural parts of northern Sumatra [8]. In addition, most of studies show contribute in biogas system standard for specific country depend on demography and culture.

The application and improvements of biogas system also have been introduced by adding several materials. Biogas purification system was presented to remove H$_2$S siloxane and it is found the significant improvement on biogas system economically [9]. A biogas fed SOFC CHP system based on multi-scale hierarchical modeling was introduced to improve the biogas system [10]. By using NaOH and Ca(OH)$_2$ absorbents on horizontal pipe separation system of mobile anaerobic digester has significantly improved the quality product from dairy cow fertilize [11]. Swine manure and placenta in real-scale systems in the biogas development and found that potential to be applied on circular economy [12].

In this paper, the design and development of biogas system for residential was proposed for Pasirmulya village as an alternative energy. In addition, the project management was also discussed in order to determine the critical activities for planning purposes.

2. Materials and Methods

This community service project presents the Critical Path Method (CPM) in determining the time. This method identifies the critical path to an activity which is determined by the dependence between activities. Activities are specific tasks that have results that can be measured in terms of the duration of project duration work.

In the CPM method there are two estimated time and costs for each activity contained in the network. The two estimates are the normal estimate of completion time and costs (normal estimate) and the estimated time for completion and costs that are accelerated (crash estimate). In determining the estimated completion time, the term critical path will be known, a path that has a series of activities with the longest total amount of time and the fastest project completion time. The critical path contains critical activities from the beginning to the end of the path.

The next step is to prepare a plan using the Critical Path Method (CPM) technique, which is to find the critical point of the biogas project by using a network diagram. Determination of the critical point
in a project work is done by finding the greatest time value of each activity that is connected in one path. Before determining the critical path, a list of activities can be determined as listed in table 1.

| No | Activities                          | Predecessor | Time (Minutes) |
|----|-------------------------------------|-------------|----------------|
| 1  | **Project Planning**                |             |                |
|    | A Design of biogas system           | -           | 60             |
|    | B Bill of Material                  | -           | 30             |
| 2  | **Project Development**             |             |                |
|    | C Purchasing material               | B           | 60             |
|    | D Team briefing                     | -           | 10             |
| 3  | **Development of piping system**    |             |                |
|    | E Measuring path                    | D           | 15             |
|    | F Cutting process (piping)          | A, C        | 35             |
|    | G Grouding                          | E           | 90             |
|    | H Piping Assembly                   | F           | 45             |
|    | I Piping system                     | G, H        | 60             |
| 4  | **Base plate Development**          |             |                |
|    | J Base/cover pate                   | C           | 60             |
|    | K Existing base cover replacement   | J           | 45             |
|    | L Assembly with piping system       | J           | 10             |
|    | M Assembly & grounding              | L, K        | 15             |
| 5  | **Assembly 3 and 4**                |             |                |
|    | O Finishing piping system           | I           | 10             |
|    | P Finishing cover base plate        | O, M        | 20             |
|    | Q Finishing at user stove           | P           | 10             |
| 6  | **Project Testing**                 |             |                |
|    | R Testing trial                     | Q           | 30             |
|    | S Quality inspection                | R, O, M     | 60             |
| 7  | **Project Presentation**            |             |                |

3. Results and Discussion
After determining the list of activities to be carried out, a network diagram of each work activity for making biogas can be drawn in figure 1.
Based on the network diagram and activity table being carried out, it is found that various work paths can be determined by the total time of the work path, while some of the work paths generated from the network diagram are as follows:

- Path 1: D – E – G – I – O – P – Q – R – S – T = 425 minutes
- Path 2: D – E – G – I – O – S – T = 365 minutes
- Path 3: A – F – H – I – O – P – Q – R – S – T = 450 minutes
- Path 4: A – F – H – I – O – S – T = 390 minutes
- Path 5: B – C – F – H – I – O – S – T = 420 minutes
- Path 6: B – C – F – H – I – O – P – Q – R – S – T = 480 minutes
- Path 7: B – J – K – M – P – Q – R – S – T = 390 minutes
- Path 8: B – J – L – M – P – Q – R – S – T = 355 minutes
- Path 9: B – J – L – M – S – T = 295 minutes

Based on the 9 existing paths, the critical path is the path with the largest or longest processing time for each activity and based on the results obtained path 6 is the critical path based on the working principle of counting forward or forward with the largest total time of 480 minutes with the activity code, namely B - C - F - H - I - O - P - Q - R - S - T. Critical time also interprets that the activity must be completed first and the process cannot be passed because if the processing of the process for that path is not prioritized, there can be delays in other activities. After determining the critical path, a gantt chart can be determined to make it easier for readers to indicate the stages of working on each activity. The duration of time required to complete the project was 8 hours and it was assumed that work starts at 8 am which means the project can be completed at 4 pm. The value of 8 hours based on the gantt chart was in accordance with the results obtained for the critical time, namely 480 minutes or 8 hours. The gantt chart of the biogas project manufacturing process is described in the figure 2.

Figure 2. Gantt chart for biogas project

The detailed piping system was proposed after measuring location from wastewater treatment plant location and residential. Figure 3 shows the detailed piping system design for this project.
Figure 3. Detailed piping system design

Figure 4 shows detailed base plate design as cover and inlet for biogas at the wastewater treatment location.

In the project implementation, the first step is to measure the biogas comes from wastewater treatment plant at 10:00 AM. Portable gas analyzer combustible is used to measure the level of biogas and it was found that the biogas was reached level of 33-50 as shown in figure 5. This level indicates that biogas system was potential to be used as renewable energy for residential. However, the biogas level was decreased during noon to evening due to some reasons, such as minimum supply from residential wastewater, speed of wind around the wastewater treatment plant, distance between residential and wastewater treatment plant, piping system, gas losses, and manure homogeneous.
The result shows that the necessity of biogas flowrate need to be studied to ensure biogas supply from wastewater treatment plant to residential effectively.

4. Conclusion

Based on the bill of materials made for the biogas project, the work requires 16 components for the biogas assembly. The work on a biogas project has a critical path that must be worked out first before working on other activities. The critical path or activity is the preparation of a bill of materials - purchasing materials - cutting 0.75 inch PVC pipe - assembling pipe pieces - planting pipes in the excavation line - pipe assembly with PVC elbows - assembly with a pipe line - assembly with a stove - testing biogas stove - quality check - documentation and project report preparation. This activity is an activity with the longest time, which is 8 hours so that when the activity is completed, activities other than the critical path can be ascertained as well. Based on the gantt chart, the project work process is 1 day or 8 hours with the assumption that the work starts at 08.00 in order to avoid delays in any of the project work activities.

The detailed design of Biogas system was proposed for small village and potential to be installed to other village. This project also was proposed as an alternative energy resources for residential to replace existing LPG tube consumption. For future works, the flowrate of biogas should be further investigated in order to ensure the biogas travels from inlet to outlet effectively.

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