TOWARD QUALITY CONTROL OF BIOGAS PRODUCT IN INDONESIA: AN OVERVIEW

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ABSTRACT

The quality control of the final product of biogas is essential for providing a maximum level of consumer satisfaction. The most important criteria for any biogas product are its regulatory compliance and safety. Based on a desk study of documents and laboratory experiment, this paper overviews the development of infrastructure of quality to control the quality of biogas, aiming at summarising the experience, problems and demonstrating development status of quality infrastructure in Indonesia in the hope of providing references for the present condition. The discussion is made to cover issues related to biogas that are emphasised on three pillars of the infrastructure of quality in Indonesia, i.e., standardization, metrology, and conformity assessment. From the overview, the conclusion that can be drawn is that increasing understanding and continuing the development of quality infrastructure as an effort to ensure the safety and quality of biogas in Indonesia remains essential.

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1. Introduction

Fossil-based fuels as the primary energy sources in Indonesia and dominates national energy needs [1]. Up to now, however, fossil-based fuels have been considered to contribute to enormous environmental problems—from air pollution to global warming [2, 3]. In addition to its negatives impacts, the use of fossil-based fuels has declined petroleum reserves, triggered higher oil prices in the market, and increased the number of oil imports due to national fuel consumption. Generally speaking, dependence on fossil-based fuels may create a significant economic, environmental, and energy security concern. As a result, numerous attempts have been made to replace fossil-based fuels with new and renewable energy sources.
To overcome the aforementioned energy-related problems in Indonesia, the government has stepped up its effort by encouraging the adoption of alternative energy policy through the implementation of new and renewable energy programs set in National Energy Policy (NEP) (Govt. Decree No. 79/2014) [4]. The main direction of NEP is to target a higher portion of new or renewable energy in the national energy mix to reach 23% by 2025 [3, 5]. Hence, the NEP could help ensure sustainable energy security and supply, improve the environmental quality of life, and foster national economic growth. In addition, the NEP has encouraged the scientific community to take part in reducing demand for fossil-based energy by pursuing some potential energy sources include solar, waterfall, geothermal, wind, and biomass [5, 6, 7]. In this regard, bio-energy such as biogas-based biomass could be the most potential source.

During the past decade, the biogas industry has been one of the fastest-growing fields in Indonesia for an energy source for heating supply, electricity, and vehicle. The energy efficiency derived from biogas is purity dependent because high energy conversion occurs only at the high-quality biogas [8]. Thus, regulatory compliance and safety become essential criteria for biogas products. In Indonesia, the quality of biogas may refer to SNI 8019: 2014 [19] whose application is voluntary.

Production of biogas is a complicated process led to possible obtains biogas with various levels of impurities [9]. The existence of impurities in biogas product may cause problem resulting in less safe and less energy efficiency. Therefore, a properly functioning of quality infrastructure will ensure the availability of high quality and safety of the biogas that meets consumer requirement to support the use of commercial biogas. It indicates that the quality must be carefully reassured before the practical utilization of biogas.

This paper briefly overviews the quality infrastructure that is designated for controlling of biogas quality product with the aim in summarising the experience and demonstrating available quality infrastructure in Indonesia in the hope of providing references for the present condition.

2. Methodology

This study was conducted by collecting and reviewing the available data on public platform including journal article, books, data sets, reports, and government regulations regarding the research topic.

3. Results and Discussion

3.1. Biogas Production

Typically, biogas refers to a gas mixture containing a high portion of both carbon dioxide (CO$_2$) and methane (CH$_4$) produced by a fermentation process of organic materials using bacteria under anaerobic conditions. An anaerobic fermentation process of organic material into biogas is a biological process that takes place in 4 successive stages [9, 10, 11] that is schematically presented in Figure 1 [12].

Stage 1: Hydrolysis of macromolecules (proteins, polysaccharides, and lipids) contained in organic materials into macromolecules. Stage 2: Fermentation of micro molecules produces intermediate compounds. Stage 3: Acetogenesis of compounds by acetogenic microorganisms produces acetic acid, CO$_2$ and H$_2$ compounds. Stage 4: Methanogenesis of acetate, CO$_2$, and H$_2$ into methane using methanogenic microorganisms, accompanied by generating many other impurities such as nitrogen (N$_2$), oxygen (O$_2$), hydrogen (H$_2$), hydrogen sulfide (H$_2$S) and ammonia (NH$_3$). From the process, it is known that biogas production involves a complex biological process, indicating that it is possible to obtain biogas with different purity levels. Table 1 lists the main compound that generally make up biogas and its impurities [13].

| Table 1 | Main Compound in Biogas and Its Impurities |
|---------|------------------------------------------|
| Component | Description |
| CO$_2$ | Carbon Dioxide |
| CH$_4$ | Methane |
| H$_2$S | Hydrogen Sulfide |
| N$_2$ | Nitrogen |
| O$_2$ | Oxygen |
| NH$_3$ | Ammonia |
Figure 1. A schematic diagram of decomposition of organic macromolecules into biogas under anaerobic conditions

| Components                        | Concentration (%) |
|-----------------------------------|-------------------|
| Methane (CH\(_4\)) - main        | 50 - 80           |
| Carbon dioxide (CO\(_2\)) - main | 25 - 50           |
| Nitrogen (N\(_2\)) - impurity    | 0 - 10            |
| Hydrogen sulfide (H\(_2\)S) - impurity | 0 - 3          |
| Oxygen (O\(_2\)) - impurity      | 0 - 2             |
| Hydrogen (H\(_2\)) - impurity    | 0 - 1             |

The low purity level of biogas product means that the product contains a high concentration of impurities. The use of such low quality of biogas may cause energy inefficiency, increase safety issues, and low profitability of the biogas. On the other hand, the higher of the CH\(_4\) content, the higher the heating value produced during the combustion process [14, 15, 16]. Therefore, an attempt to produce biogas which complies with the quality requirement is a crucial consideration for industrial biogas processes.

Figure 2 maps some biogas producers in Indonesia along with their plant location. A significant increase in the number of biogas producers in Indonesia presents an opportunity to sustain energy security and supply. Thus, available quality infrastructure (standardization, metrology and conformity assessment) at the national level will allow biogas producers to provide a maximum level of consumer satisfaction and safety.
3.2. Quality Infrastructure in Indonesia

Obtaining a high-quality of biogas that meets existing standard in an effort to maintain the availability of biogas as an efficient energy and environmentally friendly. For this reason, it is very necessary to provide quality infrastructure (standardization, metrology, and conformity assessment) to support biogas producers to access and compete in the market by demonstrating quality and safety of their product to comply with available standard.
Quality infrastructure is defined as a system created by government or private institutions accompanied by the necessary policies and regulatory frameworks in an effort to support and improve the quality, safety, and environment in the provision of goods, services and processes \[2, 17\]. Indonesia’s quality infrastructure has three pillars (key elements), namely standardization, metrology and conformity assessment (accreditation and certification). Based on National Law No. 20/2014 and President Decree 4/2018, the three pillars of national quality infrastructure are independently managed by National Standardization Agency of Indonesia (BSN), and they form a close network based on a technical hierarchy (Figure 3) \[18\]. The BSN has taken the lead on this issue with a focus on being able to optimally implement quality infrastructure to create a system that enables products to meet the quality and safety requirements. In most cases, the government has to enforce standards and technical regulations. For instance, when producing biogas, it is necessary to demonstrate compliance with quality and safety standards that harmonize to international requirements.

**Standardization**

Standardization of a product refers to a condition of understanding to which all appropriate parties must grow together to assure that any processes regarding the creation of a product are conducted under a set of guidelines \[18\]. The agreement assures that the end product with all other similar items in the same level has consistent in quality and all conclusions made can be compared. Standardization of product is obtained by establishing a general guideline concerning how a product or service is created, as well as how a business is driven and how all processes are governed. The objective of standardization in biogas product is to implement a good consistency to specific standards within a selected environment. The national standards for biogas product will contribute to drive a consistent approach at national level for improving its quality and safety. To maintain the quality of biogas and support the commercial use of biogas, the government through BSN has decreed rules set out in the Indonesian National Standard (SNI). The SNI was developed by the Technical Committee (TC 27-04: Bioenergy) and firstly established in 2014 i.e., SNI 8019: 2014 \[19\]. Development of SNI 8019: 2014 was a collaborative process that involves stakeholders including government (regulator), producers and users from across Indonesia with expert input. The quality parameters of biogas products based on SNI 8019: 2014 can be seen in Table 2. The SNI for Biogas was developed by referring to various normative references (Table 3), meaning that the SNI 8019: 2014 for biogas has been harmonized with others standards (national and international). Thus, it provides an opportunity for the global market to accept Indonesian biogas.

| Parameters                                      | Requirements |
|-------------------------------------------------|--------------|
| Dew point temperature at 20000 kPA (°C, max)    | 5            |
| Wobbe index (MJ/Nm³)                            | 39 – 41      |
| Methane number                                  | 80 – 118     |
| Methane (% vol., min)                           | 80           |
| Hydrogen sulphide (mg/Nm³, max)                 | 23           |
| Hydrogen (% vol., max)                          | 0.1          |
| Carbon dioxide (% vol., max)                    | 16           |
| Oxygen (% vol., max)                            | 1            |
| Sulphur total (mg/Nm³, max)                     | 50           |
| Relative density                                | 0.55 – 0.75  |

Table 2. quality requirements for biogas based on Indonesian National Standard (SNI) 8019: 2014 \[19\]
### Table 3. List of standards used as normative references for the development of SNI 8019:2014

| No   | Title                                                                                      |
|------|-------------------------------------------------------------------------------------------|
| SNI 3619 | Handling of compressed cylinder                                                        |
| ASTM D1142 | Standard test method for water vapor content of gaseous fuels by measurement of dew point temperature |
| ASTM D2385 | Standard test method for hydrogen sulfide and mercaptan sulfur in natural gas (cadmium sulfate iodometric titration method) |
| ASTM D1145 | Test method for sampling natural gas                                                    |
| ASTM D1945 | Standard test method for analysis of natural gas by gas chromatography                  |
| ASTM D 3588 | Standard practice for calculating heat value, compressibility factor, and relative density of gaseous fuels |
| ASTM D4084 | Standard test method for analysis of hydrogen sulfide in gaseous fuels (lead acetate reaction rate method) |
| ASTM D4468 | Standard test method for total sulfur in gaseous fuels by hydrogenolysis and rateometric colorimetry |
| ISO 6974 | Natural gas -- determination of composition with defined uncertainty by gas chromatography |
| ISO 6976 | Natural gas -- calculation of calorific values, density, relative density and wobbe index from composition |
| ISO 10101 | Determination of water by karl fischer method                                           |
| ISO 10715 | Natural gas -- sampling guidelines                                                       |
| ISO DTR 22302 | Natural gas -- calculation of methane number                                               |
| GPA 2172 | Calculation of gross heating value, relative density, compressibility and theoretical hydrocarbon liquid content for natural gas mixtures for custody transfer |
| GPA 2166 | Obtaining natural gas samples for analysis by gas chromatography                          |

**Metrology**

Metrology is the measurement science, supporting both theoretical and experimental testing at the level of uncertainty in all fields of science and technology [20, 21]. Metrology consists of three metrology subfields including scientific, industrial, and legal metrology [2, 22]. Scientific metrology, in particular, includes the development of a new method of measurement, development of reference materials (standards), and deliver the reference materials to end users [22]. In Indonesia, scientific metrology is coordinated by the *Standar National Satuan Ukur* BSN (SNSU-BSN), as a national metrology institute (NMI), but at the international level, metrology is coordinated by BIPM. The task of NMI is to disseminate measurement traceability to accredited and testing calibration laboratories, certified reference material producers, accredited reference laboratories, and registered proficiency test providers [23].
In cases of biogas products, metrology is intended to verify the quality of biogas products, where in measuring the concentration of biogas constituent must consider the sources of uncertainty that can affect the final results of the measurement. In ISO/IEC 17025:2017 [24], it is stated that an accuracy and traceability of measurement results can only be achieved by performing a calibration of testing instruments and by using certified reference materials. Traceability in the field of measurement is defined as the nature of measurement results of a reference standard that is linked to an appropriate standard (local or international standard) via an unbroken chain [25].

Quality infrastructure of metrology in Indonesia for supporting an availability of certified biogas reference materials is under development. In making the certified reference materials of biogas, the preparation is carried out in accordance with ISO 6142-1:2015, a specific gravimetric method for Class I mixture [26], and other ISO related standards. Figure 4 shows the automatic weighing system (AWS), which is available at Building 456 Kawasan PUSPIPTEK Serpong Tangerang Selatan Indonesia, as an adequate tool in preparing gas reference materials in accordance with ISO 6142-1:2015. The composition requirements of the biogas reference material are made based on SNI 8019:2014 (Table 2) [19]. The biogas reference material is used in calibrating biogas testing instrument to ensure the generated data are valid and traceable.

![Automatic weighing system (AWS)](image)

Figure 4. Automatic weighing system (AWS) for the preparation of biogas reference material in accordance with ISO 6142-1:2015 [26].

**Conformity Assessment**

Conformity assessment is systematic processes that carefully evaluate the data to assure that all products meet the requirement of a standard [1, 27]. The primary forms of conformity assessment are accreditation and certification. Different of conformity assessment are available depending on the type of product or service and the level of potential risk. Several benefits for producers in conducting the conformity assessment process may include providing the consumer with confidence, giving the producer a competitive edge, and helping regulators in assuring the quality and safety condition [27, 28].

Assessment of conformity is a crucial step in obtaining product or service on the national market. For a biogas product, a certification is the best alternative for the producer to ensure
their product meets the requirement of the standard. Certification is a provision that can be conducted by accredited independent body or laboratory that is also known as third-party conformity assessment. In Indonesia, the requirements to accredit certification bodies are explained in SNI ISO/IEC 17065:2012 that was adopted identically from ISO/IEC 17065:2012. It consists of requirements for of personel's competency, operation and quality product consistency, certification for process and service. Certification bodies operate this International Standard to fill the need in the biogas conformity assessment in Indonesia where a biogas producer requires assurance to meet relevant technical requirements as regulated in SNI 8019: 2014.

4. Conclusions

The existence of three pillars of quality infrastructure in Indonesia in supporting the availability of quality biogas products has been presented. Biogas as sustainable energy may achieve security and supply of energy, improve the environment, quality of life, and foster national economic growth. Since either domestic or international biogas market is developed rapidly, better control of the biogas quality can better its utilities. With this regard, available quality infrastructures (standardization, metrology, and conformity assessment) at the national level will allow biogas producers to offer a maximum level of consumer satisfaction and safety.

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