IDN-LCI: The conceptual framework of the Indonesian life cycle inventory database to support the life cycle assessment

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Abstract. Divers economic activities in Indonesia such as agriculture, plantation, industry, forestry, industry, constructions, civil, property, and others have been affecting the environment. Assessment of the environmental impact was critical to reduce the damage to the environment and to ensure production and market sustainability. Life Cycle Assessment (LCA) was the popular method in the environmental analysis based on the ISO 14400 and 14044 that consist of activities such as (1) goal and scope definition, (2) life cycle inventory, (3) inventory analysis, (4) impact assessment and interpretations. More than 40 years LCA has been established. However, the most problem occurred was the availability of Life Cycle Inventories (LCI) database. 70-80 % time and cost in LCA analysis are the data collection and inventory analysis. In this research, we proposed the Indonesian LCI Database. The result of this study was a conceptual framework, actor analysis of Indonesian LCI Databases. The result of this study was the theoretical framework that integrated stakeholder participation, such as academic, business, government, and society. Also, the technical standard and the role of the stakeholder for Indonesian life cycle inventory was designed.

1. Introduction
Indonesia is an archipelago country consists more than 17000 islands with divers economic activities such as plantation, mining, industries, trading, transportation, building, and others. Currently, a commercial actor is trying to contribute to the environment by introducing eco-friendly production. From 1995, Ministry of Environment, Indonesia has launched the Program for Pollution Control, Evaluation, and Rating (PROPER) at the national level for public environmental reporting. In 2019, the Ministry of Environment and Forestry included the Life Cycle Assessment (LCA) in PROPER to increase environmental quality (PerDirjen PPKL, 2018). LCA was the comprehensive concept to assess the environment of product developed in Europe and the USA in the late 1960s and early 1970s [1]. The Life Cycle Assessment (LCA) is an instrument to assess the ecological and human health impact connected to life cycle activities such as production, use, and end of life of the product, process, and operations [2]. The International Organization for Standardization (ISO) make a series of the LCA standard such as ISO 14041:1998, 14042:2000, 14043:2000, and 14040:2006 [3][4]. As a method with international standard, the LCA approach consists of: (1) goal and scope definitions, (2)
Inventory Analysis, (3) Impact Assessment, and (4) Interpretations. Figure 1 showing the method of LCA.

**Figure 1.** The LCA method consists of (1) goal and scope definition, (2) inventory analysis, (3) impact assessment, and (4) interpretation

Data collection and inventory analysis were the most difficult, with 70-80% total cost and time during the LCA analysis. The data collections are starting with defining the goal and scope followed by the data collections. The data collections are using direct measurement and secondary data. The limitation of the direct measurement was costly and needed a long time to conduct. The secondary data can collect from the industry, no-government organizations (NGOs), government report, academic report, research report, and others. However, the data collection are delicate due to the different standard and value from the stakeholders. The Life Cycle Inventories (LCI) database is also valuable to use to reduce the time and cost in data collections. Currently, the LCI database available in many sources such as US-LCI (NREL 2014), Australian LCI (ALCAS, 2011), Quebec LCI (Lesage and Samson 2016), WF LDB, Plastic Europe dB, AgriBalise, AgriFootprint.

In the Southeast Asia countries (ASEAN), there are several initiatives to build the country LCI database such as Thailand LCI database starting at 2006 and Malaysian LCA (SIRIM) started at 2011. Also, the ASEAN SIRIM proposed by Malaysian society with the project from 2015-2016. However, the Indonesian LCI database was initiated by the Indonesian community doesn’t exist. The Indonesian LCI database (IND-LCI) was essential to support the community, industry, academic, researchers, and government to implement the PROPER. Furthermore, the LCA research initiative has been established since the 1990s by Indonesian researchers. In addition to, the Indonesian Life Cycle Assessment Network (ILCAN) has been established to coordinate and strengthen the research and development and implementation of LCA.

In this research, we proposed the conceptual framework of the Indonesian Life Cycle Inventory (IND-LCI) database. The theoretical framework consists of actor, data management, and strategy to manage the LCI database.

2. Method
The Indonesian Life Cycle Inventory (LCI) database called IDN-LCI developed with several processes such as stakeholder meeting, team development, and FGD, scope definition, life cycle inventory, and database management system development (figure 2).

**Figure 2.** The Conceptual framework to develop the Indonesian Life Cycle Assessment (LCA) Database

3. **Result and Discussion**

LCA was the essential tool in Indonesia and including to the PROPER as the environmental standard, which is the regulator of the PROPER in the Republic of Indonesia is the Ministry of Forestry and Environment. Conducted the LCA was the very taught work for the business to required the standard from the government. The data collection and inventory analysis were the most difficult due to the problem in data collection. The Indonesian Life Cycle Inventory (LCI) database was essential to simplify the assessment. The scope of the IDN-LCA consist of the agro-industry, energy production, minerals, energy resources, food production, manufacturing, building and others.

3.1. **Stakeholders**

Developing a standardized database needs participation from the stakeholders. The stakeholders consist of academicians, business, government, and society (figure 3). The academicians come from academic institutions such as IPB University, University of Indonesia (UI), Pelita Harapan University (UPH), Gadjah Mada University (UGM), Bandung Institute of Technology (ITB), Indonesian Institute of Sciences (LIPI), Syah Kuala University (UNSIAH) and others. The business such as PT PLN (persero), Pertamina, Palm oil company, mining, etc. The society consist of the ALLIN, GAPKI, ICMA, etc. The Indonesian government involved in the LCI database development consist of Ministry of Forestry and Environment (KLHK), Energy Resources and Minerals (ESDM) Indonesia, Ministry of Trade and Industry (Kemenperin) Indonesia, and The National Development Planning Ministry (BAPPENAS), Indonesia.
3.2. Forum Group Discussion and co-working
The society was co-ordinate the IDN-LCI database and provided the services to the community. The Indonesian Life Cycle Assessment Network (ILCAN) involved coordinating the database development. This society members come from the practitioner, government, business person, and academics. The forum group discussion (FGD) conducted in standard development. In the beginning step, FGD conducted to introduce the LCA standard and application in different country. Then, the specific FGD was conducted by team to develop the database standard. In addition, ILCAN working together with the members collected the baseline data, validated the data, validated the process, database integration, and managed the services.

The academics provided scientific data based on research activities. This research result contributes to developing the standard process and assumptions. The new optimization method and process development also were contributed by the academic side. The bussiness provided the information of the process, material, energy input, product result and environmentally impact of the production process. The database collected not only from one industry, but validated with others industry with the same product and production system. Collaborated with the academic, find the solution to optimize the production, and reduce the impact on the environment. The government, as regulators, can get the benefit by the achievement to implement the LCA in many sectors. By supporting the database, development can help to manage and give a recommendation to the business to optimize the process to reduce the environmental impact.

3.3. Database Management Standard and Services
The services of database sharing was provided by web-based, desktop-based and spreadsheet based. The web-based provided the information to society to access and provided the direct assessment based on the information form the users. Then, the desktop based and spreadsheet provided for the society members who involved as contributors to the database development. Conceptual process and framework of the IDN-LCI database shown in figure 3.

**Figure 3.** The stakeholder of the IDN-LCI database consist of academic, business, government and society (ABG-S).
4. Conclusion and Future Work
The result of this study was the conceptual framework, actor analysis of Indonesian LCI Databases. The result of this study was the theoretical framework that integrated stakeholder participation, such as academic, business, government, and society. Also, the technical standard and the role of the stakeholder for Indonesian life cycle inventory was designed.

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