Actor analysis on energy efficiency measures in Indonesia's energy-intensive industries: A case study of the fertilizer industry

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Abstract

The industrial sector is a crucial sector to Indonesia's economic growth. At the same time, the sector has always been one of the highest energy consumers in Indonesia, making energy efficiency in industry important. This study aims to investigate the possibility of using actor-based analysis to improve energy efficiency measures in Indonesia's energy-intensive industries by using the fertilizer industry as a case study. A stakeholder analysis was conducted to identify relevant actors, and an adaptation to the AOC (actors, objectives, context) framework is used to analyze the qualitative data obtained through document analysis and semi-structured interviews. The results show that energy efficiency in the Indonesian fertilizer industry is incorporated as a part of energy management and Green Industry Certification conducted by Indonesia's Ministry of Industry. The results also reveal actors who are involved in the energy efficiency of the fertilizer industry in Indonesia, their objectives in formulating and/or implementing energy efficiency measures or policies, and the contexts in which actors see their objectives. These results lead to three improvement suggestions for industry and policymakers. I believe that the adapted AOC framework can be applied to other industrial sectors in Indonesia as they fall under a similar legal framework and have similar actors involved. This research contributes to the advancement of the literature in the use of the AOC framework for industrial energy efficiency by demonstrating how the AOC framework, with the addition of cognition and motivation aspects, is utilized. Yet, further research on actors and energy efficiency in Indonesia is still necessary to get a more comprehensive picture of how actors influence energy efficiency measures in the Indonesian industry.

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List of Abbreviation

AOC	Actors, Objectives, Context (framework)
BAU	business as usual
BOE	barrel of oil equivalent
Btu	British thermal unit
CIT	Contextual Interaction Theory
DSM	Demand Side Management
ECPF	Energy Conservation Promotion Fund
FC	fertilizer company
GDP	gross domestic product
GJ	Giga Joule
GWh	Giga Watt-hour
HC	fertilizer holding company
IDR	Indonesian Rupiah
kWh	kilowatt-hour
LSIH	*Lembaga Sertifikasi Industri Hijau* (Green Industry Certification Agency)
MNE	multinational enterprise
MOEF	Ministry of Environment and Forestry
MOEMR	Ministry of Energy and Mineral Resources
MOI	Ministry of Industry
MOSOE	Ministry of State-owned Enterprise
MTOE	millions of ton oil equivalent
PT	*perseroan terbatas* (limited company / Co. Ltd)
SEC	specific energy consumption
SMEs	small and medium enterprises
SOE	State-owned company
SIH	*Sertifikasi Industri Hijau* (Green Industry Certification)
USD	United States Dollar

Chapter 1 Introduction

1.1 Background

Indonesia has been enjoying high and steady economic growth since 2011, with annual gross domestic product (GDP) growth ranging between 5 to 6% (Statistics Indonesia, 2015, 2020b). Per capita income Indonesia also reached IDR 57.3 million per year, equal to USD 4,050, in 2019, upgrading the status of Indonesia from a middle-income country into an upper-middle-income country (Statistics Indonesia, 2020b). Various sectors have contributed to this growth, but manufacture has always played the biggest role. The statistics show that manufacturing sector contributed 18.21% in 2016, 20.16% in 2017, 19.86% in 2018, and 19.7% in 2019. The agriculture, forestry, and fishery sector, the second biggest contribution to Indonesia's GDP, contributed only around 13% in the same period.

The big contribution of manufacture in economic growth also correlates to big consumption of energy. Since 2009, the industry sector has always been the biggest or the second biggest final energy consumer in Indonesia (Ministry of Energy and Mineral Resources, 2020). Between 2009 and 2011, the industry was the biggest consumer and it consumed 43% to 45% of total final energy, translated into around 44 million ton oil equivalent (MTOE) to 55 MTOE. However, between 2012 and 2019, industrial energy consumption ranked the second after transportation sector with a share ranging from 30% to 40% of the total final energy, equal to the amount of energy between 41 MTOE and 54 MTOE.

1.2 Problem Statement

The high amount of industrial energy consumption in Indonesia causes concern regarding energy supply. It is because not only the industry has been one of the sectors which consume energy, but also it is projected that industrial energy demand will continue to grow. It is projected that the energy demand of industry will grow up to 230.9 MTOE by 2050 through the business as usual (BAU) scenario (Suharyati et al., 2019). As the industry is a crucial sector in Indonesia's economic growth, the growth in industrial energy demand must be kept up with the growth in energy supply to maintain industrial growth.

Aside from increasing energy supply, implementation of energy efficiency measures is also needed to build a sustainable and more efficient industry. The measures will also help to reduce

greenhouse gases (GHG) emissions, considering energy and industrial sectors had the highest level of emission in Indonesia in 2018 (Prihatno et al., 2020). One way to measure energy efficiency is to use energy intensity, defined as the ratio of energy use or energy supply to GDP (Martínez et al., 2019). The energy intensity of the Indonesian industry was at the level of 1.9 barrels of oil equivalent (BOE) in 2019 (Ministry of Energy and Mineral Resources, 2020). The report mentioned that this value was lower compared to Thailand and Malaysia, but it was still higher compared to the Philippines. Moreover, energy flow analysis across the manufacturing industry shows that specific energy consumption (SEC) of several industries in Indonesia is still higher than the average global SEC for the same industries (Vivadinar et al., 2016).

Fertilizer, cement, metal, food and beverages, and ceramic sub-sectors are considered as the energy-intensive manufacturing subsectors in Indonesia (Suharyati et al., 2019). Among these industries, Indonesia's fertilizer industry is still not energy efficient. The energy intensity of ammonia production, the most important basic compound for fertilizer production, of some Indonesian fertilizer companies was 34.75 GJ/ton (Pupuk Kalimantan Timur, 2019) and 37.94 GJ/ton (Pupuk Sriwidjaja, 2019) in 2019. These values were higher compared to the best available technique which uses 28 GJ per ton ammonia produced (European Commission, 2007). This data shows that there is still a big potential to optimize energy efficiency measures so that energy efficiency in Indonesia's fertilizer companies can reach the maximum level.

To investigate this potential improvement, actor analysis is chosen as the approach for this research. Energy efficiency is a part of the energy transition, and transition in energy is "enacted by a range of actors and social groups" who "have their own resources, capabilities, beliefs, strategies, and interests" (Koehler et al., 2017). These factors possessed by the actors make it necessary to place actors as the main focus of analysis so that possible improvements to the currently established system can be revealed. Moreover, existing research on industrial energy efficiency in Indonesia has always focused on techno-economic and organizational aspects of energy efficiency. Related topics from previous research include energy intensity (Setyawan, 2020), companies' operational performance (Sajilan et al., 2019), companies' ownership (Ramstetter & Narjoko, 2014), and organizational barriers (Soepardi et al., 2018; Soepardi & Thollander, 2018). Therefore, the actor-analysis approach will also give new perspectives in understanding current industrial energy efficiency in Indonesia.

1.3 Research Objectives

The objectives of this research are

- to develop recommendations for more effective energy efficiency measures for fertilizer companies, other energy-intensive companies, and policymakers,
- to understand the current practice of energy efficiency in Indonesia's fertilizer industry in the context of techno-economics and policy aspects,
- to investigate possibilities of using actor-based analysis to improve energy efficiency measures in Indonesia's energy-intensive industries by using the fertilizer industry as a case study, and
- to understand actors who are involved in energy efficiency measures in the fertilizer industry along with their objectives in various contexts.

1.4 Research Questions

Main research question:

How can energy efficiency measures in Indonesia's energy-intensive industry be improved?

Sub-questions:

1. How is the current practice of energy efficiency in the Indonesian fertilizer industry in terms of techno-economics and policy?
2. Which actors are involved in the current practice of energy efficiency in the Indonesia fertilizer industry?
3. How do the involved actors perceive their objectives and contexts in the energy efficiency of the Indonesia fertilizer industry?
4. Based on the analysis of actors, objectives, and context, what opportunities are available to improve energy efficiency in the Indonesian fertilizer industry?

1.5 Thesis Outline

The thesis will compose of six chapters. Chapter 1 will be an introduction where study background, research objectives, and research questions are described. Chapter 2 will be a literature review on context which includes background information on Indonesia's manufacturing industry, fertilizer industry, and the production process. Next, chapter 3 will discuss the main theoretical framework, which is the AOC framework, and its adaptation for this study. Chapter 4 is about the methodology which will be used to conduct the research. Then, chapter 5 will present the results and findings of the interviews and will discuss these results and findings. The discussion will reveal

possible strategies which can be used to improve energy efficiency measures in the Indonesia fertilizer industry. Chapter 5 also includes a discussion of whether the theoretical framework can be generalized into other energy-intensive industries besides the fertilizer industry. Finally, chapter 6 will give a conclusion, recommendations for industry and policymakers, and suggestions for future research.

Chapter 2 Context of Energy Efficiency in Indonesia's Industry

This chapter contains relevant background information about energy efficiency in the fertilizer industry. The first part of the chapter discusses industrial energy efficiency in Indonesia, in general, to give an understanding of the current research regarding energy efficiency in the Indonesian industry. Then, the chapter will explain the current condition of the fertilizer industry in Indonesia along with descriptions of fertilizer subsidies and ammonia production technologies. The information was mostly obtained through literature review and document analysis, but some information regarding the subsidies and current practice of energy efficiency was also obtained through interviews with the respondents. The information obtained from interviews could be considered as results that belong to chapter 5. However, to make the information easier to understand and for the convenience of the readers, the information obtained from interviews is included in this chapter along with the information obtained from document analysis.

2.1 Energy Efficiency in Indonesia Manufacturing Sector

Existing research has discussed energy efficiency in the Indonesian manufacturing sector through diverse approaches with various results that help us to understand different aspects of energy efficiency in the Indonesian manufacturing sector. Most of the research utilized quantitative analysis from statistical data, such as annual survey and decennial census data on medium-large plants published by Statistics Indonesia[1], to investigate the relations between various factors and energy efficiency in Indonesia's manufacture. Such research usually approaches energy efficiency through energy intensity which can be obtained by comparing energy use or supply with the output produced (Martínez et al., 2019). Energy intensity in Indonesia's manufacturing sector overall has been decreasing 65% from 1980 to 2015 with a decrease of 28% for the chemical sub-sector which includes the fertilizer industry, mainly due to an increase in energy efficiency within the industries (Setyawan, 2020).

Investigation into the relationship between ownership and energy efficiency in Indonesia by Ramstetter & Narjoko (2014) found that state-owned enterprises (SEOs), multinational enterprises (MNEs), and domestic private enterprises had no significant difference in energy intensity. The presence of MNE, assumed to be more energy-efficient, did not consequentially

[1] Statistics Indonesia (*Badan Pusat Statistik*) is a non-departmental government agency that is responsible for providing statistical data in Indonesia.

encourage energy efficiency implementation in other types of enterprise. On the other hand, international trade is found to have a quite significant impact on companies' energy efficiency performance as importing intermediate goods lead to an increase in the performance (Imbruno & Ketterer, 2018) while exporting products reduces the fuel-to-output and electricity-to-output ratio of the companies (Roy & Yasar, 2015). Energy efficiency is also positively affected by foreign direct investment and industry value added (Rudenko & Tanasov, 2020).

Analysis of energy efficiency barriers in Indonesian steel mills conducted by Soepardi et al. (2018) has revealed various barriers in energy efficiency. The study reported that energy efficiency was affected directly by financial-economic and management-organizational barriers and indirectly by the policy. The management-organizational barriers can be grouped into linkage barriers consisting of (1) clash among different interests, (2) lack of management capacity, (3) unwillingness to change from the management side, (4) greater attention to the production process, and (5) lack of energy manager's authority (Soepardi & Thollander, 2018). There also exist independent but strong-driving barriers which include insufficient management understanding of energy efficiency and complicated process in decision making.

2.2 Industrial Energy Efficiency in Other Southeast Asian Countries

This sub-chapter discusses energy efficiency policy for industrial sectors in other Southeast Asian countries. The discussion is necessary to understand the energy efficiency of Indonesia's industry in comparison with other countries that have similar levels of economic development. The discussion will also be useful in providing insights or lessons learned for Indonesia's industrial energy efficiency. Three Southeast Asian countries, which are Malaysia, the Philippines, and Thailand, were chosen based on the consideration of their economic development, political system, and geographical conditions which are relatively similar to Indonesia. The discussion on this sub-chapter will focus on the policies, programs, major actors, and barriers to industrial energy efficiency for each country.

2.2.1 Malaysia

Energy efficiency policies in Malaysia's industrial sectors have been focusing on electricity. It is reflected in the 2008 Efficient Management of Electrical Energy Regulations (EMEER) which requires energy consuming and generating facilities to conduct measures for an "efficient management of electrical energy" (Copenhagen Center on Energy Efficiency, 2015). This requirement only applies to facilities that generate or consume the energy of more than 3

million kWh (258 TOE) for 6 consecutive months. The facilities are also required to have an electrical energy manager who then conducts an accountable energy efficiency management process. Meanwhile, the Malaysian Government has also set fiscal incentives for companies that perform energy conservation services or manufacture energy-efficient equipment (Copenhagen Center on Energy Efficiency, 2015). These incentives include income tax exemption, import duties, and sales tax exemption.

There are five major actors for energy efficiency promotion in Malaysia: Ministry of Energy, Water, and Green Technology; Energy Commission; Malaysia Energy Center; Economic Planning Unit; and Department of Standards Malaysia (Delina et al., 2010). The Ministry is responsible for the development and enforcement of energy efficiency policies and programs. The Energy Commission is assigned to regulate activities related to energy supply, enforce supply laws, and promote the development of the energy industry. Malaysia Energy Center acts like a research center that also connects governmental bodies and industrial sectors. The Economic Planning Unit is responsible for designing energy efficiency policies and plans, and lastly, the Department of Standards has tasks in standardization for energy-efficient products and accreditation of energy efficiency management.

Industrial sectors and small and medium enterprises (SMEs) have been given high to medium priority as they are the highest energy consumers in Malaysia (Copenhagen Center on Energy Efficiency, 2015). For the industry, the Malaysian Industrial Energy Efficiency Improvement Project was formulated in 1998 to improve energy efficiency in Malaysia's industrial sectors (Delina et al., 2010). The project consisted of eight components, including energy auditing, energy efficiency promotion, energy service companies (ESCOs) support, energy technology demonstration, and financial institutions participation. The project initially targeted energy-intensive industrial sectors which were iron and steel, cement, wood, food, glass, pulp and paper, ceramics, and rubber industries, but later on, oleo-chemical, plastic, and textiles industries were also added. Yet, Malaysia still has some barriers to energy efficiency promotion, including low awareness of energy efficiency techniques and their benefits, limited access to information on the technologies, lack of personnel on energy management, and lack of financiers for energy efficienct investment (Van den Akker, 2008).

2.2.2 The Philippines

The main policy for energy efficiency in the Philippines is the Energy Efficiency and Conservation Act (Republic Act No. 11285, 2019). The act uses the term "designated establishment" to refer to private or public entities considered as energy-intensive industries. The designated establishments are classified into two groups: Type 1 with annual energy consumption between 500,000 and 4,000,000 kWh (43 and 344 TOE) for the previous year and Type 2 with annual energy consumption of more than 4,000,0000 kWh (344 TOE) for the previous year. Many of the obligations for both types are the same, such as conducting energy management based on ISO 50001, record monthly energy data, and set up annual targets, plans, and verification for the implementation of energy efficiency projects. The only difference in obligation is that Type 1 must appoint a certified energy conservation officer (CECO) while Type 2 must appoint a certified energy manager (CEM), even though in the law CECO and CEM have the same responsibilities. The Republic Act also regulates fiscal incentives and non-fiscal incentives like awards and technical assistance from the government. The fiscal incentives are not described and only mentioned in relation to the relevant investment regulations.

Four major actors are involved in energy efficiency promotion in the Philippines (Delina et al., 2010). The Department of Energy has some responsibilities including formulation of policies and programs, encouraging private sectors to participate, and maintaining cooperation and coordination between governmental bodies and private entities. There is also the Energy Regulatory Commission who has tasks to enforce rules and regulations, issue permits, and approve the retail rate of electricity. The Philippine Council for Industry and Energy Research and Development acts in arranging priorities, plans, and policies for research in the energy and industry sector, and the Council has also supported some energy efficiency projects. Lastly, standard organizations under different departments conduct testing of products' energy efficiency and issues standards regarding the energy efficiency of products.

Similar to Malaysia, the industrial sector has received high priority for energy efficiency because the sector is the second biggest energy consumer in the Philippines (Copenhagen Center on Energy Efficiency, 2015). The Philippines Government has set energy efficiency plans and programs as parts of the country's National Energy Plan (Department of Energy, 2018). The plan consists of medium-term programs, conducted from 2019 to 2022, and long-term programs, conducted from 2023 to 2040. The medium-term programs include the establishment of cross-

sectoral energy performance and rating systems, campaigns on energy efficiency policies, programs, and best practices, and enabling mechanisms for private sector participation, while long-term programs include the institutionalization of Energy Efficiency Knowledge Management System and developing advanced research and development capacity for energy efficiency. Meanwhile, there are still several main barriers to energy efficiency promotion, such as insufficient financial incentives, lack of technical specifications for energy efficiency technology, and lack of awareness about the benefit of energy efficiency projects (Delina et al., 2010).

2.2.3 Thailand

The main policy framework for energy efficiency in Thailand is the Energy Conservation Act which was enacted in 1992 (Delina et al., 2010). It aims to encourage the production and use of energy-efficient machinery and equipment. The law targets factories, buildings, and producers or distributors of energy equipment and machinery. An energy audit is also required by the law for companies with an annual energy usage of more than 18,900 million Btu (477 TOE).

The enactment of the Energy Conservation Act has created the Energy Conservation Promotion Fund (ECPF) which then enabled the implementation of the Demand Side Management (DSM) Program. These two initiatives addressed some barriers to energy efficiency in the early 1990s, such as low awareness of the benefits of energy efficiency, limited incentives for adoption, and lack of awareness in the financial sector, and since then have become a success story of energy efficiency in Thailand (Polycarp et al., 2013). The ECPF is an independent source of funding for the promotion of energy efficiency by providing loans, grants, and subsidies. The fund was effective to strengthen the capacity of the financial sector and providing leverage for additional finance.

Meanwhile, the DSM program consists of two phases (Delina et al., 2010). Phase I was conducted from 1993 to 2000 and it had six major sub-programs: residential, commercial/government building, industrial sector, load management, energy conservation attitude promotion, and monitoring and evaluation. The first phase succeeded in promoting industrial energy efficiency, raising consumers' awareness, and strengthening government capacity (Polycarp et al., 2013). The government also exceeded the initial energy efficiency target with a much lower cost than the original estimation. The success of the first DSM phase led to Phase II starting from 2000 onward (Delina et al., 2010). The second phase targeted residential, commercial,

and industrial sectors with strategies such as load management technology in SMEs and improving standardization of energy use in companies and the social sector.

Even though there are still some barriers to energy efficiency in Thailand, for example, investment-related barriers, administrative barriers, and technical capacity barriers (Delina et al., 2010), the success of Thailand's ECPF and DSM provide some valuable insights (Polycarp et al., 2013). These insights include a strong commitment to energy efficiency shown by Thailand Government, not completely relying on international support, and minimal international involvement in the policymaking process. Moreover, Thailand Government was able to coordinate closely with the private sectors during the development of DSM plan, receive international support over long period of time, and provide low-interest credit lines to banks through the revolving fund.

2.3 Fertilizer Industry in Indonesia

Up until 2018, there were 157 fertilizer and nitrogen compound material companies in Indonesia of which 76 companies received only domestic investment, 5 companies received only foreign investment, and 76 companies were from other types of investment (Statistics Indonesia, 2020a). The majority of these companies were private companies, but there were 3 SOEs, 3 local government-owned enterprises, and 6 companies owned by both national government and private entities. The report also shows that the industry generated around 380.8 GWh of electricity in 2018 from which 5 GWh was sold and at the same time it bought 231.5 GWh of electricity. The fuel consumption of the industry was dominated by natural gas with the amount of 78 million m^3 and by coal which was around 43 million kg (Statistics Indonesia, 2020a).

The fertilizer market in Indonesia can be segmented by type into 5 segments: nitrogenous, phosphatic, potassic, micronutrients, and secondary fertilizer (Mordor Intelligence, 2020). Urea, which falls under the nitrogenous fertilizer segment, is the most dominant fertilizer produced and used in Indonesia, leading to a surplus that is exported to countries like Malaysia, Germany, and Japan. To maintain affordability, fertilizer subsidies from the Indonesian government are available to both suppliers and farmers. Despite a big number of fertilizer and nitrogen compound companies shown by the statistics, in reality, based on the market share, the fertilizer market in Indonesia is dominated by 5 big players: PT. Pupuk Kujang, PT. Pupuk Kalimantan Timur, PT. Yara Indonesia, PT. Pupuk Sriwidjaya Palembang, and PT. Petrokimia Gresik (Mordor Intelligence, 2020). PT. Yara Indonesia is part of Yara International ASA, a Norwegian chemical company, and it only does business in marketing and selling fertilizer. Meanwhile, the other four companies have

production sites in Indonesia and are under a state-owned holding company called PT. Pupuk Indonesia Holding Company.

Figure 1 Fertilizer market concentration in Indonesia (Mordor Intelligence, 2020)

2.4 Fertilizer Subsidy in Indonesia

Fertilizer subsidy is provided by Indonesian National Government to help the farmers get affordable fertilizer. The fund for the subsidy is annually set in Indonesia's State Budget by the Ministry of Finance (MOF) (Directorate General of Agriculture Infrastructure Ministry of Agriculture, 2021). Based on the subsidy mechanism, the Ministry of Agriculture (MOA) annually allocates the type of the fertilizers, the amount or quota of the fertilizers, and maximum retail prices for the fertilizers which are subject to the subsidy. The subsidy is then implemented by the Ministry of State-owned Enterprises (MOSOE) who appoints PT. Pupuk Indonesia, a state-owned fertilizer holding company, for producing and distributing the subsidized fertilizer. The holding company has several subsidiaries which also happen to be the major fertilizer companies in Indonesia. The fertilizers can come from the ones produced domestically as well as from imported fertilizers, meaning that if the holding company cannot produce a sufficient amount of subsidized fertilizer, the holding company can import the fertilizer. In 2020, fertilizer types that were applicable for subsidy included urea, SP-36, ZA, NPK, and organic fertilizer (Regulation of the Minister of Agriculture of the Republic of Indonesia Number 01 of 2020, 2020). The comparison between the

subsidized fertilizer quota and the production capacity of the holding company is shown in table 1.

Table 1 Comparison between subsidized fertilizer quota and production capacity of fertilizer holding company (adapted from PT. Pupuk Indonesia, n.d., Regulation of the Minister of Agriculture No. 47/2017, Regulation of the Minister of Agriculture No. 1/2020)

Fertilizer types	2018 Production Capacity (ton)	2018 Subsidy Quota (ton)	2020 Subsidy Quota (ton)
Urea	9.362.500	4.100.000	3.274.303
SP-36	500.000	850.000	500.000
ZA	750.000	1.050.000	750.000
NPK	3.120.000	2.550.000	2.688.000
Special formula NPK	-	-	17.000
ZK	20.000	-	-
Organic	-	1.000.000	720.000
Total	13.752.500	9.550.000	7.949.303

From table 1, the subsidized fertilizer quota was very big compared to the production capacity. The targeted quota from the government could be as high as 44% of the total production capacity for urea and 86% for NPK, two nitrogen-based fertilizers which are produced from ammonia. This high ratio between subsidized fertilizer quota and capacity production seems to affect companies' decisions on production process and feedstock. Because energy efficiency in fertilizer industries depends on the production process and feedstock, fertilizer subsidies may then be related to energy efficiency.

However, interviews with the fertilizer company (FC) and the fertilizer holding company (HC) result in different views regarding the impact of subsidy on companies' energy efficiency measures. FC claims that fertilizer subsidy positively affects the company because the Ministry of Agriculture sets the quota and price of subsidized fertilizers on an annual basis, so the company needs to be efficient to meet those requirements, including to be efficient in its energy use. On the other hand, HC claims that the subsidy does not influence the company's decision regarding energy efficiency as energy efficiency measures would still be conducted regardless of the subsidy. This difference may be caused by the different roles of FC and HC in fertilizer production; FC as the fertilizer producer gets the real pressure of meeting the quota requirement set by the subsidy policy,

while HC as the decision-makers views the subsidy as another obligation from the Government and regards energy efficiency mainly as an effort to reduce production cost.

Based on this information, the impact of fertilizer subsidy on energy efficiency in the fertilizer industry is not certain. Interviews with officials from MOA and with experts from other fertilizer companies are required to further bring light to this matter. Due to the limitation in time and resources for this research, such interviews could not be conducted. Therefore, fertilizer subsidy will not be considered as a context of energy efficiency in the fertilizer industry for the rest of this research.

2.5 Ammonia Synthesis for Fertilizer Production

Ammonia is the basic building of all nitrogen-based fertilizer, include urea, and it is also the most energy-intensive process in fertilizer production, accounting for around 90% of total energy consumption (International Fertilizer Association, 2014). It is synthesized by reacting hydrogen with nitrogen, where the nitrogen comes from the atmosphere while the hydrogen can be extracted from various feedstocks, commonly natural gas and coal (Talaei et al., 2018). Hydrogen is mainly produced through the steam reforming process from natural gas (figure 1), which also becomes the standard ammonia production for SIH criteria (sub-chapter 2.5) of the fertilizer industry in Indonesia (Regulation of the Minister of Industry of the Republic of Indonesia Number 27 of 2018, 2018). It starts with the desulfurization process of the feedstock, which is the natural gas, to remove the sulfur content (S and H_2S) from the natural gas. The gas then goes to a reformer in which hydrogen (H_2) is synthesized with the help of steam and air. Co-converter then transforms CO gas in the mixture into CO_2, and this CO_2 is then separated from the mixture by the absorber and removed from the gas mixture by the stripper. Ammonia (NH_3) is then formed in an ammonia converter, and the product is refrigerated as needed.

The type of feedstock contributes significantly to the energy use of the fertilizer industry. The main driver of energy intensity decline in the fertilizer industry has been the feedstock switch, especially from coal to natural gas, as older technology based on coal or coke consumes more energy compared to newer technology based on natural gas (Dasgupta & Roy, 2017). The steam reforming process that uses natural gas as the feedstock is the most widely used technique for ammonia production (Rafiqul et al., 2005). This technique can also be considered the best available technique in terms of energy because it only consumes 28 GJ/ton ammonia produced, much lower compared to ammonia production from heavy hydrocarbons like petroleum which consumes 38

GJ/ton ammonia produced, or from coal which consumes 48 GJ/ton ammonia produced (European Commission, 2007). The report also mentions possible improvements to make the technology more energy-efficient, including the use of catalysts and the re-utilization of residual heat into the production process.

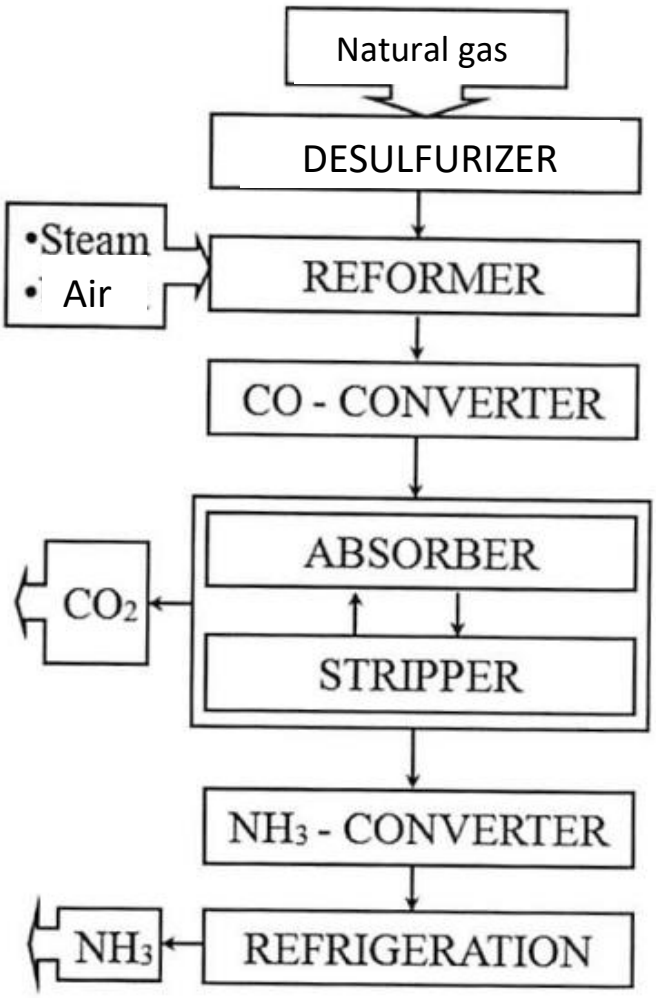

Figure 2 Diagram of ammonia production through steam reforming process (Regulation of the Minister of Industry of the Republic of Indonesia Number 27 of 2018, 2018)

2.6 Current Energy Efficiency Practice in Indonesia Fertilizer Industry

Energy efficiency in Indonesia is generally regulated by Regulation of the Government of the Republic of Indonesia Number 70 of 2009 (2009). The regulation requires that entities whose annual energy consumption is equal to or more than 6000 TOE have to conduct energy efficiency measures. This threshold is much higher compared to the thresholds in Malaysia and the Philippines. Furthermore, the energy efficiency measures must be conducted based on National

Master Plan on Energy Conservation (RIKEN), which is established based on the National Energy Plan (RUEN). RIKEN is applicable for 5 years with possible annual evaluation if required. RIKEN was set in 2011, but after the 2017 RUEN was enacted, no new RIKEN has been issued so far. The 2017 RUEN itself does not mention industrial energy efficiency in detail.

Meanwhile, according to experts from MOEMR, energy efficiency can be divided into energy efficiency for energy users and energy efficiency for energy suppliers. Energy efficiency for energy users is further grouped into four categories: industry, transportation, buildings, and household. MOEMR generally formulate energy efficiency policies for all categories, but the Ministry also collaborates with related governmental agencies in the process, such as collaborating with MOI for energy efficiency in the industry and collaborating with the Ministry of Transportation for energy efficiency in the transportation sector.

The energy efficiency for industrial sectors in Indonesia is mainly regulated by the MOI through its regulatory scheme. It is incorporated by the Ministry through an industrial certification scheme called *Sertifikasi Industri Hijau* (SIH or Green Industry Certification) based on the Law of the Republic of Indonesia Number 3 of 2014 (2014). Energy efficiency becomes one of the criteria for SIH along with raw material standard, production process, product quality, management, and waste treatment (Regulation of the Government of the Republic of Indonesia Numer 29 of 2018, 2018). The regulation also requires that the criteria for energy-intensive industries, including the fertilizer industry, must be further described in a separate regulation. For the fertilizer industry, the criteria are grouped into technical and managerial criteria, in which energy-related criteria are included in the technical criteria (Regulation of the Minister of Industry of the Republic of Indonesia Number 27 of 2018, 2018). The Regulation sets the criteria for specific heat consumption, GHG emission limit, and ammonia production process. The SIH criteria also clearly require fertilizer companies to extract ammonia from natural gas, which emits less CO2 compared to coal or petroleum. An interview with fertilizer company confirms that the company mainly uses natural gas as the feedstock for ammonia production while coal is used only for power plants.

The SIH certification itself is conducted by *Lembaga Sertifikasi Industri Hijau* (LSIH or Green Industry Certification Institutions) who have to get a license from the MOI to audit companies who have applied to get SIH certification. LSIH can be either institution under the Ministry or private companies, and specific industrial sectors are assigned to specific LSIH. Until 2020, the fertilizer companies can receive SIH from five different LSIHs, in which two of them are

institutions under MOI while the other three are private certification companies (Regulation of the Minister of Industry of the Republic of Indonesia Number 14 of 2020, 2020).

It can be seen that energy efficiency in the Indonesian fertilizer industry is considered only as a part of the bigger system in the factory. It may cause energy efficiency to be overlooked by other components of the system like product quality and environmental standards, but at the same time, it gives an advantage in the form of seeing energy efficiency more comprehensively and holistically. This comprehensiveness is important because energy efficiency in industry is related to a lot of aspects of the production process, such as the production technology, management, and waste and emission coming from the process. Interviews with various actors show that the actors understand the wide range of implications of energy efficiency measures in the industrial process. In addition, experts from LSIH ensure that all SIH criteria are equally important because companies cannot get certified by focusing on few criteria while ignoring the others. So in the context of SIH, it will be unlikely that energy efficiency will be overlooked by other SIH criteria.

2.7 Summary of the Background Information

To make it easier for the readers to find the connection between background information and the research on this thesis, the information explained from sub-chapter 2.1 to 2.6 is summarized in this sub-chapter. The summary is written in key points which are directly relevant for this thesis research.

- There are financial-economic barriers and management-organizational barriers that affect the energy efficiency of the energy-intensive industry in Indonesia (Soepardi et al., 2018).
- Lack of technology and lack of financial incentives are common barriers to energy efficiency in some other Southeast Asian countries (Delina et al., 2010).
- The threshold of mandatory energy management and energy efficiency measures in Indonesia (6000 TOE/year) is much higher than the threshold in Malaysia (258 TOE/6 months) and the Philippines (43 TOE/year).
- Although statistically it is recorded that there are more than a hundred fertilizer companies in Indonesia (Statistics Indonesia, 2020a), only five companies hold the majority of the fertilizer market share (Mordor Intelligence, 2020). Among the five companies, one is a private company while the other four are SOEs.

- The Indonesian Government provides fertilizer subsidies to farmers through state-owned fertilizer companies. However, it is not clear whether the subsidy affects companies' policies on energy efficiency.
- There is no separate certification mechanism for industrial energy efficiency in Indonesia. However, energy efficiency is a part of the SIH certification scheme conducted by Indonesia's Ministry of Industry.

Chapter 3 Theoretical Framework

As this research focuses on the actor-analysis approach, the AOC framework will mainly be used with some adaptations. The framework is chosen because it allows analysis of actors in several different contexts and it is a very broad and general framework that can be modified depending on the research's purpose. Therefore, this chapter consists of two parts. In the first part, the original AOC framework will be explained, and in the second part, an adaptation of the framework for this study will be discussed.

3.1 AOC Framework

AOC framework has been proposed by Jakob et al. (2020) and it is defined as "a generalized political economy framework to inform and enable comparison of country-specific case studies of how economic structure, political institutions, and the political environment shape policy outcomes". The framework is based on the assumption that policies are the reflections of actors with the biggest influence during the decision-making process and that policymakers have choices to pick a certain policy or some certain policies to be implemented from a range of policy package.

As the name tells, there are three main components in the framework: actors, objectives, and context. Actors are divided into societal and political actors, and each actor has its list of objectives that the actor considers important in the context where the policymaking process happens (Jakob et al., 2020). The objectives are further divided into two groups: (1) societal objectives that matter directly to societal actors, and (2) political objectives that matter indirectly to political actors. The framework argues that both societal and political objectives are mostly related to societal actors but the political objectives can have political impacts, such as affecting public opinions about the current government or influencing election results. So, even though political objectives only matter indirectly to political actors, these actors will still pay attention to the political objectives. Meanwhile, context is very broad, and it can include economic, institutional, discursive, environmental, and/or other relevant contexts. Context is argued to be important in the framework. Contexts can define how certain policy objectives become relevant for societal actors, identify the form and degree of societal actors' influence on political actors, and explain how political objectives are deemed important by individual political actors. Moreover, contexts also organize the form and degree of political actors' influence on the making, implementation, and enforcement process of the policy.

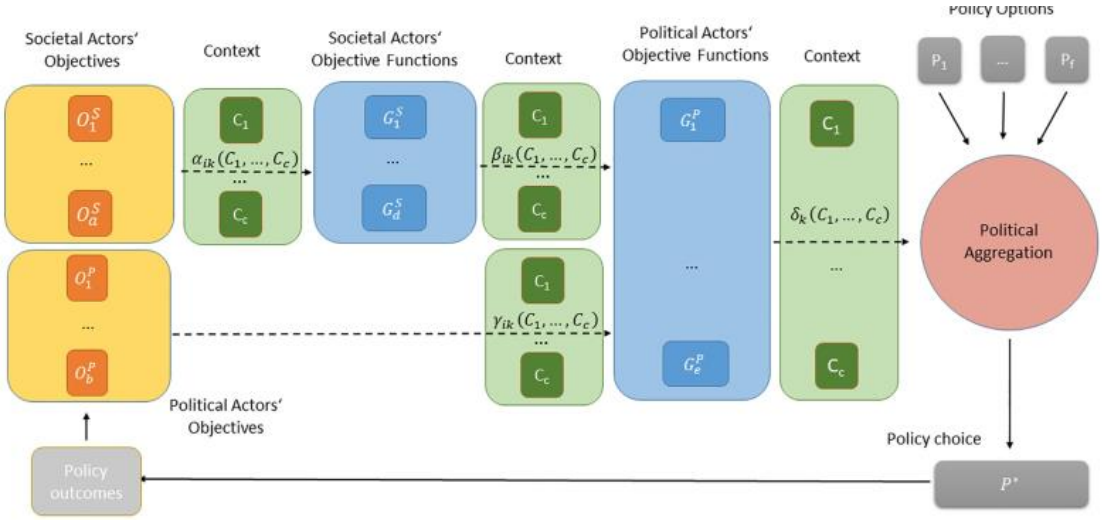

Figure 3 Schematic of AOC framework (Jakob et al., 2020)

Jakob et al. (2020) provide a schematic illustration for the AOC framework (figure 3). The scheme illustrates the interaction between actors, their objectives, and contexts which then lead to political aggregation. In a policymaking process, there exist big groups of policy objectives, represented by a and b in figure 3, which are important for certain societal actors and certain political actors. Policy objectives that matter to the societal actors become societal actors' objectives (O_1^S- O_a^S) while policy objectives that matter to the political actors become political actors' objectives (O_1^P - O_b^P). However, societal actors and political actors see their objectives through certain contexts (C_1 - C_c). These contexts make specific actors give weights to specific policy objective(s) and these weights cause actors' views on their objectives to change. For societal actors, one of the weights is illustrated by α_{ik}, representing the importance of a specific objective k for specific societal actor i, and together with the other weights they change societal actors' objectives from O_1^S- O_a^S to G_1^S- G_d^S. Political actors also have weights to specific policy objective(s), denoted by β_{ik} which represents the importance of a specific objective k for a specific political actor i. Yet, political actors are also influenced by societal actors, and γ_{ik} illustrates the importance that societal actor k has for political actor i. As political actors view their objectives from C_1 - C_c contexts, these two weights (β_{ik} and γ_{ik}), transform political actors' objectives O_1^P - O_b^P into G_1^S- G_d^S. Finally, through the policy process, political actors influence policy outcomes, implementation, and enforcement to some degree as represented by δ_k. P_1 – P_f represents the set of policy options that can be implemented while P^* is the chosen policy. The scheme also shows how the chosen

policy and the outcome can influence the objectives of political actors, indicated by the arrow from P* to policy outcome and the arrow from policy outcome to political actors' objectives.

3.2 Adaptation of the AOC Framework

I propose an adaptation from the original AOC framework (Jakob et al., 2020) to be used to investigate the energy efficiency measures of fertilizer companies in this thesis research. The adaptation is deemed necessary because the original framework does not provide clear mechanisms on how to sort actors, objectives, and contexts. Jakob et al. (2020) themselves admitted that their intention with the AOC framework was to provide a very general framework for research in the field of energy studies. Another reason is the difference in research objectives between this thesis research and the research done by Jakob et al. (2020). The research using the original framework aims to investigate how objectives and context influence actors in choosing the energy policies of a country. Meanwhile, this research aims to investigate how objectives and context specifically influence companies as actors in choosing energy efficiency measures that they implement.

The adapted framework keeps the components of the original framework and their relations to each other. The main difference is in the outcomes of the framework. The original framework leads to governmental policies as the result of political aggregation between the objectives of societal and political actors. Meanwhile, the adapted version leads to companies' energy efficiency measures as the result of political aggregation between the objectives of societal and political actors. Fertilizer companies are considered as societal actors because Jakob et al. (2020) does not distinguish economic actors from social actors.

The objectives in the adapted AOC framework refer to the aims or purpose of energy efficiency measures that societal and political actors consider important. Both societal and political actors identify objectives that are important to them, and these objectives can be seen differently by actors depending on the context. For example, the economic benefit of energy efficiency for companies may not be an important objective for policymakers in the context of formulating good energy efficiency policies. However, the objective may become important when policymakers view it in the context of encouraging companies to comply with the policies. The objectives of political actors are reflected in the energy efficiency policies that they formulate and design, while the objectives of societal actors are reflected in their motivation to conduct energy efficiency measures. Despite different actors having different objectives, a specific actor may also pay attention to the objectives of other actors as they could have a direct or indirect impact on the actor (Jakob et al.,

2020). For example, energy efficiency measures that societal actors choose to implement may be affected by the policies enacted by political actors, while these political actors may have certain objectives that they want to achieve through the policies. If political actors do not consider societal actors' objectives in energy efficiency during the policy formulation process, societal actors may not implement the policies properly. It then causes the political actors to not be able to achieve their objectives.

Cognition and motivation are also added in this adapted AOC framework. The addition of cognition and motivation is considered necessary to further understand how actors see their objectives and contexts. The original AOC framework only mentions the objective as an "underlying policy objective which matters for societal and political actors" (Jakob et al., 2020), which is very general and wide. Jakob et al. (2020) did not explain the technical details on how to reveal actors' objectives from interviews. The terms of cognition and motivation come from Contextual Interaction Theory (CIT) by Bressers (2016). In the theory, cognition is defined as "sufficient understanding (both content-wise and relational), sufficient scope of boundary judgments" while motivations are interpreted as drivers toward the purpose and instrument of a policy. In CIT, motivation applies to both target groups and implementers of the policy, equivalent to societal actors in the AOC framework, and cognition applies only to the target groups. Compared to the AOC framework, CIT seems to provide more technical details to understand actors. However, CIT cannot solely be used for this research because the theory focuses only on the implementation of certain policies. CIT also does not consider contexts which I think is important to comprehensively understand energy efficiency in the industry. Therefore, the cognition and motivation components of CIT are added to the adapted AOC framework to complement the technical details of the original AOC framework. In the adapted framework, cognition is applied to all actors because it refers to actors' understanding which forms actors' objectives. Meanwhile, motivation is applied only to societal actors because it is related to actors' drivers toward energy efficiency measures which include the implementation of energy efficiency policies formed by political actors.

For the context part of the framework, the study will focus on three explanatory variables: (1) techno-economic, (2) organization/institution, and (3) environment context. Techno-economic context refers to financial and technical aspects of energy efficiency in the fertilizer industry, organizational context denotes managerial aspects of fertilizer companies in regards to energy

efficiency, and environmental context refers to environmental issues related to energy efficiency. The decision in choosing these variables is based on previous research and governmental documents. Organization contexts are chosen as the study conducted by Soepardi et al. (2018) on another energy-intensive industry in Indonesia revealed that management-organization barriers, compared to other barriers, more significantly affect energy efficiency improvement. Meanwhile, technological context is relevant as ammonia production in the fertilizer industry depends on the feedstock type while changing feedstock type has been a crucial driver in reducing the energy intensity of the fertilizer industry (Dasgupta & Roy, 2017). The environment context is considered because energy efficiency has been included as a way to reduce greenhouse gas emissions in Indonesia's National Energy Plan (Presidential Regulation Number 22 of 2017, 2017).

Figure 4 shows a schematic of the theoretical framework for this research. This framework is the result of an iterative process, meaning that changes to the framework are made during the research process. According to the scheme, the options for energy efficiency measures that companies can take are formed by the aggregation between the objectives of societal actors and the objectives of political actors. These objectives are seen by the actors in certain contexts, and actors may view their objectives differently in a different context. The objectives of societal actors are influenced by other factors, namely cognitions and motivations in conducting energy efficiency, while the objectives of political actors are influenced by their cognition regarding energy efficiency. The cognition and motivations of societal actors could be influenced by the political actors. At the same time, the cognition of political actors, as well as the motivation and cognition of societal actors, could be influenced by the outcomes of energy efficiency measures chosen by societal actors.

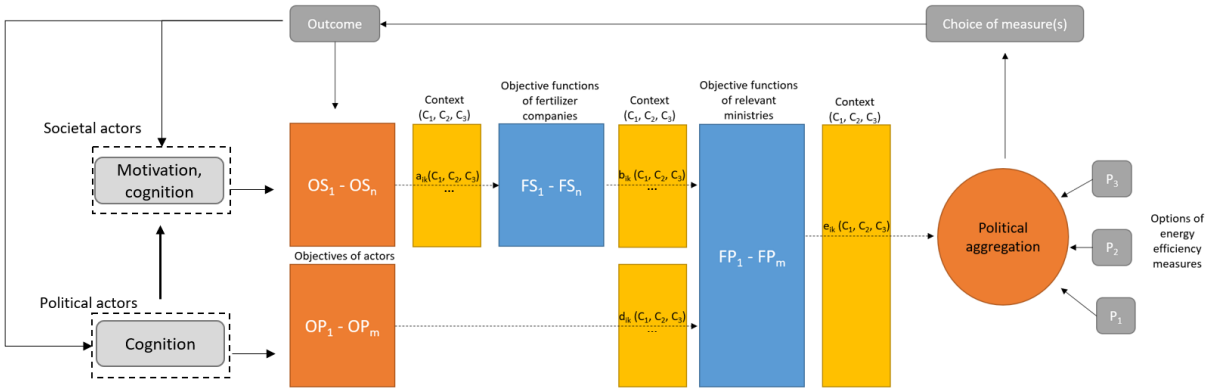

Figure 4 Schematic of the proposed analytical framework for this study (owned documentation, adapted from Jakob et al. (2020) and Bressers (2016)).

The components in the schematic of the proposed AOC framework adaptation (figure 4) are similar to the original framework. OS_1 – OS_n is the range of objectives of energy efficiency measures that societal actors find important and OP_1 – OP_m is the range of objectives of energy efficiency measures that political actors find important. Based on Jakob et al.'s (2020) classification of actors in the AOC framework, societal actors consist of fertilizer companies and LSIH. Political actors consist of relevant governmental bodies, who in this case are some ministries from Indonesian National Government, and these actors influence the motivation and cognition of societal actors. The C_1, C_2, C_3 represent techno-economic, organizations, environment contexts respectively. OS_1 – OS_n is influenced by societal actors' cognition and motivation in conducting energy efficiency measures, while OP_1 – OP_m is influenced by political actors' cognition regarding industrial energy efficiency. The a_{ik} represents the weight or importance of specific objective k for specific societal actor i, which, for example, is a fertilizer company. When the fertilizer company sees its objectives through C_1 – C_3 contexts, the weights cause the company's views regarding its objectives to be transformed into FS_1 – FS_n. Meanwhile, b_{ik} represents the weight of specific objective k for specific political actor i, which, for example, is the Ministry of Industry (MOI). Yet, MOI is also influenced by the fertilizer company, and d_{ik} represents the importance that the fertilizer company has for MOI. So, when MOI sees its objectives through C_1 – C_3 contexts, the weights b_{ik} and d_{ik} cause MOI's views to change from OP_1 – OP_m to FP_1 – FP_m. The e_{ik} represents the degree to which MOI influences the outcomes, implementation, and enforcement of energy efficiency measures. P_1, P_2, and P_3 represent available options of energy efficiency measures from which a choice of measure(s), reflecting the objectives of both actors, is applied by the fertilizer company.

The impacts of energy efficiency measure outcomes in figure 4 are different compared to the original framework. Investigation on the feedback shows that fertilizer companies regularly conduct evaluations and receive feedback from other stakeholders regarding the outcomes of companies' energy efficiency measures. Because the companies then must improve their energy efficiency measures based on the feedback and evaluation results, this process also influences how companies see their objectives. It is especially for the objective of achieving the company's target on energy efficiency (sub-chapter 5.2), which is then correlated to the company's motivation. Meanwhile, the political actors also receive feedback and conduct evaluations regarding their energy efficiency policies. However, the investigations find that these evaluation process only affect the policy instruments and do not make political actors change their objectives. So, it can be said that the outcome of energy efficiency measures chosen by the companies only influences the objectives of societal actors and does not influence the objectives of political actors. Yet, the outcome influences on both societal actors' and political actors' cognition were indicated during the interviews, resulting in the relation as shown in figure 4.

Chapter 4 Methodology

4.1 Research Object, Research Unit, and Research Boundary

The objects of this research are actors who are involved in the formulation and implementation of energy efficiency measures in fertilizer companies in Indonesia. Based on the AOC framework (Jakob et al., 2020), actors are divided into political actors and societal actors. In this study, political actors are governmental institutions in Indonesia that establish policy frameworks for energy efficiency in the fertilizer industry while societal actors are the fertilizer companies themselves that implement energy efficiency measures.

The actors mentioned in the previous paragraph also became the research units of this study. Fertilizer companies were selected using two criteria: the top five fertilizer companies in Indonesia based on their market share, and they had to produce nitrogen-based fertilizer. The relevant governmental institutions were decided through an existing stakeholder theory (Chevalier, 2008). Stakeholder analysis for choosing the relevant actors is further discussed in sub-chapter 4.2.

Meanwhile, this research narrowed down to focus on energy efficiency measures for ammonia production in the fertilizer industry rather than the complete chain of fertilizer production. Ammonia production consumes the biggest portion of energy in the fertilizer industry or around 90% of the industry's total energy (International Fertilizer Association, 2014). Energy efficiency measures analyzed were limited to the measures performed by the selected companies.

4.2 Stakeholder Analysis for Actor Selection

As the actor is an important component of the AOC framework, identifying the relevant actors is a crucial step for this research. A stakeholder analysis was used to identify the right actors on energy efficiency measures in Indonesia's fertilizer companies. It was expected that stakeholder analysis will provide "knowledge about the relevant actors to understand their behavior, intentions, interrelations, agendas, interests, and the influence or resources they have brought – or could bring – to bear on decision-making processes" (Brugha & Varvasovszky, 2000).

Reed et al. (2009) have categorized various stakeholder analysis methods into three main sequences: 1) identifying stakeholders, 2) differentiating between and categorizing stakeholders, and 3) investigating relationships between stakeholders. This study used the first sequence of stakeholder analysis, which is identifying stakeholders, in combination with the definition of actors

from the AOC framework (Jakob et al., 2020). There are several methods in this category, but this paper particularly used the methodological framework developed by Chevalier (2008) because the framework provides flexibility in choosing and modifying the methods for stakeholder identification. This flexibility allows the stakeholder analysis to be done efficiently without losing research focus on actors' objectives and contexts. Three identification methods from the framework were utilized: (1) identification using checklists for listing possible relevant stakeholders (Appendix B); (2) identification using written records and population data; and (3) identification by other stakeholders to pick the right political actors. Stakeholders were identified in the checklist by analyzing regulation documents regarding energy efficiency in Indonesia. Written records and population data, mainly statistics on Indonesia fertilizer companies and the market share of Indonesia fertilizer industry, were used to identify which fertilizer companies should be interviewed. Identification by other stakeholders using interview question number 4 (Appendix A) was helpful to confirm and specify the actors listed on the checklist.

Aside from the stakeholder analysis, the actor identification process also incorporated actor criteria from the AOC framework. AOC framework defines the actors as "societal and political actors most relevant for the formulation, implementation, and enforcement of energy policies" (Jakob et al., 2020). These criteria were useful to determine which actors had to be interviewed and which actors did not necessarily need to be interviewed. Information about actors who were interviewed and who were not is provided in table 4 in sub-chapter 5.2.

4.3 Data Collection

The main data collection methods of this study were interviews. Semi-structured interviews were conducted with respondents who represented institutions that have been identified as actors through stakeholder analysis. Interviews were held online, and each interview lasted around 30 to 60 minutes. Consents were explained to the respondents at the beginning of the interview, and written consent forms were obtained after the interviews. Research Ethics Policy of the University of Twente (University of Twente, 2019) was also considered and complied with during all research processes. Before the interview, relevant government policies and company documents were analyzed so that I had appropriate background information on the current conditions of industrial energy efficiency policies and energy efficiency in the fertilizer companies.

Interview questions (Appendix A) consisted of both closed questions and open questions. Closed questions, consist of questions number 2, 3, 5, 6, 7, 8, and 9, included yes/no questions and

questions which provided Likert scale as answers. The closed question aimed to keep the respondents focus on specific issues or aspects of industrial energy efficiency and to enable comparison of the answers from various actors. Meanwhile, the purpose of open questions was to explore particular issues more extensively by giving respondents a chance to answer the questions freely.

The nine interview questions (Appendix A) collected different variables and information from the respondents. Question 1 was about the general cognition of energy efficiency. One of the ways to investigate the cognition of actors is to ask the actors about the definition of improving energy efficiency. During the interview, each actor was given a very basic definition, which is "minimizing energy use in industrial production while performing the same task". Aside from understanding actors' conception regarding industrial energy efficiency, asking the definition of energy efficiency to the actors also serves as a function to set the context of energy efficiency during the interview process. Then, question 2 asked about actors' objectives, and question 3 asked about the contexts of energy efficiency. Question 4 and question 6 were parts of stakeholder analysis. Question 5 investigated feedback mechanisms to understand how the outcomes influence certain aspects of actors (sub-chapter 3.2, 5.1). Questions 7 and 8 asked about cognition and resources as parts of CIT, and lastly question 9 investigated whether fertilizer subsidies influenced companies' decisions on doing energy efficiency. Additional questions were also asked the respondents to get more comprehensive and detailed information on the answers to each question.

Information regarding the interviewed institutions and the interview date is provided in table 3. As two LSIH accepted the interview request that I sent, two LSIH were interviewed. Meanwhile, stakeholders which were identified (sub-chapter 5.2) but were not interviewed include local governments, covering both provincial and/or municipal governments, the Ministry of Agriculture (MOA), the Ministry of State-owned Enterprises (MOSOE), the Ministry of Environment and Forestry (MOEF), and international organizations.

Table 2 Institutions who were interviewed and the interview dates.

No.	Name of Institution	Actor Name	Interview Date
1	Center for Industrial Pollution Prevention Technology	LSIH	9 June 2021
2	Center for Industrial Certification	LSIH	12 June 2021
3	A fertilizer company	FC	15 June 2021
4	Indonesia Ministry of Energy and Mineral Resources	MOEMR	18 June 2021
5	A fertilizer holding company	HC	23 June 2021
6	Indonesia Ministry of Industry	MOI	13 July 2021

4.4 Data Analysis

Analysis of the collected data from the actors consisted of two types of analysis. The first one was stakeholder analysis. Actors' answers to questions number 4 and 6 (Appendix A) were analyzed to determine relevant stakeholders in the energy efficiency of the fertilizer industry. The second analysis was the analysis of actors' objectives and energy efficiency contexts. The respondents gave their answers in the form of the Likert scale, and these answers were analyzed to determine the actual objectives and contexts. Both stakeholder analysis and analysis on the objectives and contexts used cognition to get insights behind respondents' answers. Cognition here refers to actors' knowledge, perception, and associations regarding policies and procedures for improving energy efficiency. Respondents' cognition was shown during the interviews when they gave their reasoning behind their answers. The analysis then gave results on the objectives of each actor, and the contexts of energy efficiency in the fertilizer industry, which then led to recommendations.

The data which was obtained from Likert-scale questions had to be analyzed and interpreted carefully due to several reasons. These questions include the questions regarding the role of local government, actors' perception of objectives, and actors' perception of the contexts. First, during the interviews, respondents often showed hesitancy in giving a lower scale like 1 or 2 as an answer and they tended to substitute it with scale 3 which represented a neutral stance to the questions. This tendency means that scales 3 and 4 should be seen to represent lower values than they should have. Secondly, respondents sometimes mixed their own perspectives with the perspective of their organizations even though they had been constantly reminded to answer the questions from the perspective of their organization. Thirdly, the respondents who were interviewed only represent a small sample due to time and resource limitations. It means that the answers that the respondents

provided may not represent the answer of the whole organization. It is especially true for cognition because the cognition of each individual inside an organization can vary based on the individual's educational background. However, this research has tried its best to get the most relevant respondent who was responsible for energy or energy efficiency in each organization.

Chapter 5 Result and Discussion

5.1 Actors in Energy Efficiency Measures of Indonesia Fertilizer Industry

Stakeholder analysis has resulted in a list of actors involved in energy efficiency measures in Indonesia's fertilizer industry (table 3). Six stakeholder groups have been identified based on the stakeholder checklist developed by Chevalier (2008). Each group can consist of one stakeholder, such as in the group of agencies with legal jurisdiction over energy efficiency implementation, or several stakeholders, such as in the group of national governments which refer to national government agencies. Based on the AOC framework, these stakeholders can be categorized into two groups, which are societal actors and political actors. Societal actors include fertilizer company (FC), fertilizer holding company (HC), *Lembaga Sertifikasi Industri Hijau* (LSIH or Green Industry Certification Agency), and International Standards Organization (ISO). Political actors include the Ministry of Energy and Mineral Resources (MOEMR), the Ministry of Industry (MOI), local governments, the Ministry of Agriculture (MOA), the Ministry of State-owned Enterprise (MOSOE), the Ministry of Environment and Forestry (MOEF), and international organizations. Five stakeholders were interviewed: FC, HC, LSIH, MEOMR, and MOI.

Table 3 List of actors involved in the energy efficiency of Indonesia's fertilizer industry.

Stakeholder type	Name of stakeholder	Role in AOC framework	Role in CIT	Note
Individuals	Energy manager in fertilizer companies	Societal actor	Target group	Considered as part of fertilizer companies
Agencies with legal jurisdiction over energy efficiency implementation in fertilizer companies	LSIH	Societal actor	Implementer	Interviewed
Business and commercial enterprises	Fertilizer companies, fertilizer holding company	Societal actor	Target group	Interviewed
Government authorities at the district and regional levels	Local governments where fertilizer companies are located	Political actor	N/A	Not interviewed
National governments	MEOMR, MOI, MOA, MOSOE, MOEF	Political actor	N/A	MEOMR and MOI

				were interviewed.
International government bodies	UNFCCC, UNIDO	Political actor	N/A	Not interviewed
International union	ISO	Societal actor	N/A	Not interviewed

Societal actors are the ones that implement energy efficiency measures and get direct advantages or disadvantages from the measures. How fertilizer companies perceive and conduct energy efficiency measures will directly affect energy efficiency in the whole fertilizer industry. Aside from companies' reasons or motivations in doing energy efficiency, there are also some legal obligations regarding energy that fertilizer companies must comply with. These legal obligations include conducting energy management, implementing energy efficiency measures, and using energy-efficient technology in companies' operations (Regulation of the Government of the Republic of Indonesia Number 70 of 2009, 2009). The obligation for conducting energy management specifically targets big companies which are defined as the companies whose annual energy use exceeds 6000 TOE. Because the fertilizer companies in this research fulfill the criteria, the companies must conduct energy management, which usually includes energy efficiency measures. The fertilizer companies are also subject to obtaining the 'Green Industry Certification' or SIH certification (Law of the Republic of Indonesia Number 3 of 2014, 2014). The law designs the SIH to be voluntary at the initial phase and it intends to gradually make the certification scheme obligatory. However, even though it has been 7 years after the law was enacted, the interview revealed that SIH is still in the voluntary phase. So, for now, big companies in Indonesia, including fertilizer companies, are not yet obliged to get the certification.

Different with fertilizer company, fertilizer holding company does not conduct energy efficiency measures directly. Yet, the holding company still has high importance in forming the energy efficiency policy of its subsidiary companies. An interview with an expert from the fertilizer company shows that the decision-making process in the environment- and energy-related matters is top-down. It means that the holding company sets particular targets for GHG emission reduction or energy intensity of the production process, and then the subsidiary companies must do the necessary works to achieve the targets. So, the role of the holding company is more about directing fertilizer companies' policy, resources, and motivation regarding energy efficiency. This

role is very important because the subsidiaries of the holding company are also major fertilizer producers in Indonesia.

Meanwhile, the political actors influence energy efficiency measures by setting regulations and requirements related to energy efficiency. MOEMR plays a role as the main policymaker of energy efficiency in Indonesia through formulating energy plans, setting standards and requirements of energy efficiency, and developing related schemes or programs such as energy labeling. This wide range of MOEMR's responsibilities in energy efficiency regulation leads the Ministry to have intensive collaboration with other relevant institutions. An interview with MOEMR revealed many stakeholders are involved in the policy formulation and evaluation process. For industrial energy efficiency, these stakeholders include government agencies such as MOI, Ministry of Environment and Forestry, National Energy Council, and coordinator ministries, and non-governmental organizations such as business or industry associations, NGOs, and exporters and importers.

MOI specifically sets regulations for the industry, including for the fertilizer industry. Because energy efficiency is considered as a part of SIH certification, MOI plays a role in formulating SIH mechanisms and creating SIH standards. The Ministry also supervises the implementation of SIH, and more importantly, appoints the certification agencies or LSIHs. LSIHs then have a role in implementing SIH regulations by assessing companies that apply for SIH certification. Although according to Regulation of the Minister of Industry of the Republic of Indonesia Number 14 of 2020 (2020) SIH can be either institution under MOI or private certification companies, LSIHs are considered as societal actors. The reason is that they relate more with fertilizer companies and their objectives rather than with political actors and their objectives (sub-chapters 6.3 and 6.4). Moreover, experts from LSIHs acknowledged that LSIH's role is limited to implement SIH regulations and standards set by MOI. This same reason also makes LSIHs equivalent as the implementers based on CIT.

Aside from actors with significant influence, some actors with a low level of influence on energy efficiency in the fertilizer industry have also been identified in table 3, which include international organizations, ISO, local governments, MOA, and MOSOE. International organizations like UNFCCC or UNIDO may influence policy formulation on the national level. However, when answering interview question number 4 (Appendix A), the respondents did not mention any of these organizations. The same thing happened with ISO. The expert from FC only

mentioned ISO regarding the company's success in getting ISO 50001 certificate, but the respondent did not consider ISO to be important in the company's energy efficiency implementation. The respondent may consider ISO certification as something that has to be done or fulfilled. Therefore, because the stakeholder analysis could not give strong indications that international governmental bodies and international organizations significantly influenced energy efficiency measures in Indonesia's industry, they were not included as interview respondents.

The importance of local governments, covering both provincial and municipality governments, is more complicated to determine. Figure 5 shows the score on the importance of local government as a stakeholder in the energy efficiency of the fertilizer industry. The scores were given by each actor who was interviewed. In this graph, score 1 means very unimportant, and score 5 means very important. Most actors gave a score between 3 and 5, which is relatively high, except for the expert from MOI that gave a score of 2. There is also a difference between the two LSIHs, where the expert from LSIH 1 gives the importance a score of 3.5 and the expert from LSIH 2 gives 5 full scores.

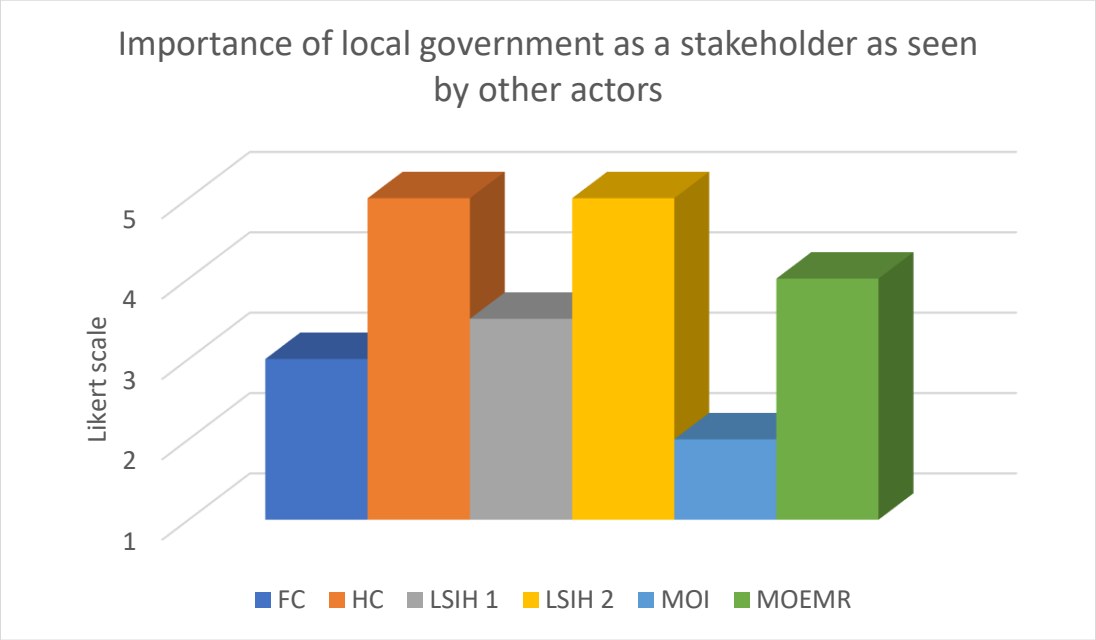

Figure 5 Importance of local government as a stakeholder, rated by each interviewed actor. FC: fertilizer company, HC: fertilizer holding company, LSIH: Green Industry Certification Agency, MOI: Ministry of Industry, MOEMR: Ministry of Energy and Mineral Resources).

Despite the result shown in figure 5, these numbers cannot be interpreted as they are because of various reasons found during the interview. Some actors tended to be reluctant to give low numbers even though they knew that local governments did not have an impact on energy

efficiency in the fertilizer industry. Other actors did mention the insignificance of local government's role, but then they associated local governments in other roles such as in promoting companies' products or in environmental quality control. Experts from MOEMR mentioned that local governments could be important only for the energy efficiency of companies that require a permit from local governments, which mostly small- and medium-enterprises whose energy use is likely to be less than 6000 TOE per year. Meanwhile, the expert from HC associated local governments' role in regulation regarding coal transportation which may hinder the production process, leading to potential unscheduled shutdown that wastes energy, so it conflicts with energy efficiency measures. However, the example cited by the expert from HC does not fit with what this study is about. Therefore, despite the result shown in figure 5, local governments are not considered to have significant influences on the energy efficiency of fertilizer companies in Indonesia. Only the expert from MOI directly acknowledged the low level of local government influence on energy efficiency measures in big companies. Yet, in doing so, the expert also added the importance of local governments on promoting energy efficiency measures in small and medium enterprises.

Meanwhile, the cases for MOA, MOSOE, and MOEF are different. Because the experts from FC and HC have different views regarding the relationship between fertilizer subsidy and energy efficiency measures in the companies, an interview with MOA is necessary to make the matter clear. However, due to lack of research time and lack of contact person from the Ministry, the interview could not be conducted. The same thing happens with MOEF and MOSOE. Several actors mentioned both Ministries concerning GHG emission reports and fertilizer companies' policies during the interview along with the role and importance of the two Ministries, but interviews with MOEF and MOSOE could not be conducted. It may cause this research to lack some insights regarding the importance of global warming context and how it may influence other actors' objectives as well as insights regarding the influence of MOSOE on fertilizer companies.

5.2 Cognition regarding Industrial Energy Efficiency

In this research, cognition regarding energy efficiency refers to energy efficiency definition and relations of energy efficiency with other aspects in fertilizer companies. Although in the original CIT cognition is only considered for the target group (Bressers, 2016), which in this research is the fertilizer company, understanding cognition of all actors proves to be helpful in understanding actors' views on objective and contexts of energy efficiency measures (sub-chapters

5.3 and 5.4). So, I think that it is important to discuss the general cognitions regarding the energy efficiency of all actors before jumping into the discussion of the objectives and context.

The result on actors' cognition regarding industrial energy efficiency is shown in table 4. All actors commented that they in general agreed with the definition, but the majority of them gave some additional remarks on their organization's definition of energy efficiency. The additional remarks given by the actors show differences in the perception of energy efficiency. These differences are observed between actors who are involved directly in the industry (FC, HC, LSIH, and MOI) and actor who deals with energy efficiency in general (MOEMR). FC, HC, and LSIHs tend to associate energy efficiency with the company's product or production rate while MOI associates energy efficiency with energy intensity. On the other hand, the energy efficiency definition adopted by MOEMR is more comprehensive as it includes not only productivity but also safety, security, and comfort.

Table 4 Actor definition regarding energy efficiency.

Actor	Agree/disagree	Additional remark or organization's definition
FC	Agree	No additional remark
HC	Agree	Energy efficiency is an effort to reduce the energy use per ton product.
LSIH 1	Agree	Using less energy without reducing both the quantity and quality of the company's products.
LSIH 2	Agree	Using the same amount of energy to achieve a higher production rate.
MOI	Agree	Energy efficiency also means decreasing energy intensity
MOEMR	Agree	Energy efficiency is an effort to utilize energy efficiently and appropriately without compromising safety, security, comfort, and productivity.

The difference in the understandings of energy efficiency among the actors is natural because each actor has different educational backgrounds and engages in different activities regarding energy efficiency. The experts from FC and HC involve directly in the fertilizer production process, so understandably they associate energy efficiency with reducing energy use for the production. Experts from LSIHs do not involve directly in the production process. However, because they act as the auditors for SIH, they are also in close contact with the companies. It makes the LSIHs also associate energy efficiency with products and production lines. It also needs to be considered that many SIH standards for the fertilizer industry are related to fertilizers as the product and the production process (Regulation of the Minister of Industry of

the Republic of Indonesia Number 27 of 2018, 2018), further supporting LSIHs' view on energy efficiency.

Meanwhile, the cognitions of experts from the two political actors regarding energy efficiency show clearer differences. The expert from MOI specifically sees energy efficiency as a decrease in energy intensity because the Ministry focuses more on energy intensity when dealing with energy issues in the industry. It is shown in the SIH energy criteria for urea production (Regulation of the Minister of Industry of the Republic of Indonesia Number 27 of 2018, 2018) which focuses on how to decrease energy intensity during the production process. The statistic report on the Indonesian manufacturing industry also mainly uses the data of energy consumption in comparison to industrial outputs (Statistics Indonesia, 2020a), further emphasizing the importance of energy intensity in showing efficiency in the industry. On the other hand, MOEMR acts as the general regulator of energy efficiency in Indonesia, so the Ministry looks at energy efficiency in several different fields at the same time; MOEMR divides energy efficiency into two main categories, which are energy efficiency for energy suppliers or generators and energy efficiency for energy user or consumer. The latter one consists of four sectors, including industry, household, building, and transportation. Each category requires its own regulation, and the regulations between different categories can be very different. So, it is logical that MOEMR has a much broader definition of energy efficiency compared to MOI and the other actors.

5.3 Objectives of Actors

The result on objectives that actors consider important is shown in figure 6. The first five objectives, located from the top of each radar chart to the clockwise direction, were asked to all actors: (1) reducing GHG emission as part of NDC target; (2) national energy security and self-sustenance; (3) reducing the production cost of fertilizer; (4) improving and/or maintain company's image; and (5) complying with government regulation. Two additional objectives were added by some actors: (6) achieving the company's target on energy efficiency by FC and (7) reducing energy consumption and energy intensity by MOEMR. In the rest of this thesis, these objectives will be referred to by using shorter terms: emission objective for objective 1, energy security objective for objective 2, production cost objective for objective 3, company's image objective for objective 4, compliance objective for objective 5, company's target objective for objective 6, and energy consumption objective for objective 7.

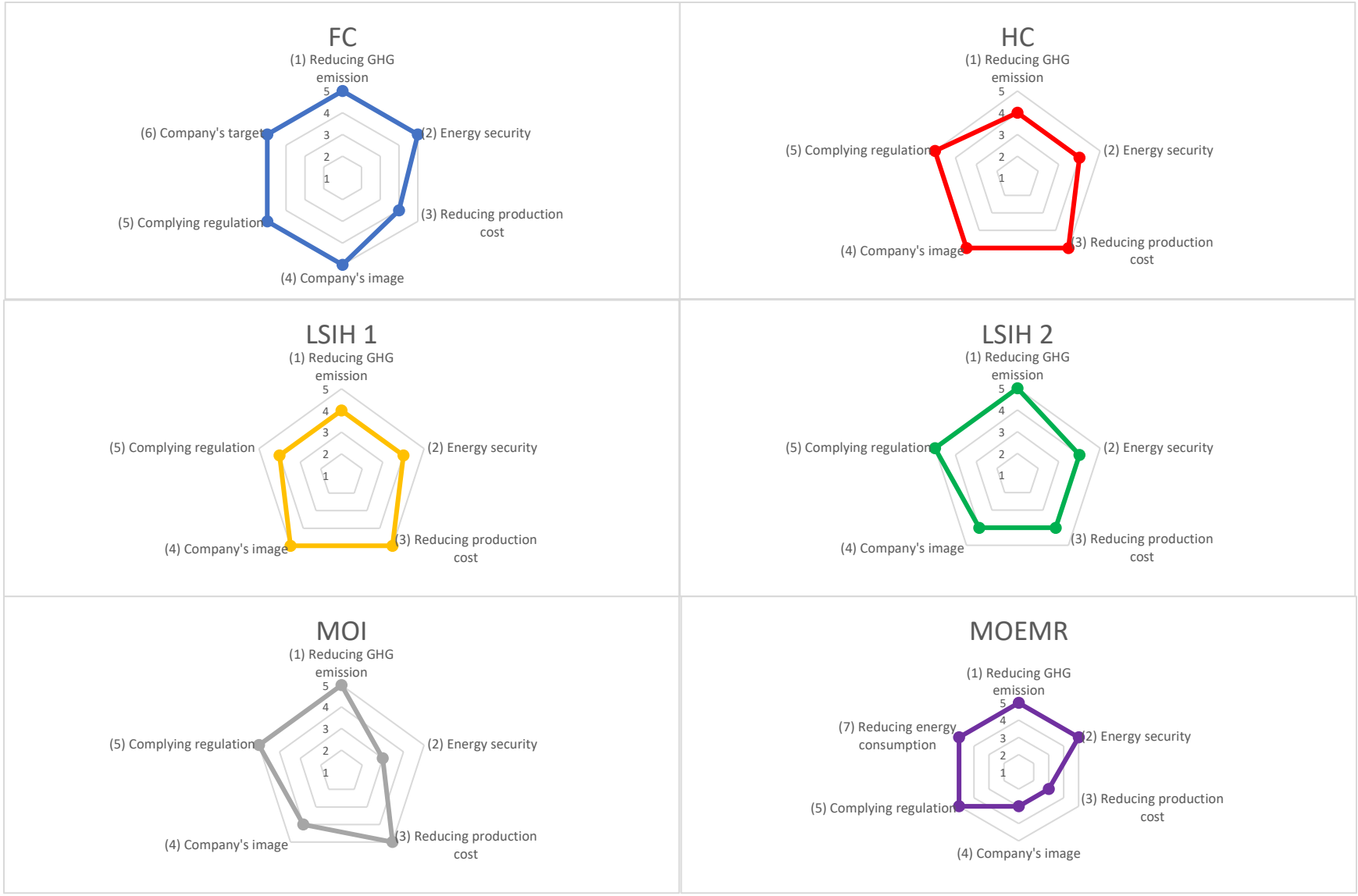

Figure 6 Actors' objectives regarding energy efficiency measures in fertilizer industry.

Based on the AOC framework (Jakob et al., 2020), emission, energy security, and energy consumption objectives compose political objectives while production cost, company's image, compliance, and company's target objectives compose societal objectives. Emission, energy security, and energy consumption objectives are considered the political objectives because they are the targets that the Indonesian Government set. They can also have further political consequences, such as the Government's image in the international community for the NDC target and public trust and even reelection for the national energy security.

The result shows that actors highly rate the importance of every objective by giving scales that range from 3 to 5. It cannot be said that there is a clear cut among the perceptions of societal and political actors regarding societal and political objectives as some societal actors rated certain political objectives to be more important than some societal objectives and the other way around. For example, even though FC and LSIH 2 are considered societal actors, they both regard emission objective (political) as very important but regard production cost objective (societal) to be less important. On the other hand, political actors like MOI and MOEMR also regard compliance objective (societal) as very important, and MOI does not even consider energy security objective (political) as important. The two LSIHs also have some different views; LSIH 1 gives higher scales to production cost and company's image objectives (societal) but LSIH 2 gives higher scores to compliance objective (societal) and emission objective (political). Meanwhile, compliance objective (societal) receives a higher score from almost all actors.

These results are somewhat different from the ideal condition based on the AOC framework. According to the framework, political actors should mostly care about political objectives and societal actors will mostly focus on societal objectives. However, if we put actors' cognition into consideration, we can obtain the actual objectives for each societal and political actor.

In general, societal actors regard societal objectives to be more important than political objectives as societal objectives are directly related to their interests in implementing energy efficiency. The expert from FC considered both emission and energy security objectives important, but at the same time, the expert mentioned the requirement from MOEF and MOEMR to report GHG emissions monthly in many parts of the interview. The expert also associated energy security objective with energy prices, in a way that if national energy security was threatened, the price of energy sources would also increase. It means that emission and energy security objectives are not

considered the actual objectives by FC's expert. The expert saw them as important only because of external factors which indirectly affect the company. This perception of emission objective also shows how political actors could influence the cognition of societal actors, which in turn influence how societal actors see their objectives on energy efficiency. Different from FC, the expert from HC associated energy efficiency objectives more with production efficiency and profit, so overall the expert rated societal objectives more important than political objectives.

The case for LSIHs is different. Both experts from LSIH 1 and LSIH 2, who deal with the technical aspects, mentioned the importance of following SIH procedures and standards, including the ones for energy efficiency, many times during the interview. However, the expert from LSIH 1 looked at the given energy efficiency objectives from the perspective of fertilizer companies. It is reflected in the respondent's reasoning behind the answers; production cost and company's image objectives were rated highly because successful energy efficiency measures had to come from the company's internal interests as reflected by the objectives. Meanwhile, compliance objective was rated less important because SIH was still voluntary. The expert from LSIH 2 rated the emission objective as very important but the respondent associated the answer with GHG emission criteria in SIH standards. So, from the interviews with experts from two LSIHs, it can be said that the main objective of LSIH regarding energy efficiency measures is to ensure compliance with energy efficiency criteria in SIH.

For the political objectives, officials from MOI and MOEMR in general regard political objectives as more important than societal objectives. Yet, both actors have some differences regarding political objectives. The official from MOI especially associated energy security objective with energy suppliers or generators rather than energy users like the fertilizer industry, leading the actor to give only 3 for the objective. On the other hand, MOEMR has a broader focus and authority on energy efficiency, so it is natural that experts from MOEMR also considered energy security objective to be very important. Another difference is that the official from MOI considered production cost objective (societal) as very important. However, the respondent associated the answer with reducing energy intensity, which then would also reduce GHG emissions. So, the main objective for MOI is still GHG emission reduction as mentioned in the emission objective. Despite these differences, officials from both MOI and MOEMR considered compliance objective (societal) as very important. From the interview, the officials saw this objective as something obvious that fertilizer companies have to do. The respondents may be aware

that as policymakers, they have the resources to ensure fertilizer companies do the required energy efficiency measures. So, it can be said that compliance objective (societal) is not the actual objective of both MOI and MOEMR.

Based on the analysis above, the objectives of each actor in energy efficiency can be summarized in table 5. The expert from FC considered an additional objective, which is to achieve the company's target on energy efficiency. It is due to the nature of its relationship with HC; HC and FC have a top-down relationship in environmental and energy aspects in which HC sets the targets and FC has to achieve the target.

Table 5 Objectives of each actor on energy efficiency in the fertilizer industry.

	FC	HC	LSIH	MOI	MOEMR
Objectives	(1) Reducing GHG emission (4) Improving and maintaining the company's image (6) Achieving the company's target on energy efficiency (5) Complying with government regulation	(3) Reducing production cost of fertilizer (4) Improving and maintaining the company's image (5) Complying with government regulation	(5) Complying with government regulation	(1) Achieving GHG reduction target	(1) Achieving GHG reduction target (2) National energy security and self-sustenance (7) Reducing general energy consumption and energy intensity

Regarding CIT, motivation can be further drawn from these objectives, especially for FC and HC who are equivalent to the target groups and the implementer. It can be said that the motivations for both FC and HC are to fulfill government regulations and requirements and to increase profit. Government requirements here are not only from the laws or regulations but also requirements from MOSOE as both FC and HC are SOEs. This motivation also shows political actors' influence. Motivation to increase the company's profit is drawn from how the companies regard related objectives highly and from HC's emphasis on product efficiency. Meanwhile, the main motivation of LSIH is to implement established SIH standards and regulations which can be seen from the interviews. This motivation is also natural for LSIH as LSIH needs to maintain its credibility and competency as LSIH which are given by MOI.

5.4 Contexts of Energy Efficiency in Indonesia's Fertilizer Industry

The result on contexts of energy efficiency in Indonesia's fertilizer industry as seen by actors is shown in figure 7. The first six contexts, located from the top of each radar chart to the clockwise direction, were asked to all actors: (1) global warming; (2) incentives and disincentives from the government; (3) abundance of energy resources; (4) available technology for the production process; (5) company's capacity and knowledge on energy efficiency; and (6) company's interests and priorities on energy efficiency implementation. Three additional contexts were also added by some actors: (7) price of energy resources by FC, LSIH 1, and MOI; (8) environmental pollution by FC; and (9) product competitiveness by HC. In the rest of this thesis, these contexts will be referred to by using shorter terms: global warming for context 1, incentives for context 2, energy resources for context 3, technology for context 4, company's capacity for context 5, company's interest for context 6, resource price for context 7, pollution for context 8, and competitiveness for context 9.

The eight contexts can be classified into three big groups of contexts. The first group is the environmental context consisting of global warming and pollution. The second one is the techno-economic context consisting of incentives, energy resources, technology, resource price, and competitiveness. Lastly, the third group is the organizational context consisting of the company's capacity and company's interest.

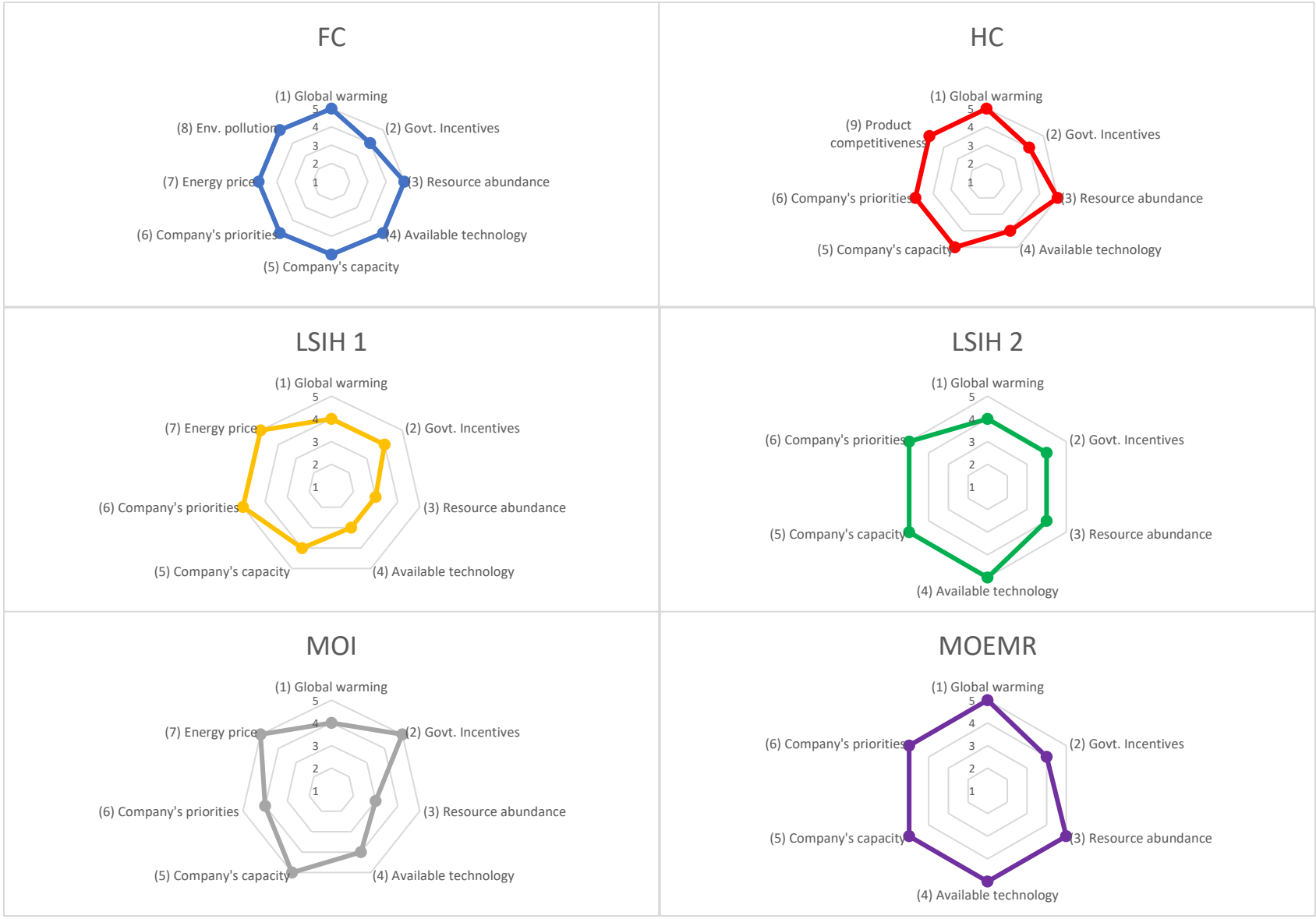

Figure 7 Context of energy efficiency in Indonesia's fertilizer industry as seen by actors.

The result shows that actors highly rate the importance of every context by giving scales that range from 3 to 5. Although each actor views the contexts differently, several findings can be observed from the figure. First, organizational contexts, either company's capacity or company's interest, are deemed important by most actors. Organizational contexts are especially related to FC and HC, so it is not surprising that they both consider the context very important. However, the organizational contexts also influence other actors, including LSIH and the political actors. Experts from LSIHs, as the implementers of SIH, understand that organizational contexts are important key factors in determining the success of energy efficiency in companies. It is reflected as the experts from both LSIHs emphasized the company's capacity and interest aspects in the form of energy management during the interview. The LSIHs also continuously give feedback regarding SIH criteria to MOI when they assess that the targets set by the certification scheme are not practically feasible considering companies' capacity and ability. The official from MOI confirmed that the Ministry continuously evaluated SIH policy based on suggestions and feedback from both LSIHs and the fertilizer company association. So, it can be said that FC and HC, as societal actors, exert influences on MOI, a political actor, in the form of companies' organizational context. This influence can be either indirect through LSIHs or direct to the Ministry. Meanwhile, for the MOEMR, organizational contexts played a role in the decision-making process of energy efficiency policy. It is reflected as the officials from MOEMR understand the importance of developing companies' capacity and capability on energy efficiency to make energy efficiency policy successful.

Second, global warming and resource price contexts are considered important by some actors, but they are considered less important by the other actors. Global warming context is related to actors' view on reducing GHG emission as one of the energy efficiency objectives. So, it is not surprising that only experts from FC, HC, and MOEMR considered the context very important; MOEMR officials associated energy efficiency policy with GHG reduction while experts from both FC and HC mentioned their obligations to report GHG emission regularly to MOEMR and MOEF. It means that MOEMR formulates energy efficiency policy by considering global warming context while the reporting result from FC and HC may influence MOEMR and MOEF in their decision-making process. Meanwhile, experts from LSIH 1, LSIH 2, and MOI saw the global warming context as less important because they considered the context as a general topic. Nevertheless, there are also separate criteria for GHG emission reduction in SIH. So, the global

warming context is still important for SIH in general, but the three actors do not associate the context directly with energy efficiency.

Similar to the global warming context, the resource price context is also considered very important by some actors but unimportant by the other actors. Yet, the interviews revealed that this context is closely related to the cognition of actors. Experts from FC and HC associated energy resources context with the price and continuous supply of energy resources which were important for the fertilizer production process. So, although it was only the expert from FC that mentioned the importance of energy resource price during the interview, experts from both HC and FC actually considered the context important. Experts from LSIH 1 and MOI also considered the resource prices context very important because they believed that the price of energy resources could motivate companies to implement energy efficiency measures. Through this context, we can even see how MOI as a political actor influences the decision-making process; one of the incentives that the MOI has been able to implement is reducing natural gas prices for companies with SIH certification. It shows how MOI has tried to design the policy so that it involves energy resource pricing as an incentive for the companies. As natural gas is a crucial material in the fertilizer industry, this incentive would further motivate HC to encourage energy efficiency measures to its subsidiaries, including FC.

Thirdly, the technology context is also considered differently among different actors. The experts from FC, LSIH 2, and MOEMR considered the context very important. The expert from FC mentioned the importance of technology to further improve energy efficiency even though the expert also mentioned how expensive the imported technology was. Meanwhile, the officials from MOEMR emphasized technology improvement along with companies' internal behavior change through energy management. On the other hand, the experts from HC, LSIH 1, and MOI considered production technology to be less important because energy efficiency measures do not always necessarily mean technological change. Instead, the measures can focus on non-technological changes which are relatively cheaper. Despite these differences, it can be seen that this context influences the decision-making process of the political actors: MOEMR focuses its energy efficiency policies on both behavioral change and technological improvement, while MOI incorporates more non-technological standards and criteria in SIH than the technological ones. Moreover, during the interview, the expert from MOI mentioned that the Ministry connected certain industries, including the fertilizer industry, with international agencies like Energy

Conservation Center Japan (ECCJ) so that the industries could develop their technologies to be more energy-efficient. It indicates that in the technology context, fertilizer companies as societal actors indirectly influence MOI as a political actor in terms that the Ministry helps the companies to develop their technology. The influence is considered indirect because, from the interview, it is not clear whether the companies push the Ministry to help them with their technology or the other way around. It is also possible that the Ministry is motivated by its own agenda. Still, it makes technology context relevant for energy efficiency in the Indonesia fertilizer industry.

Lastly, actors' perception of incentive context is interesting to note because most actors consider the incentive context less important. However, this result is not surprising if we consider actors' knowledge, especially, of the incentives. The interviews revealed that the experts from FC, LSIH 1, LSIH 2, and MOEMR had little knowledge about incentives for energy efficiency for the industry. The expert from HC mentioned an incentive that the company has gotten but it did not affect the company's decision regarding energy efficiency measures. Meanwhile, the expert from MOI admitted that there should have been incentives, but their implementations had not been effective. Some incentives were even said to have not reached an agreement with the other relevant government bodies such as the Ministry of Finance regarding tax reduction. This lack of understanding and clarity regarding the incentives from both societal and political actors means that there is little to no influence of societal actors on political actors nor influence of political actors on the policy-making process regarding the incentive context. As shown in the context of energy pricing, incentives can be powerful tools to motivate fertilizer companies to implement energy efficiency measures.

Therefore, based on the analysis above, the contexts of energy efficiency in Indonesia's fertilizer industry can be summarized in table 6. The environment context consists only of global warming, techno-economic context consists of energy resource price and available technology, and organizational context consists of capacity and knowledge of the fertilizer companies as well as companies' interests and priorities regarding energy efficiency.

Table 6 Context of energy efficiency in Indonesia fertilizer industry.

Energy efficiency context		
Environment	**Techno-economic**	**Organizational**
(1) Global warming	(3) Energy resource price (4) Available technology	(5) Capacity and knowledge of company (6) Company interest and priorities

5.5 Generalization for Other Energy-Intensive Industries in Indonesia

After analyzing the research result and proposing suggestions to improve the energy efficiency of the Indonesian fertilizer industry, I then tried to generalize the theoretical framework used in this research (figure 4) so that it can be applied to other energy-intensive industries in Indonesia. As explained by Yin (2018), an analytic generalization is possible based on a modification of theoretical concept, which in this case is the AOC framework with borrowed terms from CIT. The generalization is then confirmed by the findings of this research. So, the generalization will be at a conceptual level rather than on the specific case of the fertilizer industry.

Based on the findings of this case study, the theoretical framework used in this research can be applied to other energy-intensive industries in Indonesia based on two main arguments. The first one is other energy-intensive industries fall under the same energy efficiency mechanism and legal framework as the fertilizer industry. Companies from these industries, especially whose annual energy use is greater than 6000 TOE, are subject to energy management and GHG emission reporting obligation. Moreover, MOI has issued specific SIH standards and requirements for most sectors in energy-intensive industries in Indonesia. Although up until now SIH is still voluntary and companies' motivations to get certified may differ, especially for private companies, there is a plan in the future to make SIH obligatory for all companies from energy-intensive industries. When this happens, energy efficiency requirements and obligations for all energy-intensive industries will be the same.

The second argument is that as the energy efficiency mechanism and legal framework are the same for energy-intensive industries in Indonesia, actors who are involved in the process are also relatively be the same. Societal actors will still be companies, which may include holding company if it exists in the industry, and specific LSIH(s) based on the industrial sectors. The main political actors will still be MOEMR, MOI, and MOEF while the role of MOSOE will depend on the type of the company; naturally, MOSOE will be a significant actor for energy efficiency in SOEs but not a significant actor for the private companies. The objectives of each actor and the context of each industry may differ, but the interaction among actors and their objectives in the industry-specified contexts will be relatively similar to the interactions found in this case study. Therefore, the actors, objectives, and context in other energy-intensive industries in Indonesia can be analyzed by using the framework in figure 4.

Yet, applying this framework to industrial sectors outside the energy-intensive industries and to smaller companies is possible but it needs to be done more carefully. Big companies from outside the energy-intensive industries are subject to similar general energy policies, like an obligation to do energy management. So, they will have similar energy requirements compared to the companies from energy-intensive sectors. However, some actors and some requirements regarding energy efficiency may be different because SIH mainly still targets energy-intensive industries. Companies from non-energy-intensive industries are not subject to SIH and, as the development of SIH regulations is quite slow, it is expected that this condition will persist in the near future. Meanwhile, smaller companies, or companies whose annual energy consumption is less than 6000 TOE, have different energy requirements, such as they are not obliged to do energy management. The involved actors may also be different because smaller companies may have more influence from local governments and their regulations compared with big corporations. It occurs because operational permits for small- and medium-enterprises are issued by local governments, while big companies receive their permits directly from the national government. So, this framework is possibly applicable to big companies from non-energy-intensive industries or to smaller companies, but adaptation may be necessary.

Chapter 6 Conclusion

6.1 Improvement Suggestion

Based on the result and its analysis, three suggestions are proposed to further improve energy efficiency measures in the Indonesian fertilizer industry. The suggestions are explained below.

1. **Give clear and valuable incentives for fertilizer companies if they implement energy efficiency measures well.** Most actors admitted that they had little knowledge of the incentives, meaning that fertilizer companies only implement energy efficiency up to the minimum standard set by the regulations to avoid legal sanctions. It may make the companies achieve a good energy efficiency level, but they will not go beyond the established standards. A case from Thailand, another developing country in Southeast Asia, also shows that fiscal incentives are crucial for improving energy efficiency in the industry (Hasanbeigi et al., 2010). Meanwhile, the fertilizer company and fertilizer holding company who were interviewed admitted that the awareness of Indonesian customers about the green measures applied by companies is still low. It makes international certification schemes like ISO 50001 to be less effective for the Indonesian market. It is reflected as only a few fertilizer companies have acquired ISO 50001 certificate (Directorate General of Renewable Energy and Energy Conservation, n.d.). So, clear and valuable incentives are still necessary as they will encourage companies to invest more in energy efficiency measures because the benefits that they will get weigh more than the effort and investment that they spend. It is important to note that the incentive cannot be solely in the form of awards or good conduct certificates. Low awareness of Indonesian customers regarding good-conduct companies will also make this kind of incentive to be less effective. Moreover, fertilizer cannot be substituted with other goods, so awards or certificates have little impact to motivate companies to do energy efficiency measures beyond legal requirements.
2. **Invest in research and development of energy-efficient technology.** Although most actors agreed that energy efficiency could be improved by conducting low- and medium-cost measures, technology also plays a big role in the energy efficiency of the fertilizer industry, especially in ammonia production. Company documents reveal that fertilizer

companies and holding companies have been transforming old production technologies with newer technologies that are more energy-efficient, but during the interview, fertilizer companies mentioned that the transformation was not easy because most of the technologies were imported, making them very costly for the company to acquire. An investment in research and development of the technology by fertilizer companies could reduce the price of the required production technologies, leading to faster and more affordable energy efficiency measures. However, decisions on investment in research and development are also influenced by government incentives and support because the initial investment usually needs quite a big amount of funding. The Indonesian Government could provide financial support for the development of energy-efficient technology by setting a mechanism similar to Thailand's Energy Conservation Promotion Fund. Moreover, research and development have long-term characteristics, so it depends on the perception of the companies regarding the benefits of such long-term investment.

3. **Lower the threshold of mandatory energy efficiency measures for companies**. The current threshold of energy use for companies that are required to conduct energy efficiency is much higher compared to Malaysia and the Philippines. Lowering the threshold means that more companies, especially the ones in energy-intensive industries, will be required to conduct energy efficiency measures and will become the target of SIH certification. As more companies apply energy efficiency measures, the energy efficiency of Indonesia's industry will also be improved. Moreover, it may also encourage the development of energy-efficient techniques and technology, either by the government or by the private sector, because the demand for such technology would increase.

6.2 Conclusion

This research has investigated the possibility of using actor analysis to improve industrial energy efficiency in Indonesia's energy-intensive industries in general and in Indonesia's fertilizer industry in particular. An adapted AOC framework has been proposed and used to analyze qualitative data obtained through interviews with actors. The analysis has been able to answer the main research question, which is '*how can energy efficiency measures in Indonesia's energy-intensive industry be improved?*', as well as the research sub-questions: (1) '*how is the current practice of energy efficiency in the Indonesian fertilizer industry in terms of techno-economics and policy?*'; (2) '*which actors are involved in the current practice of energy efficiency in the Indonesia*

fertilizer industry?'; (3) '*how do the involved actors perceive their objectives and contexts in the energy efficiency of the Indonesia fertilizer industry?*'; and (4) '*based on the analysis of actors, objectives, and context, what opportunities are available to improve energy efficiency in the Indonesian fertilizer industry?*'.

First, analysis on this thesis research has revealed that energy efficiency in the Indonesian fertilizer industry is considered as a part of other regulations, mainly Green Industry Certification (SIH) scheme. The analysis has also revealed actors involved in the energy efficiency of the fertilizer industry in Indonesia, their objectives in formulating and/or implementing energy efficiency measures or policies, and the contexts of energy efficiency in Indonesia's fertilizer industry. The involved actors consist of five main actors who can be classified into two groups: fertilizer company (FC), fertilizer holding company (HC), and Green Industry Certification Agency (LSIH), classified as societal actors, and Ministry of Energy and Mineral Resources (MOEMR) and Ministry of Industry (MOI), classified as political actors.

Moreover, each actor has its own objective(s) in doing its roles in the framework of industrial energy efficiency. Some of the objectives include improving and maintaining companies' image and complying with government regulation for FC and HC; complying with government regulation for LSIH; and achieving GHG reduction targets for MOI and MOEMR. These objectives are seen by the actors through several contexts: (1) environment context which includes global warming; (2) techno-economic context composed by energy resource price and available technology; and (3) organizational context consisted of capacity, knowledge, interest, and priorities of fertilizer companies. The analysis of these objectives and contexts has led to three improvement suggestions, which are giving clear incentives to the companies, encouraging investment in the development of energy-efficient technology, and lowering the threshold for mandatory energy efficiency for companies.

Secondly, I found that most respondents have little knowledge regarding incentives that fertilizer companies could get in implementing energy efficiency measures. I also found that both technological improvement and behavior changes in the form of energy management are considered the keys to improving energy efficiency in the Indonesian fertilizer industry, but the fertilizer company finds it difficult to improve the technology due to the cost of imported technology. These findings bear some interesting policy implications: the Indonesian Government should (1) give clear and valuable incentives for fertilizer companies if they implement energy

efficiency measures well and (2) encourage fertilizer companies to invest in research and development of energy-efficient technology by giving sufficient supports so that the companies find it profitable to invest in such research. The lack of incentive and technological improvement barrier to improving energy efficiency can also be found in other Southeast Asian countries such as Malaysia, the Philippines, and even Thailand which has been considered as a successful example in energy efficiency. It means that there is a possibility to implement successful examples like Thailand's ECPF and DSM Program in Indonesia.

Thirdly, the results also demonstrate how the AOC framework developed by Jakob et al. (2020) with the addition of cognition and motivation aspects from CIT as developed by Bressers (2016) can be utilized to analyze energy efficiency measures in the industry in relation to the policymakers. The additional components improve the technical details of the original AOC framework so that the actual actors' objectives and contexts can be sorted and analyzed deeper. To this end, this research contributes to the advancement of the literature in the use of the AOC framework for industrial energy efficiency.

Finally, I recognize the utility and limitations of actor analysis in studying energy efficiency in the Indonesian industry. Actor analysis cannot explore deeply the technical aspects of energy efficiency, which is also crucial for the industry. This research also has some limitations because some important stakeholders like MOEF and MOSOE could not be interviewed and the number of interviewed fertilizer companies is limited. However, this study gives new insights into industrial energy efficiency in Indonesia. Considering that research on industrial energy efficiency in Indonesia tends to focus on energy intensity and techno-economic or organizational barriers, some aspects like objectives, motivations, resources, beliefs, and interests of people or organizations who are involved in energy efficiency are still missed from the literature. Understandings of these aspects are important to fully comprehend industrial energy efficiency in Indonesia so that it can be further improved. Therefore, I propose that future studies should also take actor analysis, besides technical aspects, into account when analyzing energy efficiency in Indonesia.

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Appendix A: Interview Questions

General questions for all actors

1. Industrial energy efficiency is minimizing energy use in industrial production while performing the same task, which in this case is producing fertilizer. Does your organization use the same definition? (yes/no) Do you have another definition or association regarding industrial efficiency?
2. From the perspective of your organization, how important are the objectives below for formulating and implementing (industrial) energy efficiency policies (measures)? 1 is very unimportant, 5 is very important

Objectives	1	2	3	4	5
Reducing GHG emission as part of NDC target					
National energy security and self-sustenance					
Reducing production cost of fertilizer					
Improving and/or maintain the company's image					
Complying with Government regulation					
Other (…)					

3. From the perspective of your organization, how important are the issues (context) mentioned below concerning (industrial) energy efficiency policies (measures)? 1 is very unimportant, 5 is very important

Issues	1	2	3	4	5
Global warming					
Incentives and disincentives from Government					
The abundance of energy resources (coal, natural gas)					
Available technology for the production process					
Company's capacity and knowledge on energy efficiency					
Company's interests and priorities on implementing energy efficiency					
Other (…)					

4. With whom does your division/department collaborate or exchange information in the formulation, implementation, and/or evaluation of (industrial) energy efficiency policies (measures)?
5. From the perspective of your organization, please rate the following statements by choosing between 1 and 5. 1 means completely disagree, 5 means completely agree.

Statements	1	2	3	4	5
My organization is involved in the process of evaluating energy efficiency policies and measures.					

My organization welcomes feedback or suggestions regarding (industrial) energy efficiency policies (measures) from other stakeholders.					
The evaluation results and/or feedback from other stakeholders are reflected through a revision in (industrial) energy efficiency policies (measures).					

6. From the perspective of your organization, how would you rate the importance of the local government's role in the implementation of (industrial) energy efficiency policy (measures)? Please rate between 1 and 5 with 1 very unimportant and 5 very important. Could you explain your answer?

Additional questions for investigating cognition and resources (CIT)

7. From the perspective of your division, how do you rate the current energy efficiency measure in the company? Please rate between 1 and 5 with 1 very inadequate and 5 very adequate. Could you explain your answer?
8. From the perspective of your division, how do you think about the resources (time, money, skills) currently allocated by the company for energy efficiency measures? Please rate between 1 and 5 with 1 very inadequate and 5 very adequate. Could you explain your answer?

Additional questions only for fertilizer company

9. Does fertilizer subsidy influence a company's decision regarding energy efficiency? (yes/no)
    a. *[if yes]* How does it influence the company's decisions?
    b. *[if no]* Why does it not influence the company's decisions?

Appendix B: Checklist for stakeholder identification

The table below shows the checklist for stakeholder identification from Chevalier (2008). This table was used as the base to create table 3 in the stakeholder analysis process.

No.	Type of stakeholder
1	Individuals
2	Families and households
3	Traditional groups
4	Community-based groups
5	Local traditional authorities
6	Political authorities recognized by national laws
7	Non-governmental bodies that link different communities
8	Local governance structures
9	Agencies with legal jurisdiction over natural resources
10	Local governmental services in the area of education, health, forestry, and agriculture, etc
11	Relevant non-governmental organizations at the local, national, or international levels
12	Political party structures
13	Religious bodies
14	National interest organizations
15	National service organization
16	Cultural and voluntary associations
17	Businesses and commercial enterprises
18	Universities and research organizations
19	Local banks and credit institutions
20	Government authorities at the district and regional levels
21	National governments
22	Foreign aid agencies
23	Staff and consultants of relevant projects and programs
24	International government bodies
25	International unions