Analysis of water and electricity consumption of urea fertilizer industry: case study PT. X

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Abstract. Urea fertilizer industry is one of the many industry sectors that require water and electrical energy. The use of water in the fertilizer industry increases with the increasing demand for fertilizers. Therefore, to meet the needs of water and electricity, fertilizer industry builds river water treatment plants into clean water by using coagulation, flocculation and filtration. Unit power plant using gas turbines with natural gas fuel with a total design capacity of 67 MW. The purpose of this study was to estimate the consumption of water and electricity in urea fertilizer industry. The method used in this research is quantitative descriptive. This study showed total urea production in 2018 amounted to 2,170,100 tons with total water consumption by 27,742,225.4 m³ (equivalent 12.8 m³/ton of urea) and electricity consumption amounted to 376,979,956 kWh (equivalent to 173 kWh/ton urea). The result of highest percentage of water allocation is 45% for the process unit and electricity allocation is 36% for the utility unit.

1. Introduction
Indonesia is among countries with a high population growth (1.49% or about 4 million people per year). The increasing number of population will result in an increase in the need for food. To meet these needs, various attempts were made to increase agricultural output, one of which was carried out by fertilizing [4]. Based on data from Asosiasi Produsen Pupuk Indonesia (APPI), urea is the highest inorganic fertilizer production than any other inorganic fertilizer. The need of urea fertilizer increased along with the increase in food consumption [1].

Urea is a chemical fertilizer containing nitrogen (N) high levels. Nitrogen is the nutrient element indispensable plants. Urea-shaped grains of white crystals. Urea fertilizer chemical formula NH₂CONH₂ is soluble in water and is very easy to suck water (hygroscopic), and should be stored in a dry and tightly closed. Urea fertilizer contains 46% N nutrient with the understanding that every 100 kg contains 46 kg of nitrogen, 0.5% moisture, 1% biuret content, and 1-3.35 mm minimum size of 90% as well as the form of prills [5].

Urea fertilizer industry is one of the many industry sectors that require water and electrical energy. Using water in the fertilizer industry is relatively large and increases with the number of needs. In the urea fertilizer industry, water is a primary need in various purposes such as cooling water, demineralized
water, water for steam, washing tools, etc. For this purpose water management needed to produce water with quality and quantity to meet the needs of these industries [6]. In addition, the use of electricity for the operation of the entire plant facilities require large electrical energy so that the urea fertilizer plant has its own power plant units [2]. Power plant units are generated using a gas turbine generator (GTG) with natural gas fuel.

Water treatment plants and power plants are part of the utility plant in the fertilizer industry. Utility plant is a provider unit of raw materials and auxiliary materials in ammonia plant and urea plant. The purpose of this study is to estimate water and electricity consumption and their allocation for various purposes in the urea fertilizer industry.

2. Methodology
This research was conducted in September 2019 by using the database in 2018. Data collection was conducted in PT. X. The type of data collected in the form of primary data and secondary data. The primary data of urea production data, water treatment plants, water consumption, water allocation and power plant units, electricity consumption, electricity allocation. Secondary data such as journals, papers, articles, and so on. Data collected in the form of quantitative and qualitative data by means of direct observation.

Water and electricity consumption data were analyzed descriptively and presented graphically for easy interpretation. Besides presented in units monthly water and electricity consumption, water consumption and electricity are also presented specific, namely in units of m$^3$ per ton of fertilizer and kWh per ton of urea. The results of the analysis of water demand and the demand for electricity compared with literature data in order to determine the level of water use and energy efficiency.

3. Results and discussion

3.1 Production of urea
Urea fertilizer industry is divided into three parts factories, namely ammonia plant, urea plant and utility plant. Raw material for urea fertilizer is liquid CO$_2$ and NH$_3$ gas supplied from the ammonia plant. Utility plant producing electrical energy, water, instrument air/plant air, steam and water for urea and ammonia plant. Urea-making schemes in general can be seen in Figure 1.

![Figure 1. Schematic of urea fertilizer production process.](image-url)
Figure 2 shows the production of urea factual and CBP (Company’s Budget Plan) per month in 2018. PT. X delivers total urea production amounted to 2,170,100 tons/year, with a target CBP of 2,027,500 tons/year. The results showed that the yield exceeded the target CBP with a difference of 142,600 tons (surplus).

![Figure 2. Production of urea factual and CBP in 2018 at PT. X.](image)

### 3.2 Water treatment plants

Water treatment plant is part of a utility plant that serves cultivate supporter river water into clean water (filtered water) continuously. The processing of river water into clean water is done by means of clean water with impurities consisting of total suspended solid (TSS) with physics using chemicals. The raw materials used are derived from treated river water by using coagulation, flocculation and filtration. Water treatment plant was tasked meet clean water for the needs of the plant such as demineralized water, cooling water, boiler feed water, as well as domestic demand. There are four water treatment plants to meet any operational requirements of each mill and integrated with each other. The design capacity of the water treatment plants per plant is 1000 m$^3$/hour with the normal operation of 660-720 m$^3$/hour. River water is pumped by two river pumps with a capacity of 1000 m$^3$/hour (design) which runs alternately. At the suction pump is equipped with a strainer which functions to enter the entry of garbage and large suspended solids into the river pump flow only need colloidal suspension only that is involved in the air flow (turbidity). To treat river water into clean water, the chemicals needed in the process. The chemicals used in water treatment plants, namely aluminum sulphate, caustic soda (NaOH), coagulant aid, and chlorine (Cl$_2$).

### 3.3 Water consumption and allocation

Industrial water consumption of urea can be obtained based on the production of water treatment plants and their allocation to each section as well as domestic operations. Based on the calculation shows the results of the highest water consumption amounted to 2,672,386.3 m$^3$ namely in May, while the smallest net water consumption in February amounting to 1,964,101.9 m$^3$, and total water consumption in 2018 amounted to 27,742,225.4 m$^3$ (Figure 3). Specific water requirements ranged from 10.8 to 15.0 m$^3$/ton urea, with an average of 12.8 m$^3$/ton urea. Figure 4 shows the specific water consumption per month for one year.

Debit high in May due to the steam generated from the steam turbine generator (STG) and the heat that has been absorbed by the condenser to produce water that is pumped into a filter water tank.
Figure 3. Consumption of clean water per month fertilizer industry in 2018.

Figure 4. The specific water consumption per month for one year.

Water has a different function in accordance with their needs in an industry. There are three types of water in an industry based on the function that the process water, utility water, and domestic water [3]. Process water is water used in the processing of raw materials to produce a product, so that more and more products are produced as a result of process water required will be more and more. Water used for raw materials as well as washers and other raw materials. Water utilities are water required to support the implementation of a production process, water is used as cooling water and boiler water. Domestic water is water that is used by the employee for the daily needs in the industry include the need for drinking water, housing, and other necessities. Industry needs water as a raw material for the production process. Water used for the production of ammonia and urea process is called process water. This is caused by the greater the amount of production, the greater the need for process water used. Figure 5 shows the water need for urea fertilizer industrial process about 45% or 1,034,048 m³ per month or equivalent to 12,408,580 m³ per year.

The greater the amount of production, the greater the need for process water used. Figure 5 shows the water needs of the urea fertilizer industry process around 45% or equivalent to 1,034,048 m³ per month or equivalent to 12,408,580 m³ per year.

Figure 5. Percentage of water use in the fertilizer industry PT. X.

The utility water is water used as a support for other units within an industry to produce the final product. The size of this water needs depend on the amount of product produced. The more the number...
of products, the greater the need for process water used. This is because the water utility is supporting production activities. Utility water needs are around 34% or 797,826.5 m$^3$ per month or equivalent to 9,573,918 m$^3$ per year. The remaining 21% is allocated for domestic use, etc.

3.4 Power plant units
Urea fertilizer industry in order to support the operational needs of the plant continuously has a generator that is managed and consumed by itself. The main generator used in the form of Gas Turbine Generator (GTG) that is powered by natural gas. This unit meets the operational needs of factories, workshops, offices, housing, etc., amounting to 4 plants with total capacity of 67 MW design. To get maximum flexibility and maximum flexibility, all four GTGs are operated by an interconnection (parallelized) system whose load settings are adjusted to the needs.

The urea fertilizer industry electric power system is equipped with a load shedding system that aims to avoid the occurrence of a total power failure (black out) if one of the generators is paralleled trip. In these conditions, the load shedding system will cut off electricity to the loads that are not too important, such as housing, offices, etc.

In addition, the urea fertilizer industry has emergency generators which are used when the main power plant is interrupted. The tools that are used as plant emergency is an emergency diesel generator that automatically works to divert the power source from the normal source to source emergency for the loads that are very critical and uninterruptible power supply which serves for electrical loads that should not be interrupted supply of electricity as power supply to the control panel.

3.5 Electricity consumption and allocation
Gas Turbine Generator major generator used to produce electrical energy to support plant operations continuous and stable. Gas Turbine Generator (GTG) whose function is to serve the needs of electric power to factories, workshops, offices, housing and other needs. Figure 6 shows that the highest electricity consumption of 34,556,428 kWh in May, while the lowest electricity consumption data in February amounted to 27,768,368 kWh, and total electricity consumption in 2018 amounted to 376,979,956 kWh.

Specific electricity consumption needs ranged from 145.9 to 200.3 kWh per ton urea, with an average of 173.7 kWh per ton urea and the amount of specific electricity consumption in 2018 is 2113.8 kWh per ton urea or equivalent 76.09 GJ/ton of urea. Based on working paper “Global Industrial Energy Efficiency Benchmarking” made by United Nations Industrial Development Organization in 2010, specific energy consumption (SEC) of chemical and petrochemical sector is 31.5 GJ/ton of urea [7]. In this condition PT. X consumes 76.09 GJ/ton urea and can be said to be wasteful because it still does not meet the specified SEC standards. Figure 7 shows the specific electricity consumption per month for one year.

![Figure 6. Consumption of electricity per month fertilizer industry in 2018.](image-url)
Figure 7. The specific electricity consumption per month for 2018.

Figure 8 shows that the highest percentage of allocation of electric energy in 2018 amounted to 36% on utility plant or at 133,979,182 kWh. The percentage allocation of electric energy for the process plant by 8% ammonia and urea by 26% with a total of 34% or 126,090,244 kWh. The remaining 30% of 110,610,532 kWh allocated for domestic needs etc.

Figure 8. Percentage of electricity use in the fertilizer industry PT. X.

4. Conclusions
Industrial urea plant PT. X is divided into three parts, namely the installation of urea plants, ammonia plants and utility plants. Raw material for urea fertilizer is liquid CO\(_2\) and NH\(_3\) were supplied from the ammonia plant. Utility plants producing electrical energy, clean water for as demineralized water, cooling water, boiler feed water and instrument air/plant air for the purposes of urea and ammonia plant. Water treatment plants to process river water into clean water continuously by using coagulation, flocculation and filtration. Power plant units using a gas turbine generator with a fuel gas with a total capacity of 67 MW design consists of four plants. The results showed that the total urea production in 2018 amounted to 2,170,100 tons and exceeded the target CBP with total water consumption amounted to 27,742,225 m\(^3\) and electricity consumption amounted to 376,979,956 kWh. Specific water consumption ranges from 10.8 to 15.0 m\(^3\) per ton urea, with an average of 12.8 m\(^3\) per ton urea, whereas the specific electrical consumption ranged from 145.9 to 200.3 kWh per ton of urea, with the mean average 173.7 kWh per ton urea. The highest percentage of water allocation is the process units by 45% and electricity consumption for the utility units by 36%.

The high consumption of water and electricity in the production of urea fertilizer has the potential impact on pollution to the environment, so it is advisable to carry out a life cycle assessment to identify potential points for improved efficiency in the use of water and electricity.

5. References
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