# Stochastic Optimization in The Power Management of Bottled Water Production Planning

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**Abstract.** This paper review a model developed to minimize production costs on bottled water production planning through stochastic optimization. As we know, that planning a management means to achieve the goal that have been applied, since each management level in the organization need a planning activities. The built models is a two-stage stochastic models that aims to minimize the cost on production of bottled water by observing that during the production process, neither interfernce nor vice versa occurs. The models were develop to minimaze production cost, assuming the availability of packing raw materials used considered to meet for each kind of bottles. The minimum cost for each kind production of bottled water are expressed in the expectation of each production with a scenario probability. The probability of uncertainly is a representation of the number of productions and the timing of power supply interruption. This is to ensure that the number of interruption that occur does not exceed the limit of the contract agreement that has been made by the company with power suppliers.

*Keyword*: Optimization, Stochastic, Production Planning, Power Supply, Water Supply

## 1. Introduction

Population growth is rapidly increasing life these days that led to once of dependence on the higher basic needs. Humans who are part of the high growth of popolasi on earth to provide many impacts for the existing ecosystem sustainability. Its need for basic needs such as water encourage its procurement for the fulfillment of daily consumption (Strang, 2004). The high level of human activity makes the need for water both as drinking water and the fulfillment of other need is higher. Drinking water is the main need among the various needs that must always be sought to support the existence of existing existence. Various efforts were developed by humans to be able continue to meet the need of drinking water, such as water management through the bottled water industry (Ahmad and Bajahlan, 2009).

The rapid development of the drinking water industry lately, encouraging each company to develop its competitive ability. This is because the high level of demand by consumers of different types of bottled drinking water. Based on that, it is necessary to have a separate planning system of production. Planning is a very important activity in the production process. Meanwhile, production planning can be defined as a planning of what products and how many products will be produced within a certain period that will be related to the availability of raw materials, labor, machinery and other equipment. Planning is also the main managerial function for a company, which is the direction or direction to coordinate and cooperate in the company's overall operation. Various things can happen in a productivity. Certainty in production planning is defined as a deterministic, meaning that production planning of a goods is a thing that is certain and inevitable. Community needs of certain goods become the basis of a company to produce the goods. A high level of demand is a benchmark for companies to be confident that the provision of such goods will provide substantial benefit. This is what is mean by the provider of the goods.

Risk and uncertainty are factors that arise from situations that need to be considered and foreseen to overcome the unexpected later. Uncertainty defined by Galbraith (2005) as the difference between the amount of information needed to perform a particular task in production with the amount of information that has been previously owned. Realy, there are many forms of uncertainty affecting the production process: environmental uncertainty in the form of demand uncertainty and supply uncertainty, and system uncertainties such as uncertain operational results, production system failures, product quality uncertainty and product structure changes (Ho, C, 1989 ). While the risk is one of the impact of uncertainty that will affect the demand for production planning for the next period. Disruption (*interruption*) in the production process is often a constraint of a company in the production process. Many factors blamed as a disruption in the production process can be discussed in production planning such as natural conditions that allow disasters to occur during disasters (earthquakes, hurricanes and storms), unforeseen possibilities in operation (accidents in logistics and human error), instability political, security and public health (Yang, et al, 2005), even the most common is a power outage.

## 2. Literature Review

### *2.1. Prodction planning*

Planning is the most basic and very extensive management functions including estimates and calculations of the activities to be carrie out in the future following a certain rule. Planning is a means of management to achieve the goals that have been applied therefore every level of management in the organization is in dire need of planning activities (Ivancevich and Thomas, 2007). In many organizations, production planning is part of hierarchical planning, capacity / having allocation, scheduled and controlled resources that take into account the value of capacity, time period, supply and demand and so on. Production planning also talks about the product and the amount of production that the company will produce. Therefore, the interaction between production planning and scheduling is inevitable, not only scheduling / controlling of decisions that constitute a separate constraint in production decisions, but also because a disruption or constraint its implementation which may result in the optimization and / or likely of both plan and scheduling (Cai, Yiwei, et, al, 2011). In production planning, inventory of goods and raw materials into part that are not separated in attention. In conducting inventory management, the type of goods or products must also be a concern in determining the optimal policy. This is because not all types of raw materials or products can be last a long or have expiration limi that can cause harm to the company or buyer later. It is called deterioration. Forms of deterioration can be various kinds, such as the loss (damage), product failure / defect (spoilage) or drynase. Inventory control is the activities and techniques of stockpiling goods at a certain level, both in the form of raw materials and materials in the process and finished products.

### *2.2. Bottled Water*

Water is the most important substance in life after air. Three-quarters of the human body consists of water. Water is also the most severe substance due to contamination. Diseases that attack humans can be transmitted and distributed through water. Water has been regarded as one of the most important natural resources in the life on earth and its availability has been condition for everything first in economic activity (Gibbons, 1986). At the same time, it should be remember that water is a limited resource that has generated many conflicts over the allocation of its use and its hygienic water availability (Lee, 1999). Judging from this complex role, the availability of water as the main consumption of production factors in the industrial or economic field then obliges the government to invest in infrastructure that ensures its availability which is often risky to the many disruption of water supply. Drinking water is water used for human consumption. The provision of clean water for drinking water needs to meet the requirements set by the government. Drinking water is safe for health when it meets the requirements Physics, microbiology, chemistry, and radioactivity. The mandatory parameter determining the microbiological quality of drinking water is total coliform bacteria and Escherichia coli. According to the health department, the terms of drinking water is a tasteless, odorless, colorless, does not contain microorganisms that are harmful, and do not contain heavy metals. Drinking water is water that through the process of processing or without processing that meet health requirements and can be directly in drinking. Currently there are the drinking water crisis in many developing countries in the world due to the number of people who are too many and water pollution. Demographic pressures and economic development led to a continued increase in demand for water consumption, while at the same time climatic conditions are also factors that limit water availability in many geographic zones that are increasingly seen worsening as a result of the drastic climate change process lately (Doria, 2010). Many factors that cause water supply disruption include the lack of care of the community to protect the environment so as to pollute the ecosystem that preserves the cleanliness suppy, natural conditions dipasing-masig areas tend to be different, the use of uncontrolled water and so forth. It will unwittingly trigger the emergence of policies governing the use of which limits water consumption. As it is said that water is important in human life, its disruption will also have an impact on human activities. In this case will be examined further impact on the industrial field. It is well known that the quality of clean water supply is important to maintain the stability of the production system in the field of economy and industry. Due to the high disruption of water supply in the industrial field, forcing the company to make the best decision in looking at and solve the problem. It is intended to suppress the monopoly in industrial competition (Tschirhart and Jen, 2006). In the meantime, the disruption of water supply that occurs resulting in a decrease in the production power of each company that impacts on the unfulfilled number of requests. Another case with the damage that may occur due to power failure with a sudden disconnection.

### *2.3. Power Supply*
Electricity is a part that can not be separated from human life especially in the globalization and the rapid development of the curren. According to Culter-Hemmer (1999) electricity is a charge consisting of positive charge and negative charge by jumping or moving electrons from its orbit to produce electron flow. The development of science requires the fulfillment of electricity consumption in every joint of life, whether on a small scale such as households as well as a wider scope such as factories and other industries. Therefore, the empowerment of natural resources continue to be improved along with the increasing power consumption. Starting from the development power of solar energy, power of air and water energy, power of diesel energy, to the most recent is the use of nuclear. As it is said that electricity is an important thing in the joints of human life, its interference will also have an impact on human activities. In this case will be examined further impact on the industrial field. It is well known that the quality of electric power is essential for maintaining the stability of the power system. A production process in the industry rely heavily on electrical equipment to maintain the continuity of the production process (Borgeson et al, 2015). The problem of power failure is a very complicated problem because it involves several factors, such as the lack of experts in handling the disrupton, the maintenance of the generator machine, the poor quality of equipment, the theft of electric power and so forth. Efforts to overcome these disorders continue to be pursued. This is according to Borgeston (2015) due to the magnitude of the role of electricity in human life which is also the

most important contributor in the field of industry for the economic progress of a region and the state demanded fulfillment maximally.

### *2.4. Production Planning Model With Stochastic Two Stage*

According Barik (et al 2013), the problem of stochastic two-stage program was formulated to several optimization decisions which obtained in the two stages are not the same. First-stage decisions are obtained before the realization of random events and second-stage decisions are obtained after realization. "The two-stage stochastic program model is the conversion of stochastic problems into an equivalent deterministic problem. In the two-stage stochastic program model, the decision variable is divided into two parts. The first stage is to determine the decision variable of the uncertainty parameter. Next make an objective function to minimize cost and expectation value in the first stage. The market situation is relatively volatile followed by the economic development of each different country is very influential on the demand for certain goods products. Uncertainty is what makes a service provider company should see all possible risks that must be faced. The production planning model with stochastic optimization is designed to contribute to the uncertainty. The two-stage stochastic model can be written as follows.

**Set**:

$C$ : Set of Contract Type
$T$ : Set of Time
$M$ : Set of Many Production Machines
$L$ : The Hour of May Workers
$U$ : Set of Uncertainly
$I$ : Set of Power Supply Disruption

**Index**:

$c$ : Contracts Type
$t$ : Time
$l$ : Workers
$i$ : Power Supply Disruption
$Pro$ : Production

**Deterministic Parameter**:

$\prod^s$ : Function Opportunities of Scenario is $s$
$A_t^{pro}$ : Total Production time $t$ (unit)
$C_t^{pro}$ : Production Cost while $t$ (Rp)
$t$ : Time to Producing per Unit (Hour/Unit)
$A_{m,t}^{pro}$ : Number of Machines at $t$ (Unit)
$C_l$ : Worker's Salary without overtime (Rp)
$A_{l,t}^{pro}$ : Number of Employed for Producing the Time $t$ (People)
$C_{c1}$ : Cost of Power Contract (Rp/KWh)
$K_{m,t}^{pro}$ : Machine Capacity to Producing Per Production Time (Unit/Hour)
$C_m^{rev}$ : Machine Maintenance Cost (Rp)
$d_{Pro}$ : Demand of the Product at $t$ (Unit)
$C_{Gen,i}$ : Operational Cost of Generator when Power Supply Disruption (Rp/Hour)
$C_{l,c2,i}$ : Overtime Worker's Salary when Power Supply Disruption (Rp/Hour)
$inv_0^{Pro}$ : Early Production Inventory
$K_{Inv,t}^{Pro}$ : Inventory Production Capacity at $t$
$K_i$ : Maximum Power Supply Disruption Happens

**Variable**:

$Z(\cdot)$ : Objective Function
$X_t^{Pro}$ : Total Production at $t$
$inv_{pro,t}$ : Inventory of Currennt Production $t$

Production planning models with Two Stage Stochastic

**Minimize** :

$$\begin{aligned} Z(.) = \sum_{s=1}^{s} \pi^s \left[ A_t^{pro}.t. \sum_{m\in M, l\in L, t\in T} A_{l,t}^{pro} \cdot A_{m,t}^{pro} \cdot K_{m,t}^{pro} + \sum_{l\in L, m\in M, t\in T} C_t^{pro} \cdot C_{l,t} \cdot C_m^{rev}.C_{c1} \right] \\ + \left[ A_{t(i)}^{pro} \cdot t_i. \sum_{m\in M, l\in L, t\in T} A_{l,t(i)}^{pro} \cdot A_{m,t(i)}^{pro} \cdot K_{m,t(i)}^{pro} + \sum_{l\in L, t\in T} C_{Gen,(i)} \cdot C_{l,c2,(i)} \cdot K_{(i)} \right] \end{aligned} \tag{1}$$

subject to:

$$\begin{aligned} &\sum_{t=1}^{T} (c_{t,(i)}^{Pro} \cdot A_{m,t,(i)}^{Pro}) \cdot A_{l,t,(i)}^{Pro} \cdot C_{l,c2,(i)} + \sum_{m=1}^{M} (A_{m,t,(i)}^{Pro} \cdot K_{m,(i)}^{Pro}) \cdot C_{gen,(i)} \cdot K_{(i)} \\ &\leq \sum_{t=1}^{T} (c_{t,}^{Pro} \cdot A_{m,t,}^{Pro}) \cdot A_{l,t}^{Pro}) \cdot C_l + \sum_{m=1}^{M} (C_m^{rev} \cdot K_m^{Pro}) \cdot C_{c1} \end{aligned} \tag{2}$$

$$A_{l,t}^{Pro} A_{m,t}^{Pro} > 0 \ \ \forall l \in L, m \in M$$

$$C_t^{Pro} C_l C_{c1} C_{gen} > \ \ \forall l \in L, t \in T$$

$$X_{t(i)}^{Pro} \geq \sum_{l\in L, t\in T} C_t^{Pro} \cdot C_l \cdot A_l^{Pro} \cdot C_{c1} + \sum_{m\in M} A_m^{Pro} \cdot K_{m,t}^{Pro} \tag{3}$$

$$X_{t(i)}^{Pro} \geq \sum_{l\in L, t\in T} C_t^{Pro} \cdot C_{lc2(i)} \cdot A_l^{Pro} \cdot C_{Gen(i)} + \sum_{m\in M} A_m^{Pro} \cdot K_{m,t}^{Pro} \tag{4}$$

$$A_l^{Pro}, X_0^{Pro}, A_m^{Pro} > 0 \ \ \forall l \in L, t \in T, m \in M$$

$$inv_{pro,t} = inv_0^{Pro} + \sum_{t\in T} X_t^{Pro} - \sum d_{Pro} \tag{5}$$

$$X_t^{Pro}, d_{Pro} > 0 \ \ \forall t \in T, Pro$$

Equation (4.1) is a two-stage stochastic model for the bottled water production planning by looking at the lowest cost of the two production planning processes ie production planning normally or without any disruption of power supply (term 1) and production planning in the event of power supply disruption during processing Production (term 2). The above built model is intended to minimize the cost of production when there is a power supply disruption occurring at any time through a power supply termination scenario. This variable is assumed by the availability of packing raw materials that are considered to meet to produce each type of beverage packaging. While Equations (4.2) to (4.4) are constraints for the equation model (4.1). Where equation (4.2) shows the financing for production planning in the presence of power supply disruptions must be smaller / lower than the financing of production planning without any disruption of the power supply that occurs. This is based on a contract made by a bottled water company with a power supply company with the initial assumption of no interruption of power supply occurring during the agreed time. This is in contrast to the uncertainty that occurs with the disruption of power supplies that can occur at any time due to certain factors. Equations (4.3) to (4.4) indicate the large amount of bottled water production during uninterrupted power supply and with the disruption of power supply must be greater than the amount of financing and machinery. Equation (4.5) is an equation that shows the current production inventory $t$ with the sum of the initial inventory of production and amount of production time $t$ minus the number of market demand for products.

## 3. Conclusion

The built model is a two-stage stochastic model for the bottled water production planning by looking at the lowest cost of two production planning processes ie normal production planning or without any disruption of power supply and production planning in the event of power supply disruption during production process to minimize production cost. When there is a power supply interruption that occurs at any time through a power supply termination scenario. Expectations of each type of production that is expressed through the scenario $\pi^s$ opportunities to contribute financing minimum values for each respective type of bottled water production. The difficulties encountered in this calculation are related to the unnecessary demand that is necessary to be estimated.

The probability $\xi \in U$ represents the amount of production and the timing of a power supply disruption. The set of uncertainties to ensure that the amount of disruption that occurs does not exceed the limit of the contract agreement that has been made by the company with the power supply supplier. Other variables that may be added may be concerning the financing of the electrical contracts that have been made in advance in order to reduce the risk of large losses for the bottled water company.

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