The Role of Energy in Waste Management Process

Aarti Singh*, Sushil**

*Doctoral Scholar, Department of Management Studies, Indian Institute of Technology, Delhi,

**Professor, Department of Management Studies, Indian Institute of Technology, Delhi

Abstract

This paper is focused on the waste management scenario in Indian organization through system dynamic modeling technique. Waste management is not a new term for Indian organization, it is propagated term which has become an integral part of organizations. Various waste management models have been studied which focus on waste management process in a particular organization. This study represents the role of energy in waste management process through system dynamics modeling technique. In this research, a system dynamic model has been developed by adopting the verified waste management factors which are identified from the literature. System dynamic methodology is used in this research for simulating the effect of energy on waste management process. National Thermal Power Corporation Limited (NTPC), an Indian governmental organization has been chosen for conducting the study. Fly ash has been taken for representing the waste. The causal loop diagram has been used for developing the concept, which has been simulated through system dynamics model.

Keywords: Energy, Fly ash, System Dynamics, Waste Management

Introduction

Organizations develop themselves by increasing their production capacity which results in increased waste production. This increased waste generation leads to waste management. (Wilson *et al.*, 2006). Waste can be managed by using different technologies which require energy for their performance. It indicates that energy plays a vital role in managing waste. (Hofferet *et al.*, 2002). This paper focuses on the role of energy in waste management, specifically in thermal power plant. Thermal power plants utilize coal to provide energy. (Mishra, 2004). In India, NTPC has widely spread thermal power plants in different states and generate energy by utilizing tonnes of coal. The coal consumption results into a huge amount of waste generation. In thermal power plants, fly ash is considered as the major waste generated during energy production. Earlier, this waste was not well regulated thus, causing major pollution hazards in the surrounding environment (Pandey *et al.*, 2009). To regulate pollution, government applied strict rules in all the thermal power plants through notice. According to this notice, "All thermal power plants which are operating on the date of notification should have achieved the target of 50% fly ash utilization within one year, from the date of notification and all new plants whose operation starts after the date of notification should have achieved the target of 50% of fly ash utilization within one year of notification". This shows that controlling waste is a must in all thermal power plants (MOEF, 2007).

This paper focuses on the role of energy in waste management specifically in thermal power plants which are the main waste generators in Indian power sector. Thus, NTPC is chosen for system dynamic model of waste management in Indian power plants.

Literature review

India is the third coal producing country, after china and USA. In India coal is mainly used as a fuel in power plants for generation of energy (EIA, 2013). Coal is known for some of its specific characteristics like low calorific value and high ash content. Due to high ash content, the waste generated during combustion of coal is also large in terms of volume. (MOS,2008) During the combustion of coal, unburnt glassy particles are produced which get stuck on the lower walls of the furnace and as the process continues, the layer becomes thicker with time. It has to be removed periodically by using offshoot blowers. During the removal process lump of ash falls down in the hoppers, which is also known as 'bottom ash'. Apart from bottom ash, some unburnt fine coarse particles are carried by the flue gas, which get deposited at different locations along the path of flue gas. These coarse particles keep on getting deposited up to electrostatic precipitator, also called as fly ash or pulverized fuel ash. These coarse ash particles are then collected from the economizer, air preheater, and duct hopper. The highest amount of particles is collected from Electrostatic Precipitator Hopper. (Yager *et al.,* 1997). The bottom ash contributes 10-15% of the total amount of ash generated and rest is contributed by fly ash. (CEA, 2011). Every year, fly ash waste generation is increasing due to the increase in the usage of coal as fuel. Thus, for managing fly ash waste, different energy-driven equipments have been utilized by thermal power plants for managing waste (Huberman and Pearlmutter, 2008). NTPC is a government organization and one of energy producing sources in India. It utilizes coal thus, generating huge fly ash waste which has been controlled using energy-driven equipment (Shanthakumar, 2008). This indicates that energy plays a vital role in waste management. The role of energy has been shown by using system dynamic as a tool for this study.

Methodology

System dynamic has been chosen as the main methodology for conducting the study. System dynamic is a tool which combines mental model and scientific tools to solve the problem and thus, it is also known as a managerial problem-solving methodology. The managerial problems are complex in nature because it involves non-linearity, dynamic nature, and causality. These factors make them complex as compared to engineering and physical systems. Managerial systems are complex in nature and require a method which caters to all dynamic complexity (Coyle, 1996). System dynamics is the best solution to this problem as it can easily gratify all the complexities of managerial problems. It is defined as "a methodology that judiciously combines the traditional management with cybernetics and computer simulation so as to carry out analysis" (Sushil ,1993 and Chi,2009).

System Dynamics (SD) offers a framework which effectually subdues the mental model flaw. This methodology has also been widely used for controlling pollution and environmental problems in various sectors (Saysel et. al., 2002).

System Dynamic approach for the role of energy in waste management

System dynamics methodology has been widely used as a problem-solving technique for various environmental related problems. In this study, the role of energy in managing waste specifically in the thermal power plant has been visualized by using system dynamic technique. It is found from the literature that energy is one of the major requirements for managing waste. In case of NTPC, fly ash waste can be managed by using electrostatic precipitators and the entire fly ash collected is finally disposed or utilized by energy driven equipments (Singh *et al.*, 2010). It indicates the role of energy in fly-ash waste management cycle. This type of waste management delivers the utilization aspect of energy in waste management process. The utilization of green energy provides another aspect, where energy without producing waste can create a new paradigm for managing waste (Ahmaruzzaman, 2010). Renewable energy is considered as a green source of energy as it generates no waste during energy production process. Thus, it creates the reduction feature of waste management (Rosen *et al.*, 2008). The roles of energy in managing waste, including reduction, and reducing aspects have been shown in the causal loop diagram of waste management (Traber and Kemfert, 2011).

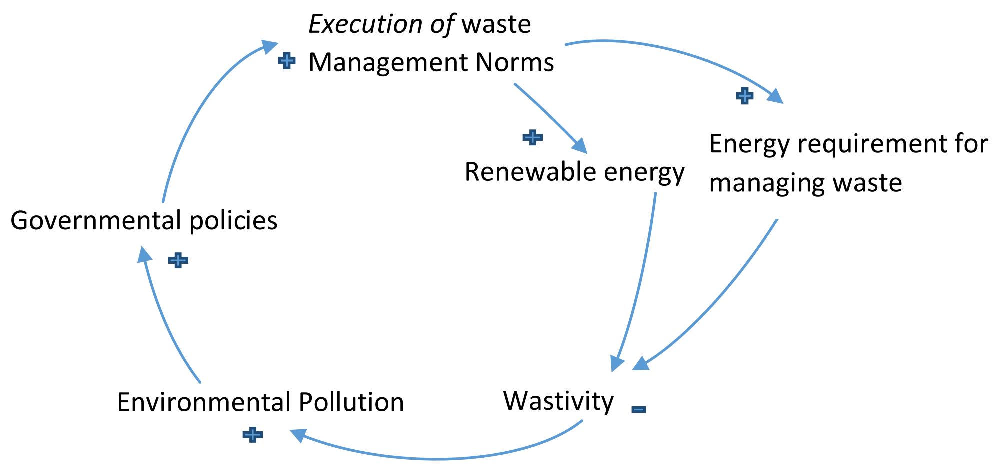

Figure 1: Causal Loop Diagram

The causal loop diagram shows the relationship between the factors of cause and effect. The energy aspect of waste management, represented by the above causal loop diagram is positive in nature and thus, it is a reinforcement loop. In system dynamics, the causal loop relationship is further going through stock and flow analysis, where the relationship between the factors have been represented by stock and flow. This represents the final system dynamics model. The system dynamics has been shown in Figure 2 below.

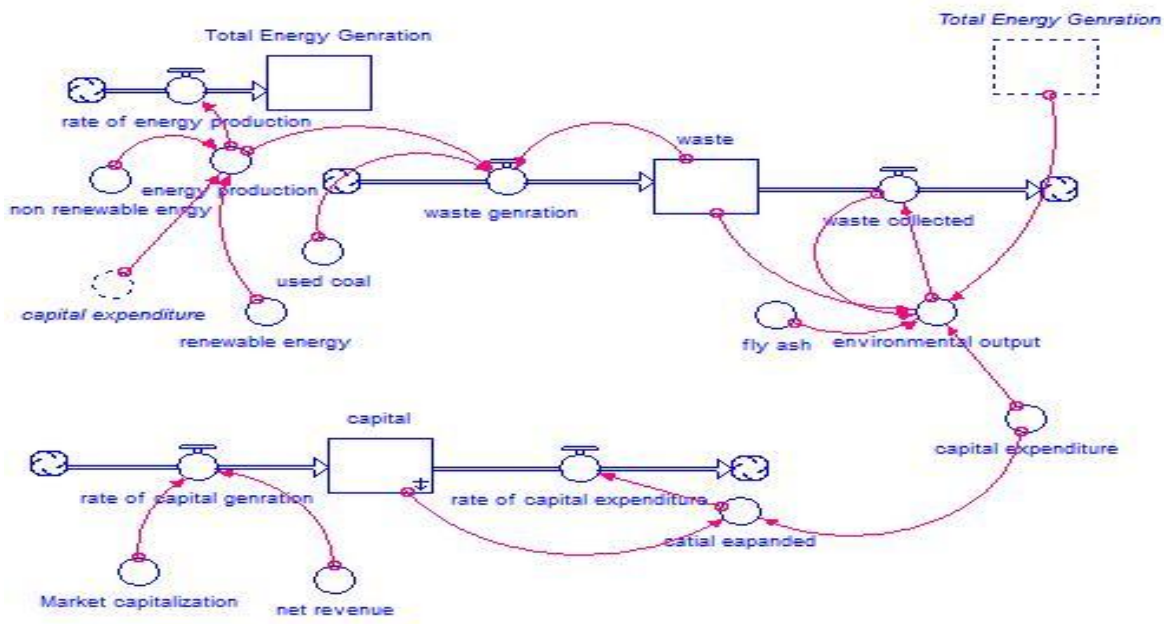

Figure 2 Stock and Flow Diagram

Result and Discussion

The final outcome of system dynamics model has been represented in Figure 3 and Figure 4. The outcome of the model indicates that energy is related to waste management and it becomes a part of the management process. Thus, we can say that the energy requirement for managing waste, itself serves as a medium for managing waste. It is also found from study that renewable energy also helps in waste management as it provides clean energy source. Thus, it reduces the requirement of non-renewable source of energy. Hence, the clean energy source reduces the load of energy generation which leads to indirect load reduction for waste management. Government as a stakeholder has been playing crucial role in this process. In this case, NTPC, a government organization also plays a leading role by providing funds for research and development, and waste management process.

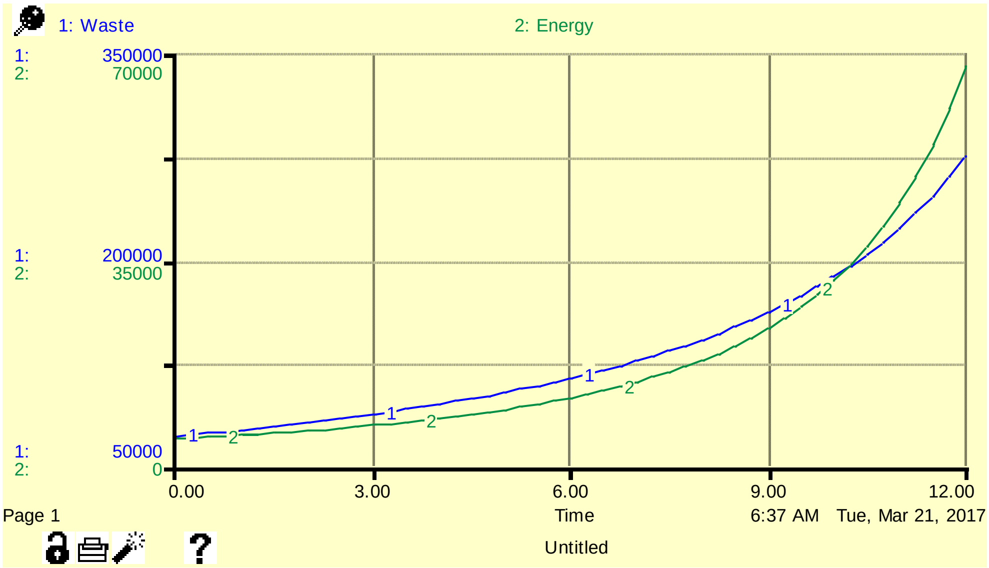

Figure 3 Comparison of Waste and Energy

The execution of waste management policies can be made by investing on the fly-ash waste management process. The role of energy in waste management process can be easily understood by integrating all the financial (representing stakeholder and execution indicator) and waste management aspects. The explanatory model defines the situation of energy in waste management which further creates sustainability in the organization. The current performance of waste management depends upon the energy requirement for managing it.

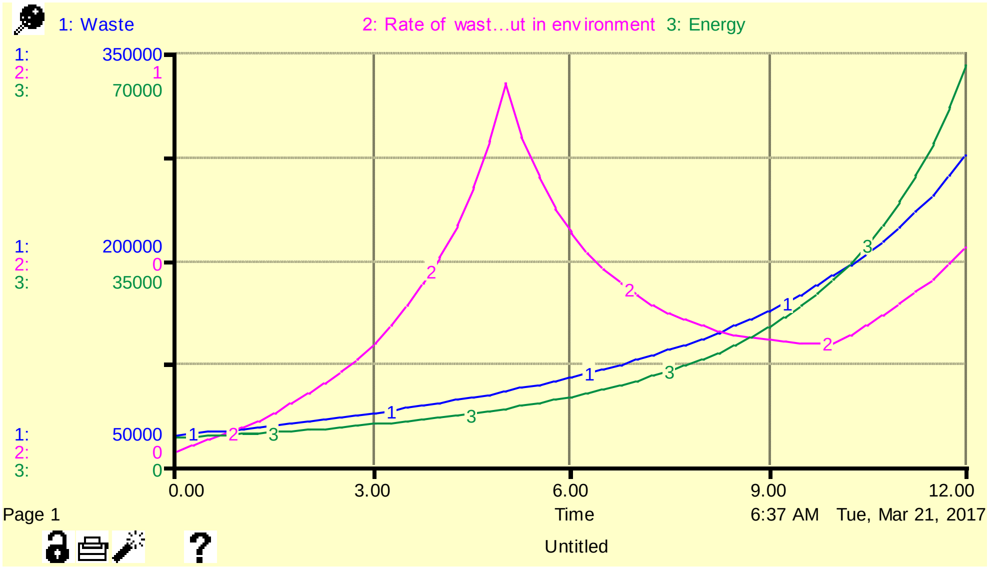

Figure 4 System Dynamics Graph for Energy and Waste Generation Relationship

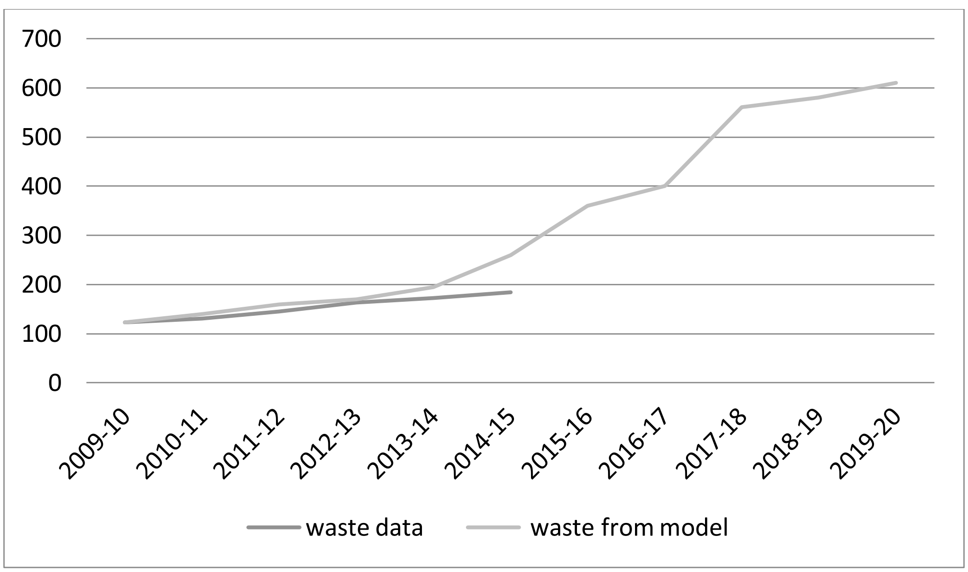

Figure 5: Model Comparison

The current scenario of fly-ash waste has been compared with simulated data, this comparison provides a validating aspect of the model. In system dynamics model, the fly-ash waste generation rate has been compared with the data available for NTPC fly-ash generation. The resulting variation lies between the range of five to ten percent as shown in Figure 5.

Conclusion

System dynamics model has been used for forecasting, in which the whole system represents the model. Instead of this, it can be used to slice the complex problem which further leads to policy intervention (Saeed, 1992). Hence, the problem produces the conceptual model and delivers a key issue to change the policies. These conceptual models were further simulated for presenting the results which helped to create new policies. This study represents the role of energy in waste management process considering coal-fired thermal power plant. NTPC is the main thermal power plant series in India, where fly-ash is the waste. In this study, the role of energy has been studied in terms of reducing waste burden and also providing a source for operating waste management technologies.

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