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Multidimensional Optimisation of a Water Distribution System and its Management

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Abstract:
A water supply system collects, treats, stores, and distributes water among water sources and consumers. Increasing population, diminishing supplies and variable climatic conditions can cause difficulties in meeting water demands; especially in arid and semiarid regions where water resources are limited. Given the system complexity and the interactions among users and supplies, a large-scale water supply management model can be useful for decision makers to plan water management strategies to cope with future water demand changes. When this long range water supply plan is developed, accuracy and reliability are the two most important factors. To develop an accurate model, as much information as possible on the system has to be considered. As a result, the water supply system has become more complicated and comprehensive structures. Stochastic search techniques thus have evolved to find the most accurate solution for the future water supply plan. Future uncertainty also has been considered to improve system reliability as well as economic feasibility. This suite of tools can be also useful in deriving consensus among compete water needs for proposed long-term water supply plans.

1. INTRODUCTION

1.1 Introduction of Project Work

A water supply system collects, treats, stores, and distributes water among water sources and consumers. Increasing population, diminishing supplies and variable climatic conditions can cause difficulties in meeting water demands; especially in arid and semiarid regions where water resources are limited. Given the system complexity and the interactions among users and supplies, a large-scale water supply management model can be useful for decision makers to plan water management strategies to cope with future water demand changes. When this long range water supply plan is developed, accuracy and reliability are the two most important factors. To develop an accurate model, as much information as possible on the system has to be considered. As a result, the water supply system has become more complicated and comprehensive structures. Stochastic search techniques thus have evolved to find the most accurate solution for the future water supply plan. Future uncertainty also has been considered to improve system reliability as well as economic feasibility. This suite of tools can be also useful in deriving consensus among competing water needs for proposed long-term water supply plans. In this study, a general large-scale water supply system that is comprised of modular components including water sources, users, recharge facilities, and water and wastewater treatment plants was developed in a dynamic simulation environment that helps users easily understand the model structure. The model was applied to a realistic hypothetical system and simulated several possible 20-year planning scenarios. In addition to water balances and water quality analyses, construction and operation and maintenance of system components costs were estimated for each scenario. One set of results 10 demonstrates that construction of small-cluster decentralized wastewater treatment systems could be more economical than a centralized plant when communities are spatially scattered or located in steep areas where pumping costs may be prohibitive. The Shuffled Frog Leaping Algorithm (SFLA), then, was used to minimize the total system cost of the general water supply system. Sizing decisions of system components' capacities – pipe diameter, pump design capacity and head, canal capacity, and water and wastewater treatment capabilities – are decision variables with flow allocations over the water supply network to meet water demands. An explicit representation of energy consumption cost for the operation of satellite wastewater treatment facilities was incorporated into the system in the optimization process of overall system cost. Although the study water supply systems included highly nonlinear terms in the objective function and constraints and several hundred decisions variables, a stochastic search algorithm was applied successfully to find optimal solutions that satisfied all the constraints for the study networks. An accurate water supply plan is achieved. However, the system reliability is not assured. A robust optimization approach, hence, was introduced into the design process of a water supply system as a framework to consider uncertainties of the correlated future data by applying a new robust optimization approach. The approach allows for the control of the degree of conservatism which is a crucial factor for the system reliabilities and economical feasibilities. The system stability is guaranteed under the most uncertain condition. It was found that the water supply system with uncertainty can be a useful tool to assist decision makers to develop future water supply schemes.

The main objectives of the project are:

- To ensure safe and equitable water supply to the entire population in Pune city for the next 30 years,
- To ensure the distribution of the water during the entire day {24x7 modality);
- To reduce the level of water losses and Non Revenue Water,
- To ensure the technical and economical sustainability of the water supply service.

2. MAIN ISSUES TO BE ADDRESSED IN PUNE WATERSUPPLY SYSTEM

The following table summarizes the existing deficiencies and problems of the existing Water Supply Facilities, the main principles adopted in this project and the corresponding infrastructures or actions that are proposed in this project

Table.1.Main Issues

Problems to be addressed	Concepts and Objectives of this project	Envisaged Actions &Facilities for achieving the objectives
Excessive amount of water supplied to the City	Rational and efficient utilization of the water resource	- Measurement of the water consumed by all users; - Adoption of adequate tariff based on telescopic water rates to promote rational and efficient use of water
High level of water losses due to leakages	Reduce the water losses in all water supply system components	- Assessment of the water losses in the system components. Establishment of a continuous leakage detection Programme. - Carry out the repair and replacements of leaking parts or structures; - Replacement of old pipes in Asbestos and Prestressed Concrete - SCADA installed to keep systematic water audit in all components through
Loss of water revenues to PMC related to the NRW	Introduce Water Charges related to the actual use of the water	- Installation of metering devices for all the connections. - Setting of efficient reading method for water consumption volumes. - Adopt adequate water tariff according to the ability to pay of various categories of users, - Regularization of illegal connections - Correct classification of commercial connections
Non Available updated and detailed information on the WS facilities	Updated and accurate knowledge of the facilities is key factor for efficient **O&M**	- Setting up digital layout of the updated network and system components on Web GIS application - On site verification and GIS digitalization of existing pipelines and other distribution works - Database of the connections location and related users data for each network pipeline
Impossibility to establish reliable water balance due to lack of bulk flow meters and consumer meters	Systematic water audit at all levels within the water supply system	- Setting up of District Metered Areas for continuous monitoring of inflow of water and consumed water - Measurement of inflow and out flow volumes in all trunks lines, reservoirs and WTPs - Setting up of SCADA and soft ware to keep systematic water audit
Inequality in the distribution of water in various parts of the City	The level of service and the amount of water supplied shall be almost uniform within the City service area	- Reduction of excessive water usage and of water losses will increase the water available for the city sectors now receiving less water; - Rationalized net work and construction of adequately located and sized service reservoirs; - Setting up of DMA sand adoption of pressure reducing valves for uniformity of the water supply conditions. - System aticinstallation offer rules device sat all connections adjusted according to local pressure levels
Some facilities are old, inefficient and leading to water losses or energy losses	Undertake the rehabilitation works to ensure efficient and safe operation up to the fixed project horizon (2031)	- Carry out the Identified rehabilitation works and replacement of inefficient equipment at WTP Sand pumping stations; - Execution of the recommended - rehabilitation works on old or leaking reservoirs

Possible contamination of the supplied water due to the Intermittent distribution of water supply combined with old and leaking pipes	Ensure continuous supply of water over 24 hours/day and 7days/week	- Rationalization of the transmission system - Adequate storage capacity in all supply zones of the town - Replacement of old pipes - Replacement of house connections - Continuous leakage detection program
Adequacy of the available human resources of the Water Supply Department of PMC	Pursue the efficient: - O&M of the system, - planning of WS upgrading, billing and collection of water charges. Improved relation with the consumers	- Re-organization and strengthening of the water Supply Department. - Hiring of new staff - Outsourcing of specialized activities

The implementation of the above project in full scale over the entire City is a very challenging task. Besides the magnitude of the project, it is also important that the population is well informed and accepts the shifting payment method from flat water fees, which are paid through a quota of the property tax, to a payment based on the actual water consumption. This change will have a significant impact on great part of the water users, which in many cases have little or no perception of the actual amount that they are paying for the water service nor of the amount of water that they presently consume. It is therefore important that the introduction of consumer meters, of the new consumption based water rates, the realization of the DMAs and of the related works for network improvement are tested over some pilot areas where it will be possible to conduct a consumer awareness campaign and to the monitoring of the consumers reactions and their perception of the benefit derived by the improved water delivery over the 24x7 distribution mode.

3.EXPERIMENTAL WORK

Figure.1. Tripper circuit

In many of industrial operations, the delivery of a variable and controlled amount of electrical power is necessary. The most common of these operations include electric lighting, electric motor speed control, electric welding, and electric heating. Although it is always possible to control the amount of electrical power delivered to a load by using a variable transformer to create a variable secondary output voltage, these transformers are physically large and expensive and need frequent maintenance (in high power ratings). There are other methods of controlling power to a load, but they are mostly not available for high power applications. We have installed this model at one of our group member's house. This circuit has a timer attached to it. We often find over flowing of overhead tanks due to excess water supplied by the motor to the tank. with the help of this arrangement we can save a lot of water and the motor as well.

Working-

1. Switch on the motor.
2. Set the time on the timer.eg-10 minutes.
3. After he time is over the timer sends a signal to the tripper ciruit and the tripper circuit restricts the further flow of current.
4. Thus the motor is switched off after the decided time has elapsed.

4.CONCLUSION AND FUTURE SCOPE

India is a country which is blessed with abundant natural resources. India has a huge network of rivers encompassing its entire territory. Yet we find parts of the country affected by draught and parts affected by floods. Striking a balance between these two extremes is very essential for the safety and welfare of our nation. Hence with the help of multidimensional optimisation techniques we can try to improve the present situation pertaining to water handling and management. if this system works out the way it is expected it can help the country massively, and make our country a better place to live in. The 24 hour water supply system that has been developed has a lot of advantages over the previous system because this system takes a lot of the unnecessary handling systems out of the chain. This system is very potent and has the ability of bringing down the losses considerably.

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