

# Knowledge Management in Civil Infrastructure Systems

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## INTRODUCTION

This article reviews current research and practice of knowledge management (KM) in the management of Civil infrastructure systems. Civil infrastructure systems, such as energy systems (electric power, oil, gas), telecommunications, and water supply, are critical to our modern society. The economic prosperity and social well being of a country is jeopardized when these systems are damaged, disrupted, or unable to function at adequate capacity. The management of these infrastructure systems has to take into account critical management issues such as (Lemer, Chong & Tumay, 1995):

- the need to deal with multiple, often conflicting objectives;
- the need to accommodate the interests of diverse stakeholders;
- the reliance of decision making on uncertain economic and social issues;
- the constraints in data availability; and
- the limitations posed by institutional structure.

## BACKGROUND

KM approaches can play a central role in facilitating the effective management of these infrastructures. While well-designed information systems can get the right information to the decision maker at the right time, the age of the components of the infrastructure and a lack of available and usable records leads to utility managers frequent inability to take

proactive measures to prevent system failures. Further, these infrastructures are interdependent, and managers at the various utilities and agencies need to work together to mitigate the risk of such threats and vulnerabilities. Analyzing each individual infrastructure system and the knowledge derived from managing each individual infrastructure becomes insufficient when managers have to make decisions at the intersection of multiple disciplines in a multihazard context. Sharing of information and ideas become critical to help detect and mitigate hazards and plan the recovery and response strategy.

Traditionally, utilities (especially the water utility) have been rich in “raw data but poor in the aggregated information derived from these data” (Rosen et al., 2003). Transforming the data into knowledge necessitates an understanding of the quality of the data and the aggregation measures used. KM approaches provide the basis for the development of relationships between different data structures and decision makers and by developing a higher level understanding of how information and process knowledge relate to one another.

Perez (2003) identified four common trends in the utility industry: the diminishing workforce, growing competition within the public sector, deterioration of employee loyalty, and increasing public involvement in government. Due to the concern about the potential negative impact of these trends on the ability to retain and share the institutional knowledge they currently possess, utilities have sought to find a method to efficiently maintain and improve the knowledge level of utility management.

Rosen et al. (2003) also point out that utilities lack a mechanism to aggregate, analyze, and restructure information in order to create knowledge. In general, many potential data users within a utility are not aware of a significant amount of the available data. Besides, in most cases, data are stored at multiple areas for the needs of the users. An organized directory of the entire data rarely exists. This creates redundancy of data and inefficiency of data retrieval.

Utilities have been recognizing the benefits of adopting KM strategies in their organizations. Foremost among these include the reduction in lost knowledge from downsizing and restructuring. Improving efficiencies of operations and workflow and improving customer satisfaction are also cited as reasons for moving toward a KM environment. Privatization of public and municipal utilities and increased regulation requires utilities to maintain a better handle of these physical and intellectual assets and liabilities.

However, there are several barriers impacting the access and use of information within a utility. These include a lack of awareness of what information (both internal and external) is available; difficulty in obtaining data access; lack of appropriate software for accessing, analyzing, and interpreting data; and the lack of complete historical data about the utility infrastructure and GIS base maps. In addition, the traditional “paper centric” nature of many utilities and lack of a central repository of information make it harder to access information that is available within a utility. Further, “a large array of critical information for the utility is maintained in the heads of a few critical people” (Rosen et al., 2003).

These problems may be compounded in the future with new security requirements that are likely to restrict the flow of information. While the absence of complete historical data is a problem that is not easily fixed, information stored on paper can have implications that are both positive and negative. It is likely to be more secure than data stored electronically while the cost of use and maintenance is likely to be higher. It is necessary to find a solution that makes information available to utility managers so that they can do their job more effectively while also controlling access to the information more effectively.

## **EXAMPLES OF KM APPLICATIONS IN UTILITIES**

The American Water Works Association (AWWA) Research Foundation completed a study in 2003 that investigated the feasibility of application of KM in the utility industry, specifically in drinking water utilities (Rosen et al., 2003). In this study, a review of 20 case studies related to utility management literature indicated that the primary areas of interest in upgrading information and knowledge management are:

- Supervisory Control and Data Acquisition (SCADA);
- Laboratory Information Management Systems;
- Geographic Information Systems (GIS);
- Maintenance Management Systems;
- Customer Relationship Management (CRM) and Tracking Systems; and
- Enterprise-wide Information Systems to tie other systems together.

The first five areas are operational systems focused on automation of specific department’s current workflow and needs. The last area emphasizes synergy in the use of data. Currently, applications of KM in utilities are very limited, but the following case studies briefly demonstrate how KM approaches can be successfully applied to utilities.

- Columbus Water Works serves drinking water and treats wastewater for almost 200,000 residents in the Columbus, Georgia region. A data warehouse was implemented to act as a central source of all information from all of their applications. The star schema database adopted in this case consists of six primary “stars”, including customers, employees, inventory, measurements, work orders, and accounting. A star schema allows for each sector data to be independent but also allows for integration of data through the central data warehouse. The utility reported that the main benefit is cost control, and it allows them to collect and distribute information between applications, better manage expenses, monitor data trends over time, and explore any unexpected variations.

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