Managing a Scarce Resource

DSM in Urban Water Governance

Managing a Scarce Resource: DSM in Urban Water Governance

Master of science thesis

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God bless Denmark with the knowledge of His kingdom
and the peace and prosperity that comes from above!

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Abstract

Meeting public water supply needs efficiently and sustainably in a rapidly urbanizing world is becoming an immense challenge to governments and utilities. Experience has shown that the supply side management approach to water governance has proven to be inadequate in meeting water demands of urban areas in a sustainable manner and protecting the environment. New water sources are not readily available as before for development. Moreover, environmental constraints, political as well as socio-economic realities have presented new planning scenarios. Water conservation is therefore becoming an imperative. When it comes to meeting urban water demand and ensuring efficient and sustainable use of resources, demand side management is appealing as a complimentary solution and is currently being promoted as an appropriate measure to ensure water use efficiency.

This study examines the role of demand side management strategies in achieving water conservation objectives in urban areas and explores how they can help water utilities achieve these objectives and ensure sustainable use of water resources. It explores the usefulness of conservation strategies by undertaking an assessment of an ongoing conservation program in Copenhagen. The empirical analysis aims at investigating primarily whether water conservation has occurred in Copenhagen as a result of demand side management strategies. It also tries to explore the extent to which these measures have been employed and the challenges and constraints faced in the process.

The study uses two assessment criteria: reduction in water use and net increase in social welfare; and based on the analysis asserts that DSM measures have been successful in Copenhagen in terms of reduction in water abstraction and consumption. It however argues that the price-measures have played the major role in achieving reduction in water consumption. The study concludes by stating that there is significant potential in the demand side management approach as a complimentary effort to the supply side management to ensure adequate supply of water to urban areas in a sustainable way.

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List of Acronyms

CW	Copenhagen Water
DASTI	Danish Agency for Science, Technology and Inovation
DHI	Danish Hydraulic Institute
DKK	Danish Kroner
DKK/m^3	Danish Kroner per cubic meter
DSM	Demand Side Management
DTU	Danish Technical University
DWWA	Danish water and WastWater Association
EE	Environmental Education
EEA	European Environmental Agency
EEB	European Environmental Bureau
EU	European Union
EC	European Communities
EPA	Environmental Protection Agency
FHWA	Federal High Way Administration
GWP	Global Water Partnership
GUES	Geological Survey of Denmark and Greenland
HMMPA	Hon Mun Marine Protected Area
IEA	International Energy Agency
IFAD	International Fund For Agricultural Development
IUCN	International Union for Conservation of Nature
KE	Copenhagen Energy
km	Kilo meter
km^2	Square Kilometer
mm/a	Milimeter per anum
m^3	Cubic meter
m^3 /y	Cubic meter per year

Mm^3	Million cubic meter
Mm^3/y	Million cubic meter per year
$m^3/c/y$	Cubic meter per capita per year
mg/lt	Miligram per liter
NERI	National Environmental Research Institute
OECD	Organization for Ecnomic Co-operation and Development
PRI	Policy Research Initiative
UFW	Unaccounted-For Water
TekSam	Institute of Environment, Technology and Social studies
UN	United Nations
UNDP	United Nations Development Program
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations International Children's Emergency Fund
US	United States
WDM	Water Demand Management
WFD	Water Framework Directive
WHO	World Health Organization
WWF	World Wide Fund for Nature

CHAPTER 1 - INTRODUCTION

1.1 Water scarcity - a pressing issue

Even though water is the most distributed and abundantly found on earth, fresh water is a scarce resource. Of all the water that is available on earth 97.3 % occurs as salt water in the oceans while about 2.7 % is fresh water the majority of which exists in the form of ice and permanent snow cover in the Polar Regions and high mountain tips. It is only less than 1 % of all the water, which is available in the form of ground water, surface water and in the atmosphere (Bauman and Boland, 1998). Moreover, not only its distribution is uneven but also its availability varies unreliably with time. This is because the main source of fresh water is precipitation, which is not uniform through out the world. For example hot deserts may receive less than 250 mm/a while equatorial regions may get about 2000 mm/a and in some instances certain areas may get as high as 11615 mm/a (Jones and Holier, 1997). As a result some parts of the world experience water shortages while other areas have excess.

Water, which plays a vital role in the physical, chemical and biological processes in the biosphere, is a fundamentally important commodity for human beings. It plays a decisive role in the enhancement of social and economic development of society and is needed in all aspects of life. With the continuous development of society water requirement in various sectors such as municipal services, food production and industry has been increasing from time to time. Globally, agriculture is responsible for the highest withdrawal so far. The water required for water supply and sanitation as well as industry is of less quantity but of high quality compared to agriculture. As world population continues to grow, water needed for domestic needs and food production will continue

to increase. More over, industrial demand has been growing due to industrial developments especially in the developing world.

Fresh water has become increasingly vulnerable to stress due to many reasons. Population growth, growing water requirement for agriculture and industry, pollution as well as changing life styles are some of the contributing factors. Different studies indicate that global water use has been increasing significantly since the last few decades. This is because the world has experienced not only rapid population growth but also a significant increase in per capita water consumption. Globally, as estimated by Jones and Holier (1997), current water use is 35 times more than it was 300 years ago. Moreover, their estimates indicate that over the last 50 years, global water withdrawal has quadrupled while the total population has doubled. According to this trend, between 1995 and 2020 global water withdrawal will increase by 31 %. Moreover, Pollution of surface as well as ground water sources is a serious problem. Increasing domestic, agricultural and industrial waste is accelerating the reduction of the availability and usability of this resource in many areas.

One basic problem that exposes water resources to vulnerability is lack of proper awareness. The fact that water has the ability to replenish itself through the hydrologic cycle, has made people hold the assumption that water remains wholesome and people can use it in whatever way they wish (Jones and Holier, 1997). This assumption has made people to develop an attitude of complacency and taking water for granted. Such attitudes are reflected in many ways in the development, governance and use of water. For example, fresh water is regarded as a resource which all members of society have the right to access. Accordingly, specifically in the developing world, governments provide public water services with heavy subsidy. The end result is that the use of water in various social and economic activities is unregulated and charges made for it are well below the operational costs.

Most of the water resources problems experienced in many areas emanate mainly from inefficient use, pollution and over abstraction. The mismanagement of water resources globally as well as locally is thus partly due to lack of a holistic perspective, which has led to complacency as well as poor management. In many cases responsibility for the management of the resource as well as the construction of infrastructure & their maintenance are distributed around different organs. Water related activities are positioned with in specific sectors & managed by sector-based institutions. The

result is that many activities are not coordinated or integrated to ensure efficiency and sustainability. With the ever-growing demand for water due to population growth, rapid urbanization and industrial development through out the world, fresh water resources thus continue to become more and more vulnerable to mismanagement.

Since water is a vital resource for life as well as development, scarcity and vulnerability of water resources pose a great challenge to sustainable development. In recent years there has been an increasing realization of not only the importance of water resources for sustainable development but also the need to manage this scarce resource more wisely and efficiently (vajpevyi, 1998). The situation calls for an urgent coordinated effort to ensure an efficient way of managing this scarce resource and this is what is echoed in many recent regional as well as international forums.

Professionals as well as politicians reiterate the need for efficient management of water resources. The following excerpt from the Bonn ministerial declaration on water management is one among such calls. "... We emphasize that ten years after the UN conference on Environment and Development and the Dublin Conference, and several years after the global water conferences in Paris and The Hague, there is still a need for greater commitment to implement commonly agreed principles on water resource management. Pressures on the world's scarce fresh water resources and aquatic systems have increased. Water pollution and unsustainable patterns of water consumption are among the causes. Water use efficiency needs to improve…."(Ministerial declaration, 2001).

1.2 The urban water challenge

Urbanization is commonly understood as "... the concentration of people in urban settlements and the process of changing in land use occupancy, which results from the conversion of rural lands in to urban areas, suburban and industrial communities..."(Lazaro, 1990). One consequence this process brings with it is the task of supplying the population with large quantities of clean water usually from surface or ground water sources. Besides, the drainage of storm runoff and effluent flows from industry as well as domestic users from the urban system become major tasks. As the population increases and the land use changes are intensified, the management of these tasks becomes a huge challenge.

The world has experienced rapid urbanization in recent decades. According to the UN (2001), currently about half of the world's population live in urban areas. The increase has been sharp especially since the last few decades. Urban population has grown from 30 % in 1950 to 47 % in 2000 and it will rise to 53 % by the year 2015 (UNFPA). This trend will continue and projections indicate that by the year 2025 more than two thirds of the world population will live in urban areas, with the highest growth rates in Asia and Sub-Saharan Africa (Besrat, 2000). According to these projections urban population in developing countries will have doubled by the year 2015.

Trends in world population growth

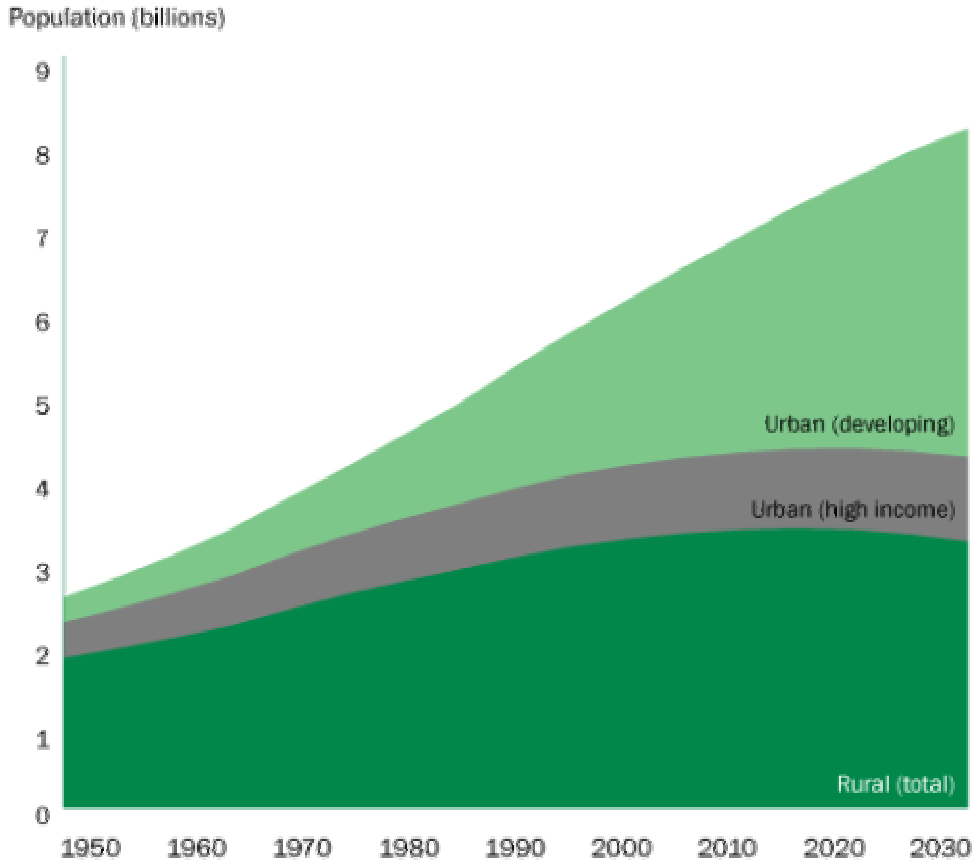

Figure 1.1 Trends in world population growth

Source: United Nations Population division 2004.

Although urban areas play an important role interms of cultural, economic and social enhancement, they are responsible for various environmental problems. Some of the problems emanate from the

fact that the rate of urbanization has often exceeded the capacities of the responsible administrative bodies to manage the transition efficiently, equitably and in a sustainable manner; and to provide and maintain the necessary infrastructural development and services. In fact, in the developing world, the rate of growth often exceeds the limited capacities & resources of governments at all levels (Uitto and Bishwas, 2000). Consequently, unplanned & poorly managed urbanization process has led to many economic and social problems. Moreover, various negative environmental effects have resulted in many ways such as air, water, and land pollution, which have and will continue to have serious impacts on the health & welfare of urban dwellers for many years to come (Uitto & Bishwas, 2000).

Water requirement has generally been increasing with urban population growth, while fresh water supply from surface as well as ground water sources for domestic use is becoming more and more scarce over time. As a result provision of adequate water supply and sanitation services to urban dwellers is becoming an enormous challenge. New sources of water supply that could be developed cost-effectively are not available any more in many urban areas. Existing sources that could be developed cost effectively have been developed or are in the process of development and water that has been harnessed has already been fully allocated (Uitto & Biswash, 2000).

Deterioration of water resources quality is also a problem. Due to growing industrialization and urbanization, solid as well as liquid waste generated in urban areas has been increasing. Urban surfaces are subject to the deposit of various types of chemical as well as biological contaminants, which are easily washed off by rain. Most common generators of these pollutants are vehicular traffic, industry, urban agriculture and litter. Increased generation of these wastes is leading to extensive pollution of water resources and the general environment. This deterioration in water quality has a serious implication, since in most cases it leads to increased cost of water treatment. Thus, it could be summed up that, in urban areas water is a problem interms of both quantity and quality.

Urban growth is universal and its environmental effects are felt everywhere. Rising urban populations place considerable strain on water supply and sanitation services and as indicated by various reports, the developing world will face a huge challenge in the coming decades with regards to water resources and environmental management in urban areas. According to some studies, it is

estimated that in 1991, 30 % of the urban population in the less developed world did not have sufficient facilities and today the number of urban dwellers with out access to basic water and sanitation facilities is much higher (Vajperyi, 1998). With this backlog of unmet needs; population growth, rapid urbanization, changing life styles and economic development will intensify the pressure on water resources everywhere especially in developing countries (European Commission, 2002).

As noted by Vajperyi (1998) rapid increase in population and urbanization thus pose serious challenges to the management of the environment and quality of life specifically in the developing world. Water and wastewater management for urban areas of developing countries are likely to become increasingly complex and challenging tasks. When the issue of increasing water scarcities and the accelerating water pollution in and around the urban centers of the developing world are superimposed on the continuing trend of rapid urbanization, the magnitude and extent of the problems associated with the issues of water and waste water management for urban areas during the 21st century are likely to increase significantly compared with what they are at present (Uitto & Biswash, 2000). This will be a tremendous challenge, which unless a significant change in management approach is adopted, will be difficult to tackle for governments as well as municipalities.

1.3 Aim of the study

Demand Side Management (DSM) has been gaining wide acceptance and is currently being promoted as an effective way of ensuring water use efficiency. Its cost effectiveness and potential to complement the supply-side effort to meet water demands in a sustainable manner seems to be appealing. As Bauman & Boland (1998) have noted, traditional approach to planning has proven to be ineffective for many utilities. Not only new water sources are not readily available as before for development but also environmental constraints, political realities, economic feasibility issues and public interest have led to new supply-side planning scenarios. When it comes to meeting demand and ensuring efficient and sustainable use of resource, DSM is beginning to get greater attention in water management. This study primarily aims at investigating how DSM can help in water conservation and generally augment the supply side management efforts to meet the growing water demand. In order to assess the potential of DSM as effective water saving strategy the following problem formulation has been conceptualized:

How can Demand Side Water Management exert conservation in public water supply; and what are the challenges and barriers faced in adopting & implementing the strategy?

The purpose of this study is therefore to explore the potential of DSM for water conservation by undertaking an assessment of a case study. This is achieved by investigating the extent of water conservation that has occurred in the case study area as a result of DSM and identifying obstacles or barriers faced in either adopting or implementing it. Through the analysis of the case, the study aims at investigating the potential use of DSM as a complimentary solution to water scarcity.

1.4 Rational for the study

I come from Addis Ababa the capital city of Ethiopia, which shares many of the urban problems specifically those related to water and sanitation. During the period 1994 - 2004 I led a citywide community based development program, which gave me the privilege to learn more about the problems of the city in general and the water supply and sanitation condition in particular. With the continuing growth in population and urbanization, I have serious concerns that meeting the city's future water demands is going to be an immense challenge.

This concerns coupled with the inspiration I got from Neiles Schroeder's[1] lectures on Copenhagen water management where I learned that water consumption has decreased over the past couple of decades due to water saving programs carried out by the water and energy company of Copenhagen, made me curious about the water conservation issue. This was further reinforced by literature review where I discovered that demand side management (DSM) is being promoted as an effective tool for achieving water saving objectives. This curiosity led me to decide to explore whether water saving mechanisms and strategies such as DSM have some thing to contribute to the effort being made to over come the water scarcity urban areas are facing.

As narrated by EEA (2001) the concept of water demand management was first elaborated in the late 1970s & through out the 1980s when the limits of the supply side solutions became apparent. In particular, economic theories concerning pricing, metering and end-user side management were

[1] Neiles Schroeder is associate professor at TekSam, Roskilde University.

developed in the 1980s (EEA, 2001). However, despite increasing interest in the subject in the 1990s, few published studies on the viability of large-scale policies exist. The search for knowledge in this research thus focuses on the prospect of DSM in water saving in urban water utilities and the intention of the study is to explore how DSM programs can help utilities achieve water conservation objectives.

1.5 Research objectives

The overall objective of this study is to explore the potential role of DSM in achieving water conservation and its contribution towards efficient and sustainable use of water resources. The general intention is thus to study relevant concepts so as to better understand DSM conceptually and assess the experience of the case study area in an effort to address the problem question. In this process the focus will be to answer the following key sub questions of the problem formulation:

1. How is DSM conceived in different sectors & what is the experience?
2. What is water demand management (WDM)?
3. How is water governed in Denmark?
4. How is public water supply managed in Copenhagen?
5. Which DSM strategies have been implemented in Copenhagen?
6. To what extent has water conservation occurred in Copenhagen and what is the contribution of DSM strategies?
7. What challenges and barriers were faced?

1.6 Scope of the study

DSM measures target all consumers including the utility itself. The industrial sector, which usually comes next to households interms of the amount of water it consumes, is one major target of a DSM program. This study however, does not include a detailed investigation on how industries have been responding to the DSM measures that have been operational for a long period & how the technological innovation in water conservation has progressed with in the sector. This is because the focus of DSM in the case study area has been on households. The rational for choosing to focus on households besides the fact that they are the major consumers, could be that industries have the incentive to be innovative interms of water consumption inorder to remain cost-effective and competitive.

It is often argued that the creation of additional capacity through measures such as artificial recharge, recycling & rainwater harvesting should be considered as part of DSM measures. However, taking note of the fact that drawing a demarcation line between DSM & the supply side management in urban water governance is debatable, and for the sake of maintaining focus on the measures that have been employed in the case study area, I have excluded a detailed discussion of these measures.

Demand forecasting, which is an important aspect of urban water management is also not treated in this study. There is no doubt that the information that is obtained from the forecasting exercise is not only helpful for the supply side planning but also for the proper planning, implementation & evaluation of DSM programs. Traditionally, it is the supply side management, which handles this task & demand forecasting results should be readily available whenever the DSM program needs them. I am of the opinion that since DSM is not intended to replace the supply side management it does not matter much which side handles this task as long as both options are employed to ensure efficient water governance.

This study aims at exploring the usefulness of DSM in water conservation by undertaking an assessment of an ongoing DSM program in the case study area. In principle I am of the opinion that DSM should be evaluated in a holistic way taking in to consideration economic, social and environmental costs and benefits within any policy framework. In this regard, cost benefit analysis can help unveil information on whether specific DSM measures are beneficial or not. This study does not however include cost-benefit analysis of the DSM measures implemented in the case study area, as data on costs and benefits of these measures were not readily available and the study does not try to comment on the efficiency of neither the program nor specific measures.

CHAPTER 2 - METHODOLOGY

The overall objective of this study is to explore the potential role of DSM in achieving water conservation and its contribution towards efficient and sustainable use of water resources. It tries to assess the extent of water conservation that has occurred in the case study area as a result of the implementation of DSM. This chapter describes my research design and explains the techniques I used in my effort to answer the problem question:

> **How can Demand Side Water Management exert conservation in public water supply; and what are the challenges and barriers faced in adopting & implementing the strategy?**

The first part of this study is the discussion on the theoretical framework. In order to gain knowledge on the subject and be able to address the problem question properly, a sound theoretical understanding of DSM is necessary. Hence, I have chosen to dwell more on the discussion of the basic concepts of DSM. Accordingly, I begun with the introduction of the evolution of DSM, where I discussed the basic theoretical aspects as conceived and applied in economics as well as electricity and water utilities. In exploring this approach to water management, I have also undertaken a case study, which I assessed and from which I have obtain data for my empirical analysis. By analyzing available data on the case study, I have examined how the strategy has been helpful in achieving water conservation and what challenges and barriers have been faced in the process.

2.1 Analytical framework

The analysis is based on the theoretical discussion and the empirical study. The purpose of the theoretical discussion beyond understanding the basic concepts is to draw parallel lessons that can give deeper understanding and help analyze the problem better. This together with the empirical research forms the basis of evidence for establishing the effects of DSM on water conservation. DSM and conservation, which are important concepts in this study, may be understood differently

in different contexts. It is therefore important to define them from the outset, since this will contribute significantly to a focused assessment of the case study.

DSM can be understood as a program, which is adopted to achieve efficient use of water resources by employing price and non-price measures. These are "…actions that are deliberately taken by a water agency with the objective of reducing demand for water or matching demand to available supply. By encouraging more efficient use of water, demand management options can, in many cases, achieve the same level of utility as supply augmentation at lower cost…"(HUNTER WATER, 2003). A more comprehensive definition, which I have adopted in this study is the one given by IUCN. Water demand management (WDM) is "…an approach that aims at conserving water both quantity as well as quality wise and optimization of water use through various mechanisms such as technologies that increase the efficiency of water use; behavioral change that can lead to sustainable use of water resources; pricing and enabling environment…" Based on this definition, I treat WDM as a strategy whose main objective is water conservation and in this study I consider it to be synonym with DSM and use it interchangeably for the sake of convenience.

It is equally important to have a definition for conservation and an outline of the criteria for measuring it in order to have a clear basis for assessment of the case study. In this regard I consider the definition given by Buamann and Boland (1998) to be more explicit and helpful. They argue that in the broadest sense reducing water losses and increasing water recycling mean the same thing interms of water conservation. In this sense water conservation is the reduction in water use or water loss. Conservation practices are therefore initiatives that lead to water use level at some future time, which is less than the level would have been had the initiatives were not carried (Baumann and Boland 1998).

In more elaborated form "…Water conservation practices are a specific subset of those practices that comprise efficient management of water resources. If some means could be devised, such as an optimal pricing policies at every level of water distribution, that would make the self-interest of each supplier and user of water coincide with the social interest, no further attention to water conservation practices would be required. In actual fact however, optimal policies are not universal, and the supply, distribution, and use of water are characterized by significant market failures. It becomes the task of the planner; therefore, to consider the efficient allocation of the water resources

at every stage of distribution and use, since no efficient self-allocating mechanisms can be presumed to exist. Among the desirable management practices that may be considered by the planner in this context are some which involve reductions in the use of water, and it is these practices which we defined as 'water conservation'…"(Bauman and Boland, 1998).

Water conservation is therefore about water use practices and habits that lead to reduction in consumption. The benefits of reduction in water use are expected to be more than the costs due to lower operating costs and deferred facility costs. Therefore from the utility side conservation means lower costs (benefits) and reduced revenue (costs) in which, overtime, the benefits should exceed the costs and the utility should enjoy a better financial standing as a result of conservation (Bauland and Buaman, 1998).

Both the outcomes of the discussion on the conceptual framework as well as analysis of the empirical data have been used to determine the situation in the case study. Data from published documents and interview regarding achievements in water use efficiency and conservation have been used in investigating whether conservation has occurred or not. However, as noted by Bauland and Buaman (1998), evaluation outcomes or estimates of costs and benefits have a number of deficiencies. One drawback that is relevant to this study is that of data aggregation. Estimates of costs and benefits or savings are often stated in aggregate forms such as changes in aggregate water use. Since all conservation measures cannot be expected to result in similar achievements or efficiency in all water uses, it becomes difficult to evaluate specific measures. This is one of the barriers faced in the assessment of the different DSM measures implemented in the case study.

2.2 Conceptual frame work

The discourse on DSM is the theoretical basis for this study. In order to get an insight in DSM, it is necessary to explore its roots. In my search for the origins of the concept and its applications, I have dipped in to literature for examination of its applications in various sectors. It was therefore unavoidable to include a discussion on how DSM is conceived and practiced especially in economics and energy as a utility. However, due to limitation of time and scope, the theoretical study on the evolution of DSM had to focus only on economics and energy as well as water utilities.

The basic concepts underlying DSM and its scope could be better understood through a framework developed by Luten et al (2004), which combines three basic elements namely: the variety of available action strategies; the domain of end user decisions or choice and habits; as well as the variety of program applications. According to them and as depicted in fig.2.1, a variety of demand side strategies are employed in order to influence the decision or choice of end users in the context of a wide array of applications.

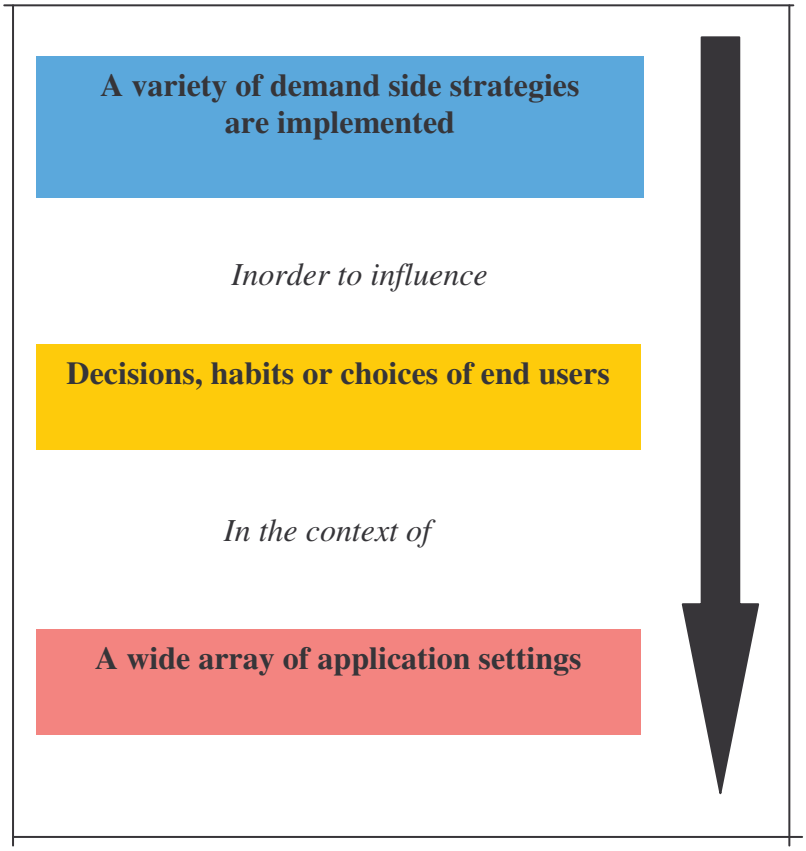

Fig.2.1 The three core elements of DSM

Source: Adopted with modification from FHWA

The rational for DSM mainly lies on the complimentary role it plays to the supply side water management and the growing concern for environmental protection and sustainable use of resources. It is imperative that water should be conserved in order to ensure sustainable use of water resources and secure future water supply needs. The DSM concept has been introduced in to the water management field since the last couple of decades to achieve this objective. It has been

employed as a strategy in many countries and literature review reveals that there is a considerable amount of experience so far. This is why I have chosen DSM for discussion as a theoretical basis of my study to address the research question.

DSM commonly referred to as water demand management (WDM) in the water sector, emerged as a complimentary strategy to the traditional supply side management. The traditional planning process in urban water utilities starts with the estimation of the per capita water consumption and projection of population to be served. Water supply demand is then calculated by multiplying the two projected values. Having the estimated future water need the next task is to look for adequate sources of supply for development. In this planning process emphasis is made on the goals of minimizing costs and ensuring the reliability of water supply systems. Water demand is often assumed to be some thing that cannot be influenced by the utility (Bauman and Boland, 1998).

Since the late 1970s this approach to planning has proven to be inadequate for many utilities. This is particularly due to the fact that it does not give due attention to water supply issues faced by utilities, which are not the same as those faced in the past. It does not take in to account the environmental, financial and political constraints and it ignores the positive role that demand side management initiatives such as water conservation activities can play. Not only new water sources are not readily available as before for development but also environmental constraints, political realities, economic feasibility issues and public interest have lead to new supply-side planning scenarios (Bauman and Boland, 1998). These concerns have led to serious consideration of conservation as an important component in the planning process and management of water supplies and DSM is appealing as a complimentary approach to address water resource problems.

2.3 Research methods

2.3.1 Case study

The empirical analysis of this study is based on information obtained from the case study. As argued by Yin (2003), using a case study is an appropriate way of investigating a 'how' or 'why' research question. A Case study not only helps the investigator to observe the working of the process considered for analysis but also gives her/him the opportunity to record what is happening. This enables the researcher to examine the meaning of the observations and interpret them with in

the context of the prescribed theoretical framework (Swiercz). Based on this argument, I am of the opinion that undertaking a case study is appropriate for addressing my research question.

The water saving initiative of Copenhagen water and energy utility, which I have selected for investigation is a program that has been going on for a considerable amount of time. Copenhagen water saving program is chosen as a case study for its relatively long time experience in implementing DSM measures and the conservation results achieved so far as recorded in various documents. The achievements in water conservation suggest that the strategy has enabled the utility to achieve water conservation, which is the basic justification for considering this initiative for investigation. I assumed this condition would facilitate an investigation to establish how the strategy has enabled such an achievement or success.

Including a second case from the developing world preferably my home city was part of the original research plan. However, I discovered later on that DSM is just being piloted and there is not much experience. Even though I am of the opinion that this combination could create a better ground to investigate the application of the strategy and establish the relationship between DSM and water conservation, I have decided to leave out the plan to include a second case study from the developing world, due to time and logistical limitations. But I am of the opinion that this will not substantially affect the overall study and the out come my research.

The empirical analysis aims at investigating primarily if water conservation has occurred as a result of DSM activities. It also targets at exploring the extent to which these measures have been employed. Furthermore, effort has been made to look in to the challenges and constraints faced in the process. To make the investigation more focused and properly evaluate the DSM activities, I have found it necessary to use some criteria and I have chosen those given by Bauman and Boland (1998). They have argued that water management practice constitutes conservation when it meets two tests namely:

i. It conserves a given supply of water through the reduction in water use or water loss; which means that the practice results in a reduction in use
ii. It results in a net increase in social welfare; which means that the overall benefits exceed costs and the practice is consistent with the conservation of all scarce resources

2..3.2 Interviews

A number of interviews with stakeholders and relevant individuals were originally envisaged. The main purpose of theses interviews was to get helpful information based on actual experience as well as expert knowledge, which is helpful in ascertaining the effect of the strategy as practiced in the case study area. Besides, I thought the information obtained from the interviews would give a clue as to whether the strategy is actually effective in achieving the objective of water conservation as often promoted. As per the original plan, the interview focused mainly on key experts who have been in the utility and are directly involved in the program. I had also in my original plan to talk to experts or researchers who are located in other relevant institutions and are knowledgeable. Face-to face interviews were planned guided by open-ended questions, which were designed in such a way that they follow semi-structured themes.

The interview work started with Jens Peter Brenøe[2] in two rounds. However, eventhough I had the privilege to have a lengthy interview with Jens Peter, I did not have a chance to get the opinion of other experts in KE. It was found necessary to e-mail specific questions to relevant departments with in Copenhagen energy so that they can respond through e-mail. Accordingly answers to some questions were obtained this way, though some times very brief. The draw back of this change of modality was that there was no possibility of further discussion to probe more information using subsequent questions. Effort was made to compensate this by contacting experts in institutions such as DWWA, DHI and DTU and requesting them for short interviews even though with out much success.

As the consumer or end user is a major stakeholder in DSM programs, it would have been beneficial for the study to obtain end-user opinion and experience through sample surveys. How ever, due to limitations in time and scope, I have ruled out the option of conducting surveys right from the outset. I have decided instead to rely on interviews in this study because of my assumption that for a research that focuses on describing and exploring a process such as the one in hand, a combination of case study and interviews was adequate (Marshall and Rossman, 1989).

[2] Jens Peter Brenøe is an expert in the Bynet og Teknik department of KE.

2.3.3 Empirical data

Published data from appropriate institutions relevant to the case study was examined and used as a source of information for the analysis. Emphasis was made on progress and annual reports of KE and Copenhagen commune from where much of the data on achievements in water saving or conservation was obtained. Moreover, official reports and different studies on the practice & outcomes of the approach were also helpful in assessing the strategy. In this regard, the Internet was also used cautiously as a source of information and helpful material.

2.5 Literature review

A literature review to understand the key concepts of DSM was necessary in order to establish a framework for DSM and its potential as well as its challenges. This was important since it served as a guide in the study and assessment of what actually is happening in the case study area. Moreover, it facilitated the effort made to judge whether the program objectives were achieved or not. It also enabled me to look in to the experience of Denmark and other countries, which have some experience in water demand management and learn from their experience on water management practice in general and implementation of DSM measures in particular. Having an overview of their experience in the areas of water policy, institutional setup, legislation and enforcement mechanisms was helpful in achieving the objective of this study.

2.6 The research process

Considering the fact that Copenhagen water saving program has been going on for a substantial amount of time, the choice of the case study was appropriate. When I contacted KE for the project work, I got an immediate and encouraging response, which lead me to think of an overambitious plan of interviewing a number of experts in KE. After having one lengthy interview however, the modality was changed and different experts had to be requested to respond to a number of specific questions through e-mail. The draw back in this approach was that it did not give me the chance for probing more information and opinion by using subsequent questions. This has made me realize that from the outset, I should have requested for a focused group discussion where I could raise my questions and the relevant experts could respond to them in a group discussion. Even though it had been possible to get helpful information through e-mail, I am of the opinion that this approach

could have been more efficient and productive with regards to the information I could gather from KE.

With regards to information from published documents, there is a vast resource on the experience of water management in Denmark in general and the case study area in particular. Most of the literature however, is in Danish and since my Danish had not improved fast enough to help me exploit this resource, I had to rely mainly on documents written in English. In a number of cases I had to use the online dictionaries and translation by friends in order to understand some important issues. However, in my opinion this limitation did not have a substantial influence on the out come of the study.

CHAPTER 3 - EVOLUTION OF DSM

In my search for the origins of demand side management and its conceptual and application framework, I have found it necessary to dip in to literature under different disciplines. This chapter is therefore devoted to the discussion of the origins of DSM. It focuses on the historical background of DSM and tries to briefly describe how it is conceived and applied in a couple of disciplines. The discussion starts with the history of demand management and how it fits into an over all resources management program. The focus will be on the evolution of the concept as it is understood and applied in economics and utilities such as energy and water. The basic objective in approaching it this way is to gain insight and better understanding of the basic concepts.

3.1 DSM in economics

3.1.1 The theory of supply and demand

The concepts of supply and demand are fundamental subjects in economics (Louw & Kassier, 2002). The theory of supply and demand is an explanation of the mechanism by which many resource allocation decisions are made. In macroeconomic theory the supply and demand economic model originaly developed by Alfred Marshal tries to explain changes in price and quantity of goods sold in competitive markets. This model, which is used as a basic building block in many modern economic models and theories is the first approximation used to describe an imperfectly competitive market (Wikipedia, 2006)

Supply and demand economics are based on the clearing of markets for goods to find a set of prices that would clear markets. Lipczynski and Wilson (2004), defines markets as opportunities for individuals or institutions to exchange goods and services at specific prices. The theory of demand

and supply describes how prices vary as a result of a balance between availability of goods or services at each price (supply) & the desire of buyers who have the purchasing power (demand) (Wikipedia 2006). Thegraph in Fig.3.1 depicts an increase in demand from D1 to D2 along with the corosponding increase in price from P1 to P2 & quantity from Q1 to Q2, required to reach a new market equilibrium point.

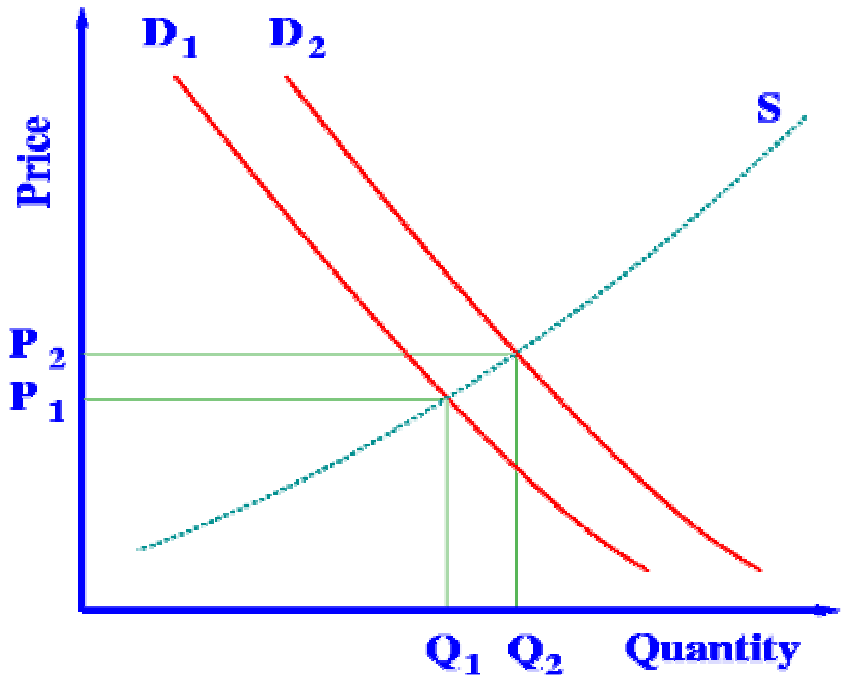

Fig.3.1 Demand and supply

Source: Wikipedia

The intersection points of the demand & supply curves indicate the market equilibrium point where the amount demanded is equal to the amount supplied. Ideally, this point indicates a situation where there is neither shortage nor surplus. In a free market, whenever shortages occur, market prices rise & price in this context acts as a 'rationing agent' enabling those who are willing to pay higher prices to get the goods or services in short supply (Lipczynski and Wilson, 2004). According to this argument, as prices rise some consumers leave the market while at the same time the higher prices attract other producers in to the market. If price is set too high, the quantity supplied is greater than what is demanded leading to unsold stock. This forces producers to make discounts on prices to attract more consumers in to the market until market equilibrium is reached

3.1.2 Limiting demand

The origin of DSM in economics is associated with the phenomenon commonly known as stagflation. According to Wikipedia (2006) stagflation is a term in macroeconomics used to describe a period of high inflation combined with economic stagnation, unemployment or economic depression. It is thought to occur when there is an adverse shock (such as a sudden increase in oil price) in a country's aggregate supply curve. The common characteristics of this phenomenon are a desire on the part of the various agents of the economy to obtain living standards that combined exceeds the supply of goods and services available.

These desires take the form of increases in money incomes that overwhelm increases in productivity, which leads to a rise in money costs and money prices and ultimately in the cost of living. This in turn leads to wage claims to compensate the rise in living cost, which leads to further rise in costs and again to higher living costs and further wage claims. This vicious circle of inflationary process of money costs, money prices and money incomes unless some how treated by concerned authorities becomes a critical problem in the economy (Vines, Maciejowski, Meade, 1983).

It is in this kind of scenario where DSM is considered as an instrument to break the vicious circle of stagflation and remedy the sickness of the economy. DSM, which gained wide acceptance in the 1950s & 1970s, is thus the art of controlling demand to overcome a recession. In other words, in the traditional approaches to economics where emphasis is made on investment in the production of goods and services with a basic objective of increasing the level of supply to meet human needs, if supplies were constrained, increasing prices were used to limit demand (Higgins, 1993).

The basic assumption underlying DSM as a strategy is that the combination of budgetary, monetary and foreign-exchange policies should be so operated as to keep the total of money expenditures on the goods and services produced in the country on a steady growth path, expanding at the moderate rate. Besides moderate expansion in the total money demand for the products of labor, wage-fixing institutions should also be reformed so as to ensure that pay in the various sectors of the economy was settled at rates that served to promote employment in different sectors (Vines, Maciejowski, Meade, 1983). This mechanism also assumes that active government intervention in the market place and monetary policy is an effective method of ensuring economic growth stability.

Moreover, proponents of this concept argue that the government is responsible for smoothening out the bumps in business cycles through deterrent mechanisms such as government spending and tax breaks in order to stimulate the economy and government spending cuts and tax hikes in due course to curb inflation (Free dictionary, 2005). In the implementation of this strategy, the government uses tools such as interest rates, taxation, and public expenditures to influence economic decisions such as consumption, investment, the balance of trade and public sector borrowing with the ultimate goal of evening out the business cycle (Wikipedia, 2006).

DSM, which was widely adopted in the 1950s & 1970s, was successful for some time. It could be argued that eventhough there were practical problems in implementing the various DSM instruments; they could be effectively used to stimulate an economy by controlling demand so as to balance the supply and demand. As a strategy it is appealing to governments since it provides them with alternatives in extending the range of instruments of control available to them (Vines, Maciejowski, Meade, 1983). From the consumer's side however, this strategy implies that the objective of controlling demand and ensuring the stability of the economy is achieved by making the consumer lose amenities. The consumer is made to forego some benefits interms of services or goods. It is therefore subject to criticism from different directions mainly from supply side management proponents. As a result, governments nowadays limit interventions in demand management to tackling short-term crises and prefer to relay on other policy instruments to prevent long-term economic problems. (Wikipedia, 2006)

3.1.3 Summary

DSM in economics is a response to an economic crisis. It is a strategy designed to remedy the sickness of the economy. The objective is to manage the crisis situation and bring it to normal in the long run, by employing economic instruments to restrain demand when supplies are constrained. It is based on the assumption that active government intervention in the market place and monetary policy is an effective method of ensuring balance between supply and demand & economic growth stability. Another underlying assumption is that the government is responsible for smoothening out the roughness in busyness cycles through mechanisms such as government spending, and tax breaks in order to stimulate the economy and curb inflation (Free dictionary, 2005). As argued by

proponents of this strategy it is logical that market forces and government regulation influence the demand for any commodity or service.

3.2 DSM in energy conservation

The process that led to the development of DSM in the electricity utility started in the 1970s following the oil embargo of 1973 and the subsequent oil shock driven energy crisis (Cicchetti, 1992). The driving force of the movement for energy conservation at the beginning was the reaction to the high increase in energy prices. The movement however continued due to the new perception of the energy problem, which was induced by the oil shock. The general public, specifically in the USA, began to think that resources are limited and energy efficiency was essential. As a result more people began pursuing environmental and energy conservation agenda on ethical grounds. After the embargo, eventhough much of the patriotic concern to conserve energy dissipated, there was a desire to improve energy efficiency and the issue was embraced by utilities (Cicchetti, 1992).

After the embargo, since the public had realized that conservation has economic value, it was not patriotism or some other form of environmental ethic that dominated the conservation movement. Today, industrialized countries place great importance on the role of increased energy efficiencies in their effort to address environmental concerns. This is because in the broadest sense, reduced use of energy to achieve the same level of economic out put on services reduces the pressure on resources (OECD/IEA, 1992). As a result DSM has become an important element of utility strategies. According to Dominioni (1992), the European community considers it as an important current as well as future resource.

3.2.1 Influencing Demand

DSM is an approach to energy efficiency & conservation and aims at ensuring energy security by reducing demand. Unlike the traditional approaches of economics to managing the balance between demand and supply, DSM in the energy sector seeks to suppress the level of demand with out the loss of amenity. Proponents of DSM such as Higgins (1993) argue that besides reducing the total cost of energy for the consumer, a unit of energy saved through DSM can be considered as energy generated. What is more appealing is the assertion that this is achieved in a cost effective and environmentally benign way.

A DSM program in the energy sector aims to achieve four broad objectives namely: energy conservation, efficiency, load management and environmental protection. It covers a wide range of activities designed to induce energy consumers to change their consumption behavior (Ferrtier, 1993). DSM involves measures that specifically seek a cost effective reduction in the use of energy below the level that would otherwise prevail. Such reductions involve elimination of waste, reduction of inefficient energy using activity, substitution of one form of energy for another, or substitution of productive factors like capital & labor for energy (Ferrtier, 1993). As noted by Cicchetti (1992) DSM activities are those, which aim at all, or subsets of utility's customers and are intended to shape the level & pattern of consumption or demand. They can be summarized under the following two broad categories:

i. Reduction of energy requirements through conservation & actions to reduce peak demand on the system by eliminating or shifting loads.
ii. Educational activities designed to modify customer consumption & appliance purchasing behavior as well as activities to improve the efficiency of the utilities own system

Based on Australian experience Higgins, (1993) states that a DSM plan involves many elements centering on retail, electricity pricing, the provision of incentives, increasing customer awareness & regulation. Pricing measures relate to time of use tariffs, availability of special rates for interruptibility and the reduction of existing cross subsidies

Education, training and Information communication activities are also important aspects of DSM in the energy sector. These activities are necessary to raise awareness & bring attitudinal change to wards energy conservation & efficiency. In this endeavor, the human element is targeted with a basic objective of facilitating conservation & efficiency in the economy as well as the society. This relates to primarily educating the general public or the consumer by providing updated & reliable information and training using different media. As Arias (1993) puts it, achieving attitudinal change requires time and effort and for the program to be effective, it must be undertaken by understanding the hierarchy prepotency in human motivation. It must relate energy efficiency to the basic needs, the environment and the social needs of the consumer in that order.

Regulation is another important aspect in energy DSM. Regulation activities refer to appliance energy labeling, the development of a house energy-rating scheme, building standards & minimum performance standards for house hold appliances (Higgins, 1993). The DSM regulation policy objective is to ensure that utilities implement DSM programs at large scale to benefit the society, utilities themselves and customers (Jan, 1993). The assumption is that as a utility program designed and implemented to improve end-use efficiency, DSM can be used to save energy at a fraction of the cost for new generation capacity. Therefore utilities can carry out DSM programs in a regulated environment in order to reduce their total energy costs. In this way DSM can provide economic benefits for both the utility and its customers.

Electricity utilities for example, are often large, investor owned and operate in a franchise market. They face some competition in generation and they need to be regulated both in wholesale market and the retail market. The regulation means that income level is set and the retail prices are determined according to this income cap (Moen, 1993). Therefore, to promote a policy that focuses on environment consciousness, reduce the wasteful use of resources and promote efficiency, responsible government bodies need to develop incentive regulation for DSM programs. The overall objective is to transform the DSM program in to a potential profitable activity for the utilities, by including some or all of the following components:

1. Recovery of program costs
2. Compensation for lost revenue or profit
3. Creation of an incentive for the utilities

Experience has shown that with out this restructuring of the regulation system to promote DSM, almost no investor owned utility would have paid any attention to DSM. This statement underlines the importance of the connection between regulation and successful DSM policy implementation (Jan, 1993).

DSM is getting increasing attention around the world because of its applicability to both efficiency and environmental issues and its potentials to some scarce capital resources. In this regard, promotion of customer energy efficiency has been a priority activity and effort is being made to deliver energy efficiency programs in a cost effective way. The central question for utilities and regulators in the energy sector is how to implement an overall effective DSM program that can have

high participation rates and energy savings at reasonable costs. This question can be addressed better using information obtained from a DSM program evaluation. Yet, literature review reveals that there has been little success in synthesizing information across programs such as the systematic assessment among various programs, designed to determine which delivery techniques work best and why. This type of information can also help in identifying what can be successfully transferred to other utilities, program types, customer classes or service territories (Pirkey & Eto, 1993).

3.2.2 Summary

DSM emerged as a response to energy crisis and environmental concerns. It aims at ensuring energy efficiency through optimal use of existing capacity, deferral of development of new capacity, conservation of energy sources as well as minimization of energy losses and environmental impacts. Technology and human behavior are two important factors that affect the progress of DSM. Eventhough innovative technology plays a significant role for the achievement of DSM objectives, it is the change in attitude and life style of the consumer that matters most in the implementation of DSM measures and achievement of the objectives. The challenge is that attitudinal and behavioral change is a process, which requires time and effort.

CHAPTER 4 - Water Demand Management

This chapter deals with the basic concepts underlying DSM in water governance. It starts by defining water demand management (WDM) and continues with the discussion of basic demand management concepts. It also briefly describes the various components of the WDM strategy and the challenges encountered in adopting them. The argument centres on the central issue of how it is possible to reduce water demand while maintaining human health and dignity.

4.1 Rational for water demand management

Several attempts have been made to respond to the increasing demand for water. In the past, the general tendency has been to increase supply in line with demand. The traditional response to growing demand for water supply had been the development of new sources and other alternatives such as conservation were not given due attention. The first signs of interest in water conservation were observed in the early 1970s in the US (Baumann & Boland, 1998). During this period, the potential for water use reduction through conservation practices as an alternative to water supply augmentation and the fact that this can lead to reduced sewer flows, was realized.

Water supply utilities thus began to encourage their customers to conserve water. Since then, water resources planning has been broadening in perspective to address new challenges such as: Untapped resources becoming rare, pollution of ground water, increased frequency of draughts, environmental concerns and requirement for high quality standards for drinking water. These and other considerations have forced urban water supply planners consider new management policies and practices that include demand management strategy and innovative solutions.

There are many reasons for conserving water, the major ones being: high level of urban water use due to changing life styles and increased industrialization, resource limitations faced by municipalities and the increase in capital costs of infrastructure expansions. Moreover, the negative

impacts of urban water withdrawals and wastewater returns on the environment and the corresponding impacts on drinking water quality are of increasing concern (Brandes and Ferguson, 2004). Modernity and wrong perceptions about water, have also significantly contributed to the increase in per capita consumption in many urban areas and as a result fresh water sources have reached or are nearing their capacity for withdrawals.

Not only new sources are no more readily available for development and they are more expensive than before, but also utilities have unmet capital costs for aging water and waste water infrastructure upgrading. Brandes & Ferguson (2004) have noted that increasing peak water and/or wastewater treatment demands create additional capital costs and the fact that urban water withdrawals as well as wastewater returns are highly geographically concentrated amplifies their impact. They have also indicated that increasing urban water withdrawals and corresponding wastewater returns are negatively affecting the environment and hence degrading the drinking water quality. Both ground and surface water withdrawals can reduce surface water flows, altering the local ecosystem.

On the other hand, reducing wastewater flows allows financial resources to be reallocated to meet higher levels of drinking water standards, while it also reduces the amount of water that needs to be treated to these levels. Decreasing wastewater volume increases the effectiveness of sewage treatment, thus decreasing pollution of receiving waters. Reducing demand also avoids the development of additional inferior water sources, and protects ground water sources by reducing over pumping (Brandes & Ferguson, 2004).

Water demand management is thus an imperative for modern society that cannot go on with the traditional supply side options alone. In fact, Lanz (2003) argues that water demand management is in line with the traditional wisdom of making best use of water. It is not only restating knowledge accumulated through out history but also supplementing the potential of wise use of water by employing new technologies and practices geared to the realities of modern society. According to him, water demand management is based on a paradigm shift and is not limited to the mere application of technology.

4.2 Altering Demand

According to Tate (1990) WDM is an approach that aims to conserve water (quality and quantity) and optimize water use through various strategies which include: Technologies that increase the efficiency of water use; Behavioral change that ensures long-term sustainability of water resources; Pricing and setting of tariffs; and an Enabling environment (policy, institutional and legislative environment). The philosophy underlying this approach is that resources are limited and need to be used efficiently. Tate (1990) thus defines WDM as any socially beneficial action that reduces or reschedules average or peak water withdrawals or consumption from either surface or groundwater, consistent with the protection or enhancement of water quality. Unlike the traditional view of water use, which sees water as a" requirement" which must be met, demand management views water use "as a "demand" that can be altered by employing various policy and technical options. Tate (1990) further argues that demand must be understood in the economic sense, whereby water used is a function of the price of water.

The overall objective of DSM in water management is to ensure more efficient use of water. To achieve this objective, in addition to regulatory and pricing measures, various programs can be designed to promote the wise use of water through the employment of more efficient technologies and practices. Demand management options may also include measures such as: modifying rate structures; reducing landscape water use; modifying plumbing systems; conducting educational programs & metering. The implementation of these measures requires some costs such as: costs for installation, maintenance and monitoring of meters; water supply and water saving devices; education & information communication; promotion programs and law enforcement. In most cases such costs are born by the consumer through higher water rates or taxes (Louw & Kassier, 2002)

Higgins (1993); Bauman and Boland (1998); Louw and Kassier, (2002) have recognized two apparently paradox issues in WDM. One of them concerns the utility, which as a producer of water suppresses demand for its product (water) by adopting & promoting DSM. The second concerns the end-users who are apparently punished with higher water price rates due to the implementation of DSM programs. They contend that these seemingly paradox issues are reconciled through the concept of economic efficiency. Bauman & Boland (1998) have argued that the idea of utilities,

which are required to serve social objectives interms of the proper management of resources and at the same time remain viable as business enterprises is not a paradox.

From a resource management perspective, conservation can be beneficial. However, from the revenue point of view, the utility may be concerned that revenues and earnings may decrease. To compensate this loss, they can increase the user charge, which appears to be punishing the consumer for their cooperation in reducing water use. From the consumer point of view, simultaneous appearance of conservation programs as well as increased charges does not necessarily imply an increased cost burden. Because it is customers who fail to respond to the conservation initiatives that will get increased bills. Those who conserve water may pay a higher unit charge for a smaller quantity of water, but the total bill should be smaller.

4.3 Basic principles of water demand theory

Unlike the assumption of the traditional supply side management approach, DSM considers water demand as some thing that can be influenced by various policy and technical instruments. One important variable is the price of water. In economic terms the amount of water used by any activity is a function of the price of water. The effect of water price on consumer behavior can thus be illustrated using this assumption as shown in fig. 4.1 (Louw & Kassier, 2002). The chart depicts two demand schedules for consumer type 1 and type 2 with significant difference in slope. Since the price of water will have an impact on demand for water, the change in the demand for water will depend on the slope of the demand function.

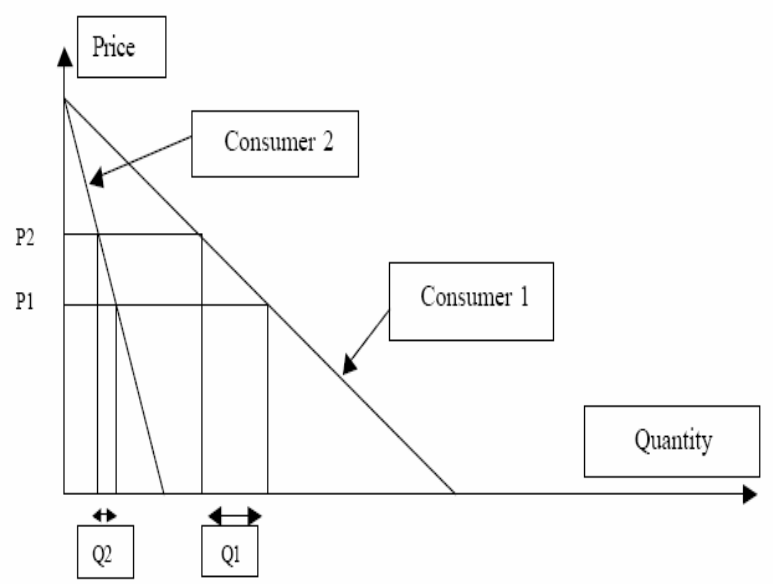

Figure 4.1: Price-demand relationship

Source: Louw & Kassier (2002)

The line for consumer 1 is less steep than that of consumer 2. When the price of water is increased from P1 to P2, the reduction in demand for consumer 1 will be greater than that of consumer 2. This shows that the price for consumer 1 is more elastic than that of consumer 2. For this reason, if increasing tariff is to be considered as a DSM measure, it will be necessary to have knowledge of the price elasticity of demand. This can help to assess the level of impact the tariff will have on the demand for water (Louw & Kassier, 2002). Besides price, other factors such as population growth increase in demand due to changes in per capita income and a change in the expectation of water consumers as to the future level of prices may influence the growth in demand for water. In any case the justification for WDM measures based on this argument is that they will induce a leftward shift in the demand schedule, maintain it or slow down the movement to the right (Louw and Kassier, 2002).

4.4 DSM components

DSM is a dynamic concept, which is subject to continuous improvement through frequent critical evaluation in the context of innovative technology and human behavior as well as changing life styles. It is an umbrella of different strategies and approaches targeted at different user groups with the main objective of achieving water conservation. As noted by Louw & Kassier (2002) three points are of significant importance in DSM namely:

i. DSM focuses on socially beneficial actions in the cost- benefit context
ii. DSM integrates water quality considerations in to all considered actions
iii. DSM views water as a "demand" that can be altered by employing various strategies

DSM can be summarized in a framework where a variety of demand side strategies are employed in order to influence the decisions, habits and/or choices of end users in the context of a wide array of applications (Luten et al, 2004). There are various measures that can be categorized in relation to the incentive & tools used, implementation time horizon, location of implementation in the water supply system, the entity carrying out the measures and the sector in which measures are taken (Louw & Kassier, 2002). For simplicity, all available options can be categorized under price related measures and non-price measures. The non-price measures include: loss or unaccounted for water (UFW) minimization, water saving technology, education & awareness raising, institutional & legislative aspects.

4.4.1 Price measures

Based on the assumption of economic theories demand for water behaves like any other good and other things being equal, water use should decline with rising prices. This assumption is one basic justification for using water pricing as an economic instrument to achieve water saving and water use efficiency. It is also argued that water pricing helps to internalize environmental and social costs of water use services as well as raise revenues for public water utilities. Eventhough it may not be practically easy to arrive at, water price is realistic when it reflects all costs, and price that takes into account all costs provides the right incentive for water saving and efficiency. However, even a price that is less than the 'right one' may serve the purpose to a great extent (PRI, 2004).

As pointed out by Lallana et al. (2001) there are various types of metered tariffs that can be used of which the major ones are: flat-rate tariff, uniform tariff, two part or binomial tariff (sum of flat-rate tariff and a uniform volumetric tariff) and block tariffs (usually incorporate a flat-rate charge, plus declining block tariffs or rising block tariffs). In many cases a minimum charge for specific volume used is included as a basic allowance to ensure equity. Similar or different tariffs may also be used in combination with varying rates or thresholds varying over time according to the customer characteristics.

Renzetti (2000) argues that different price structures send different messages to end-users. A flat rate, which is an identical constant rate for all types of water uses and users for example, may lead to wasteful uses. Declining block rate where the price of water decreases with successive increases in pre-defined volumes of water may serve some purpose, eventhough it is not a strong incentive for water saving. Increasing block rates where water price increases with a pre-determined amount of water use on the other hand encourages water saving and water use efficiency (PRI, 2004).

One important factor that distorts the price of water is subsidy. In many cases, governments subsidize utilities for capital investments or operational costs based on the assumption that water is an essential social service rather than an economic good. This reduces the price of water to all consumers irrespective of water use or income. It is often argued that from an equity point of view, subsidies needed for some segments of society should be provided directly rather than through reducing the price of water. In economic terms, efficient use of water can be achieved by setting the price of water at the marginal cost which includes environmental costs. Such price can influence water users to make efficient decisions on whether to increase or maintain their water use (PRI, 2004).

Water pricing is a sensitive issue and lots of debate has been going on for quite some time. In the midst of many opposing views there are some who argue that water tariffs should be designed to encourage conservation and not simply to recover costs. By implication this means that water price should be high enough to induce a significant change in demand (see fig.4.1). Politicians on the other hand insist that water must be affordable in order for the poor to have access to it. In reality however, the poor may not benefit from low prices, because they usually buy water from vendors at higher prices since they do not often afford to have private connections. It is therefore the high-income groups who benefit from low prices. Another effect is that when water charges are low, people tend to use it carelessly.

4.4.2 Non-price measures

4.4.2.1 UFW minimization

There is no consensus among utilities with regards to common operational definition of UFW. A utility may experience UFW in it system due to various reasons such as: incorrect estimates of

water pumped or purchased due to inaccurate or improperly installed meters at the pumping or purchasing site; inaccurate customer meters; errors in records or accounting; freely supplied water with out metering and water leaks (Yepes, 1995). UFW thus refers to the physical losses of water in the form of leakage and overflows as well as apparent losses such as necessary losses (Water used for street cleaning, sewer and water main flushing, fire fighting and other public purposes), meter and billing inaccuracies and unauthorized consumption. According to Yepes (1995) one way to describe UFW is to consider it as the difference between water supplied through the system network and water sold. In other words UFW is the amount of water that a water utility diverted under its water right or appropriation and/or purchased from other entities less the metered amounts that it supplied to other utilities or end-users.

The description given above implies that not only the installation of meters is necessary for UFW management but also the reliability of the amount of UFW is highly dependent on the accuracy of metering the water produced and consumed. Metering also allows easier detection of system leaks. Taking into consideration the fact that meters are often under-read as they age and other inefficiencies of utilities, it could be argued that apparent losses are often of significant amount. However, in most cases the majority of UFW is caused by a physical loss of water from the distribution system. In any case, the amount of loss generally reflects the efficiency level of the management of a water utility. UFW minimization thus requires coherent action to address not only technical and operational aspects, but also institutional, planning, financial and administrative issues (WHO & UNICEF, 2000).

Reduction of UFW benefits, the utility the end user as well as the environment. It translates in to water to be supplied and hence the possible deferral of expansion of capacity. This eases the utility's financial pressure to finance capacity expansion. A reduction in apparent losses results in more revenue for the utility. This also leads to less wasteful consumption as a result of which consumption is likely to decrease and hence cost savings due to decrease in production and associated costs. Moreover better understanding of consumption patterns helps utilities to optimize the operation of the supply system and knowledge of the real consumption enables utilities to reach at reliable demand projections, which are vital in capacity expansion and financial planning (Yepes, 1995).

The issue of whether it is possible to achieve large savings by tackling UFW or whether it is economically feasible may be controversial. The controversy can be partly due to the supply side management bias and the cost that is involved in implementing reduction measures. There is no doubt that production and service delivery of drinking water is expensive and leakage is resource loss in the system. How ever it can be argued that leakage reduction is not always economically viable. Depending on the objective conditions of a specific water supply system, increasing production to 'feed leaks' may be cheaper than extensive pipe repairs (EEA, 2001). Decisions on choosing UFW reduction options should thus be made based on cost benefit analysis results.

4.4.2.2 Education, awareness creation & information communication

Even though economic measures such as price and incentives or disincentives contribute significantly to the success of DSM, they have to be supported with awareness raising and public education. Education and public awareness creation plays an important role in water conservation. Infact, environmental education in its recent conceptual framework generally concerns conservation of resources. It focuses specifically on the efficient & sustainable utilisation and conservation of existing resources as well as the proper management of natural systems. In its broadest sense environmental education encompasses raising awareness about the environment, acquiring new perspectives, values, knowledge and skills required for conservation, and formal and informal processes leading to changed behaviour in support of a sustainable environment (HMMPA EE Training Manual, 2002).

The concept of modern environmental education is in line with the concept of sustainable development. In its latest form, it specifically aims at influencing people's values, attitudes and behavior toward a broad range of environmental issues. Environmental education goes much further than building knowledge and understanding about the environment and its problems. This is because environmental problems are the product of highly complex, and often long- standing, social and environmental interactions such that, solutions cannot be achieved simply by explaining that the problems exist (UNDP, 1995). It must lead to action and stimulate responsible decision-making at all levels.

Thompson (1997) has argued that more knowledge helps to increase awareness and increased awareness in turn results in a motivation to act responsibly towards conservation. However, the

process of learning is not always linear. Learning may not always lead to knowledge, awareness and change of behavior since the process may not be explained in every situation. Other human factors like: values, believes, politics, culture, history, levels of technology and understanding have also significant influence in shaping human behavior (Lundgren, 1999). Moreover, regulatory measures such as laws, sanctions and economic instruments may help to some extent in influencing people's behavior. In certain situations, it may even be difficult to change peoples' environmental behavior because human beings vary in their perceptions and ways of life.

There are other critics who hold the opinion that education can seldom influence self-interest choices and help overcome selfish and uncooperative behavior, past cultural traditions or stubbornness. They argue that the continuation of environmentally harmful actions by some careless and negligent people can undermine conservation preferences by the majority. According to this argument, environmental education may be a necessary element in devising any practicable solution, but education may not be a sufficient solution by itself. Combining environmental education with economic incentive mechanisms is likely to prove more effective than exclusive reliance on education programs (Ecovitality).

Proponents of education programs on the other hand, eventhough they admit that numerous habits related to the use of water are deep-seated in most adults, claim that a well-designed public education program can help in achieving a substantial reduction in water demand. It is also argued that consumers must be reached with information through various media in order for them to cooperate or make informed decisions. Water users must understand the nature of the water problem and the solutions advocated if they are to consciously conserve water resources.

In this regard, one basic justification for including education in DSM is the assertion that it is a helpful tool for communicating information and building awareness of the society. By reaching adults with adequate information, it assumed that it is possible to achieve some immediate result in water conservation through changed behavioral practices and water use habits. It may also lead to a way of life where water is used more efficiently, thus reducing the overall water consumption at home, in business and industry. By educating school children, it may be possible to sustain if not enhance the immediate results, since today's children are tomorrow's water customers as

households and employees in institutions, business and industry. It is therefore important that they know the value of water and its wise use while they are still young.

4.4.2.3 Water-saving Technology

In addition to public education and awareness, the development and promotion of water saving technologies is an important issue that deserves due attention. Water saving technology refers to the development and application of products and innovative processes that facilitate and /or enable water saving in residential, institutional or industrial use of water. Research and development on water saving technology, which is another critical aspect of DSM has been going on for some time with the objective of finding new technologies as well as refining existing products and production processes. Experience shows that significant water saving can be made by promoting water saving technologies in households, public places and different sectors of industry (Louw and Kassier, 2002).

The two major focus areas of research in water saving technology in public water supply are household and industrial water use. Considering household use, most of the water used is for toilet flushing, bathing and showering and for washing. Although it may not hold true for poor households, the amount of water used for cooking and drinking is minimal when compared to the other uses (EEA, 2001). There is therefore a potential to conserve water by improving water efficiency of common household uses through the development and promotion of water efficient appliances such as low flush toilets, water saving taps and washing machines. According to EEA (20001) it has been possible to achieve some reduction in water consumption due to promotion of these appliances over the past two decades. Water saving appliances are however not widely used and their promotion at household level is slow.

Facilitating access to market for products and provision of reliable information to users are two important aspects of promoting water saving technologies. The educational and awareness raising activities of a DSM program should thus focus on reaching the majority of households with a good knowledge base on the role of innovative technologies on water conservation. Besides, to enhance the promotion and use of available technologies, a reduction in the cost of the existing water-saving technologies is necessary. Moreover, there should be cooperation and collaboration among all stakeholders in various ways. According to EEA (2001), one basic step that creates a conducive

environment for such a cooperation is the establishment of rules for labeling of water saving devices such as dishwashers and washing machines stating the maximum water the device uses with clear instructions about water and energy saving.

Technology can also play a significant role in improving water use efficiency in industries. It can lead to significant reduction in water demand and water saving in industry means an immediate cost saving. The type of water saving measures and the amount of water that can be saved varies depending on the type of the industry. With the help of economic instruments industries may be encouraged to shift to products requiring small water quantities in the production process, use water efficient production process or introduce recycling of water. During the last couple of decades much emphasis has been made on the industrial sector to reduce energy consumption and associated costs and protect the environment. It was however since the 1990s that improving water efficiency was considered as a means to reduce costs. Current water use efficiency programs focus on the process of production as well as on the discharges (EEA, 2001).

4.4.2.4 Enabling environment

All the strategies, which have been briefly described so far and summarized in table 4.1, have a role to play in achieving the conservation objectives of a utility. It is however undeniable that with out an enabling environment, their effect will be either minimized or temporal. A set of institutional & legal factors that affect the capacity of the utility to design and implement DSM programs in an efficient and sustainable manner should be given enough consideration for water conservation to be realized. These conditions not only refer to the implementing capacity of the utility responsible for the DSM program but also the legal, regulatory and water policy frameworks with in which it operates. Some practical examples in this regard are the enforcement of the installation of water meters at household level, water sensitive urban design and the inclusion of Water conservation in building codes.

Demand management often involves some degree of complexity, which emanates from the need to engage in comprehensive integrated programs that includes the participation of end-users and analysis of their responses to various programs. An enabling environment is thus essential to protect the rights and assets of all stakeholders (individuals, public and private sector organizations), as well as public assets such as intrinsic environmental values. As described by Global Water

Partnership (GWP) "… enabling environment is basically national, provincial or local policies and the legislation that constitutes the "rules of the game" and enables all stakeholders to play their respective roles in the development and management of water resources; and the fora and mechanisms, including information and capacity building, created to establish these "rules of the game" and to facilitate and exercise stakeholder participation …"(GWP)

Capacity with in the Utility engaged in DSM program is also of paramount importance. Implementation of DSM demands the allocation of human and capital resources as well as a conducive environment. For the effective design, implementation and evaluation of DSM programs, experts from different disciplines must be recruited and work in an interdisciplinary approach. Not only DSM must be institutionalized but also be integrated and mainstreamed in the utility structure and functions. To coordinate activities however a department or unit could be created in utilities (Brandes and Maas, 2004). Having a strong and dedicated DSM department with in the utility may be beneficial interms of better planning, implementation, monitoring and evaluation of DSM.

Strategies	Economic measures	UFW minimization	Water saving Technology	Education & awareness	Enabling environment
Components	. Price setting & review . Green taxes	. Leakage control . Reduction of other losses	. Residential programs . Industry & institutions	. Education & awareness . Information communication	. Policy & Legislation . Capacity building
Activities	Installation of meters Implementation of tariffs Price review Implementation of green taxes	Network leakage detection Network renovation Monitoring of un-metered uses Detection of illegal uses	***Households*** Promotion of water saving appliances Research & development on innovative technology ***Industry*** Water recycling Water saving production . Effluent reuse . Research	Public awareness raising Training Information communication Education for School children Other creative sensitization activities	Implementation of policy Enforcement of laws & regulations Institutional capacity building Involvement, cooperation & collaboration of stakeholders

Table 4.1 Summary of major DSM strategies

4.4. Barriers and challenges

The adoption and implementation of DSM in urban water supply management may not be a smooth road. Literature review on the experience of different countries indicates that numerous obstacles have to be overcome before DSM can be effectively introduced and bare fruit. It starts with the struggle to overcome the inertia of status quo (business as usual tendency) at the political and policymaking level as well as the traditional bias to wards supply side management at the level of executive bodies. Other major obstacles stem from the wrong perception about water. These are reflected in the form of resistance to water pricing and water use efficiency initiatives and the reluctance to embrace the role of the private sector.

Some challenges also emanate from the fact that DSM affects various groups. It therefore requires among other things the consideration of implementation costs, environmental issues, institutional development, end-user participation and legislative issues. Inaddition, information management and dissemination are important tasks that require careful and diligent handling (Okun, D.A., and D.T. Lauria. 1991). Moreover the task involves the evaluation of the incentives and disincentives, the need for frequent rate revision and demand forecasting.

4.5. Challenges with price meaures

Implementation of pricing as an instrument requires transaction and operational costs, which in some cases may outweigh the benefit. The challenge in implementing price measures is therefore to make sure that expected benefits such as reduced demand and system maintenance outweigh costs. Since implementation costs differ from place to place depending on the objective reality of a given location uniform solutions are not feasible. As noted by the World Bank: "…solutions need to be tailored to specific, widely varying natural, cultural, economic and political circumstances, in which the art of reform is the art of the possible…" (World Bank, 2004).

Louw and Kassier, (2002) consider the installation of meters to be the most basic measure used in DSM. The effectiveness of price as a DSM instrument is dependent on metering. Metering has however some implementation difficulties. In addition to the basic capital cost of the meter, which is significant except for large consumers and business enterprises, the cost of operation and maintenance is high. On the other hand, in many cases water is not metered on individual household

level, which makes setting new tariffs complex and a delicate matter. Thus resistance to water tariffs by people who are not on a metered system is another hurdles and lack of meters on individual household level is therefore an impediment to both cost-recovery and conservation efforts.

The issue of affordability is another obstacle. When it comes to water policy concerning households, considerations of both equity and efficiency of water services surface out as important issues. Different studies (Okun, 1991; World Bank, 1992; Whittington and Choe, 1992; Ingram et al., 1995) have indicated however that, the poor are both willing and able to pay for good quality water supply. These studies also reveal that in the large cities of the developing world where the poor have limited access to reliable sources of clean water, they actually pay much more for water than other residents. The conclusion of these studies indicates that in most cases, those who do not have access to public water supplies would actually benefit from paying for services if it improved their access to water.

Industries are frequently located in urban areas where water consumption is growing fast and experience shows that they tend to use water more cost-effectively than other sectors of society (The National Academy of Sciences, 1995). According to them, industries tend to respond readily to economic and regulatory incentives. In many cases, the increasing cost of industrial wastewater treatment is one major motivation for industry to embrace a water conservation program. However, increasing water price may affect the competitiveness of some industrial sectors such as food and beverage. In the absence of a uniform approach to price setting, such industries may be forced to relocate in areas where water is relatively cheap. This may affect the employment, investment and revenue aspects of an urban area and may invite political interference in the implementation of DSM programs.

The sensitiveness of Water as an essential commodity coupled with the perception that water is abundantly found and it is the responsibility of government to provide it to consumers at little or no cost creates another hurdle for appropriate price set up and implementation. It is highly politicized and governments do not easily embrace water conservation in fear of the complications that could appear as a result of pricing. It is therefore difficult for administrative bodies to allow the increase

in water prices and enforce the system of allocation, metering, and sanctions that lead to reducing demand (World Bank, 1991; Bahl and Linn, 1992).

4.5.2 Water saving technology

There are a number of barriers that hinder the development and promotion of innovative technologies in urban water management. The first is concerned with economic and financial constraints. According to OECD (2001), continuous research and development has refined water saving technology products and made them more accessible to the public. However, Not only most of these products are expensive but also their operation and maintenance may be discouragingly high. This emanates partially from the fact that research and development requires a significant amount of investment cost. Besides the costs of installing and maintaining the products, market problems (uncertainty and failures) may also affect costs and motivation for further research and developments.

Moreover, not only creating market access and encouraging the use of water saving appliances is not easy but also lack of information on latest developments and available products is a major problem. Hence, it requires continuous education and awareness raising as well as information communication efforts to convince the public that these new devices offer benefits. This process is slow requiring time and effort since the turn over of the appliances at individual household level is slow (OECD, 2001). Absence of standards and guidelines due to institutional and regulatory gaps may also aggravate this problem.

4.5.3 Institutional and Administrative Obstacles

Organizational set up of water utilities has been biased towards supply side management. DSM which requires the contribution of economists and other social scientists has not been given due attention. As a result many utilities focus on employing engineers. Other disciplines that can significantly contribute to planning and policymaking including DSM strategies are often employed at low levels in the utility hierarchy and thus have little influence. In most cases conservation is not mainstreamed in utilities and conservation units if any are provided with limited resources to promote demand management (The National Academy of Sciences, 1995).

On the other hand, in many cases utilities lack the determination and commitment to fully implement DSM due to various reasons. For example, Yepes (1995) has identified three basic institutional obstacles with regards to utilities commitment to deal with UFW. Firstly, Utilities may lack the incentive to reduce Physical loss because of subsidies provided by the government to cover their investment and running costs, which as perceived by them, lowers their cost. Secondly low water price reduces the utility's incentive to prevent unauthorized uses and to tackle loss due to leakage. The third discouraging factor is associated with the cost UFW reduction measures entail to the utility and a requirement of commitment by the utility to provide an efficient service with the possible lowest cost. However comparison of the costs against the benefits may not show the initiative to be beneficial.

4.5.4 Evaluation of DSM

Evaluation is important for the continuous improvement of any program. IFAD (2002) describes evaluation as "…a systematic (and as objective as possible) examination of a planned, ongoing or completed project. It aims to answer specific management questions and to judge the overall value of an endeavor and supply lessons learned to improve future actions, planning and decision making. Evaluations commonly seek to determine the efficiency, effectiveness, impact, sustainability and the relevance of the project or organization's objective. An evaluation should provide information that is credible and useful, offering concrete lessons learned to help partners and funding agencies make decisions...."

Measuring the impact of DSM programs or activities is an important issue. This requires the development of appropriate evaluation methods, which can enable utilities or others involved in DSM to properly evaluate the operation and effectiveness of their programs. Proper evaluations can provide useful information on costs, performance and operations of DSM programs (Pirkey & Eto, 1993). Moreover, evaluations can help to legitimize and document the status of DSM programs as reliable capacity resources (Hirst & Reed, 1991). On the other hand, with out accurate evaluations DSM programs may not lead to effective & alternatives ways.

Carefully designed evaluation methodologies are thus needed for a wide range of DSM program types. In this regard, planning, data collection, statistics as well as techniques to evaluate & analyze the data are important aspects of DSM program evaluation. Data on the long-term water

consumption as a result of DSM programs and impact evaluations as well as information obtained from proper periodic evaluations are useful to regulatory bodies, customers, stakeholder organizations and researchers (Pirkey & Eto, 1993).

According to Dziegielewski (1996), to design, implement and evaluate demand side management programs, proper knowledge of present water uses and understanding of the important factors that influence these uses both now and in the future is necessary. This presupposes the need for developing forecasting methods to support evaluation of long-term and short-term demand management alternatives. Dziegielewski further argues that "…in order to enhance the ability of water planners to formulate, implement and evaluate various demand management alternatives, the observed sector demands during a defined season of use should be disaggregated into their applicable end uses. Only such a high level of disaggregation will permit water planners to make all necessary determinations in estimating water savings of various programs…" Louw & Kassier, (2002) also support this view and indicate that there is a need for developing forecasting methods to support evaluation of long-term and short-term demand management alternatives.

4.6 Summary

Water conservation is becoming imperative due to resource limitation and environmental concerns. In response to these concerns, DSM is emerging as an appealing approach to water conservation. It is adopted to achieve efficient use of water resources and employs price and non-price mechanisms. DSM as a means of improving end-use efficiency is attracting increasing attention in water management because of its applicability to water use efficiency and environmental issues as well as its potentials to the management of scarce resources.

Implementation of DSM however, is not an easy task. There are social and economic costs incurred in order to harvest the benefits from the implementation of DSM programs. There are also many barriers and obstacles that need to be overcome. The first step in tackling obstacles is therefore to weigh costs and benefits of DSM, which is important for making appropriate decisions in choosing and implementing strategies. Another decisive measure in this regard is to make sure that there is an enabling environment. Moreover, proper planning and continuous evaluation should be considered as major tasks. Evaluation, which is decisive for continuous improvement can serve as important sources of input for the planning work.

The central question for utilities and regulators in the water sector is how to implement an overall effective DSM program that will have high participation rates and water savings at reasonable costs. Available options such as Economic incentive/disincentive measures, UFW minimization, Education and public awareness and technological innovation play significant roles in water conservation and all options should be given adequate attention. Experience shows however, that individual measures alone give limited or unsustainable results. For this reason all available and applicable DSM strategies should be used in a complimentary and coordinated manner in order to obtain satisfactory results in a sustainable manner.

CHAPTER 5 - Water supply management in Denmark

A brief introduction to water management in Denmark is given in this chapter. As a member of the European union (EU) the Danish environment and water policies are formulated with in the framework of EU policy. The discussion in this section of the study therefore starts with EU water policy framework, which is followed by a brief description of water management in Denmark. This will lay the foundation for the discussion on water management in the case study area.

5.1 EU water Policy

EU water policy has been undergoing significant changes for some time. The EU adopted a new framework directive for community action in the field of water policy in December 2000 and this is one among such major changes. The Water Framework Directive (WFD) aims at protecting and safe guarding watercourses, lakes, transitional waters, coastal waters and ground water. It is an integrated water policy to be implemented by member states. The main purpose is to protect the water resources and ensure sustainable development of water supply. It also aims at ensuring a better link between ground water and surface water. In this regard, it gives great emphasis to monitoring and quality control as well as the linkage between ground water and the terrestrial ecosystems. Besides it gives due attention to the issue of safe guarding wetlands (WFD, 2000).

With increasing vulnerability and pressures from many directions, proper and timely policy and legislative measures to safe guard water resources is an important step governments can take. The WFD aims at preventing the deterioration of water bodies, protection and enhancement of the aquatic ecosystems and promoting their sustainable use. It gives great emphasis to the protection of the aquatic and terrestrial ecosystems by ensuring a progressive reduction of the pollution level in ground water. The WFD thus reinforces and expands efforts that has been going on to protect water resources and sets a clear target for ensuring good status of water resources in all European countries by 2015 (European Commission 2002).

It is hoped that the adoption & implementation of this Directive together with other measures such as the Environment Action program, the nitrates Directive, the urban wastewater Directive & the Bathing water Directive will facilitate and enhance the protection and sustainable use of water resources (European Commission 2002). This is because the WFD has specific objectives for surface as well as ground water resources quality improvement. For example it sets target for the removal of priority pollutants, which are about 40 - 50 toxic substances with in 10-15 years (WFD, 2000). Another objective of significant importance to water management is the cost recovery and water use information management. The WFD states that member states shall take account of the principles of cost recovery for water services and the 'the polluter pays principle'. Accordingly, water service cost has to include environmental and resource costs. In this regard, the WFD has set 2010 as a deadline when member states should ensure:

i. that water-pricing policies provide appropriate incentives that can encourage the efficient use of water.
ii. the water use data is disaggregated atleast showing the consumption share of industry, households and agriculture

The Directive has also identified specific strategies, which member states can implement to achieve the objective of ensuring a good ground water chemical status. It indicates that the parliament and the council shall adopt specific measures against pollution of water by pollutants posing risk to or via the aquatic environment. For such pollutants, measures should target at the reduction of hazardous substances or phasing-out of discharges, emissions and losses. In connection with this, it indicates that the parliament and the council shall adopt specific measures to prevent and control ground water pollutions.

In General the WFD is an important legislative measure taken to protect fresh water resources in the EU. It obliges Member States to meet a holistic ecological objective, i.e. to achieve good status of water resources. However, since the WFD is a general 'framework' it needs to be transposed in to national laws and has to be translated into concrete objectives and actions at local level. This implies that there will be room for manoeuvre by member states in the process of transposition and implementation on national and regional levels. For this reason organizations such as the European Environment Bureau and WWF, eventhough they strongly support the WFD, remain skeptical as to

whether governments will actually implement the directive fully and improve the condition of the aquatic environment as stipulated in the WFD (WWF & EEB, 2005).

5.2 Water management in Denmark

Denmark is an agricultural country where over 67 % of the land is cultivated and about 85 % of the population lives in towns and cities (NERI, 2001). During the past century, land use has significantly changed and this has influenced the Danish environment. As indicated by NERI (2001), urbanization, deposition of waste, application of fertilizers, manure and sewage sludge and atmospheric deposition have affected the terrestrial environment. Nutrient loading and hazardous wastes that affect the quality of water, and the flora and fauna have entered the aquatic environment from agricultural sources via atmospheric deposition, runoff from fields and leaching to the groundwater, as well as from urban wastewater, separate industrial discharges and sparsely built-up areas. To redress the damage caused, the country has given special attention to environmental protection since the last couple of decades.

Denmark has a highly decentralized administration. The country is divided into 13 counties and 271 municipalities. Three municipalities have county privileges: Bornholm regional municipality, Copenhagen and Frederiksberg. Copenhagen County comprises the municipalities of metropolitan Copenhagen, except Copenhagen Municipality and Frederiksberg Municipality. Bornholm Regional Municipality comprises the five former municipalities on the island of Bornholm and the island's former county. Since the reform of the late 1960s, the counties have been playing important roles. However, the Danish Municipal Reform, which will take effect on 1 January 2007 will replace the counties with five new regions and reduce the number of municipalities to 98. The new municipalities will take over most of the responsibilities of the former counties (Wikipedia, 2006).

At national level it is the parliament, which decides on the organization and legislation issues regarding the environment while the supreme authority of controlling and monitoring is given to the Danish Environment Protection Agency (EPA). Under the central authorities the two levels of authorities responsible for water and wastewater services are the regional councils and the municipalities, which the regional councils oversee. Regional councils act as environmental authorities, which grant permission for water works and waste management initiatives. Previously, they use to supervise the municipalities through the approval of local waste management plans.

After 1990, their role has been limited to preparation of overall regional plans. The regional councils are responsible for the proper use and protection of water resources in their respective regions, including the issuance of extraction permits and monitoring the quality of water. Under the provision of the Danish environmental protection act, municipalities are responsible for the planning and administration of all water works and waste management in their area in compliance with all the laws and regulations. They can also operate the utilities for water supply and sewerage systems and take responsibility for the infrastructure, distribution and discharge of water and wastewater in the from of cooperatives or municipal utilities.

Water related regulation in Denmark dates back 147 years, where the first regulation in hygiene and water was issued followed by the Sewer Act of 1907 which gave municipalities the authority to establish sewer networks and charge polluters (Andersen, 1994). According to Andersen, the Water Course Act of 1949 was another major step, which vested authorities with the competence to require licences for discharging urban industrial waste in to the surface water bodies. It also mandated the treatment of discharge to control water pollution. However environmental concerns increased during the 1960s and the government established a council called the Pollution council whose main task was to analyse the country's environmental problems and make recommendations. The council's recommendations led to the establishment of a ministry for pollution, which was entrusted with the drafting of a proposal for modern environmental legislation. The outcome was the Environment Act, which came in to effect on October 1974 as well as the establishment of the Ministry of the environment (Andersen, 1994).

According to him, this Act gave power in most practical matters to local authorities. Local municipalities were also made responsible for sewage treatment and inspection of industries. More over they were delegated to set standards within the framework of the Act and the EC directive inorder to protect the quality of the water resources. In the implementation process local authorities were required to present plans for their future activities in sewerage treatment and water quality control, with in the framework of the comprehensive planning system and under the regional plans. The plans were also subject to the approval of the counties and the minister of the environment. This Act replaced fragmented water regulations by a general Environmental Act and has contributed in many ways to the protection of the environment.

Another important step, which is considered as a turning point in Danish pollution control history, was the approval of the plan for the aquatic environment in 1987 where mandatory measures were enforced (Andersen, 1994). Since then nutrient loading discharge to the aquatic environment has fallen significantly. Policies, regulations and monitoring measures targeting the reduction of sewage, application of fertilizer & pesticides as well as industrial waste implemented in the past have contributed to the improvement of the environment. As a result the environmental quality of watercourses and lakes has generally improved (NERI, 2001). The WFD, which came in to effect in 2000 and was transposed in to Danish law in 2003 will enhance the protection of the Danish environment in general and water resources in particular (Ministry of environment, 2004). Even though the environmental quality of many of the water bodies is still not good, the implementation of the environmental policies and regulations will obviously result in the improvement of the quality of water resources (NERI, 2001).

5.2.1 Public water supply in Denmark

Ground water is the main source of Danish water supply system. The report on the state of the Danish environment by NERI (2001) indicates that, out of the total yearly consumption of 726 Mm^3 in 2000, only 16 Mm^3 was obtained from surface sources. According to DWWA (2001) the total extraction of drinking water supply in Denmark in 2001 was 416.3 Mm^3 of which 254.2 Mm^3 was extracted by the public water supplies and 162.1 Mm^3 by private water supplies. The supply system is based on the cooperation and collaboration between municipal and private water utilities as well as companies. In most cases the private cooperatives cater for the villages while the public utilities supply towns in the more densely populated areas. Private wells are also common in the rural areas.

On country level, water scarcity may not be a concern in Denmark. Interms of quantity, the sustainably exploitable water resource is greater than the total water abstracted. There are however variations in the amount available in different parts of the country. While there is adequate resource in some parts, in other areas such as Copenhagen the water resource is overexploited (NERI, 2001). As the owner of all water resources, the government has established a legal system for the safe extraction & provision of water supply to all citizens. In connection with this, the water Act of 1999 clearly defines the roles and responsibilities of public bodies. In addition to putting in place adequate legislation and thorough planning system to ensure safe and reliable supply, the

government makes sure that all Danish water is routinely monitored by the water works and authorities in accordance with EU and WHO standards (Danish EPA, 2001).

Historically, water abstraction and consumption had been increasing since World War II upto the 1970s. One example, which clearly shows this trend, is the water consumption in Copenhagen, which doubled between the Second World War and 1970 (NERI, 2001). However it remained relatively constant during the 1980s and has been decreasing through out the 1990s. According to NERI, the total water abstracted from ground water resources was about one billion m^3 in 1989. This figure has fallen to 710 Mm^3 in 2001. Since 1989, household consumption has also declined by 30 %. The reduction is attributed to two major factors: less water abstracted by municipalities and relatively wet summers during this period, which has reduced the demand for irrigation water. A green tax on mains water and a wastewater tax have also been introduced since 1 January 1994 and 1 January 1998 respectively. Water consumption by industrial enterprises, which have their own supplies systems, has been relatively constant at about 90 Mm^3/y. This is because over the past two decades many of them have invested in cleaner technology in order to reduce water consumption (NERI, 2001).

According to the Danish ministry of environment (2004), the water supply in Denmark is highly decentralized with about 2850 communal water works and approximately 90,000 individual private water supplies located through out the country. The decentralized approach contributes to good ground water and drinking water quality in many parts of the country and allows consumers to watch the quality and take responsibility in identifying possible threats and their solutions. Local authorities often own most of the large water works and consumer cooperatives operate with boreholes that have a depth of 20-200 meters. Inaddition, approximately 70,000 private wells each serving at least 10 households abstract water from shallow wells.

The Danish public wants to be supplied with drinking water from unpolluted ground water sources and the current quality of ground water is generally good eventhough, pollution from agricultural activities and chemical wastes from various sources threaten it. For this reason, over-abstraction and pollution still remain as issues of concern. In major cities such as Copenhagen water abstraction is more than the ground water recharge. As a result the ground water table has dropped and local

streams have been drying out during summer, which has lead to a number of problems in the local environment (Danish ministry of environment, 2004).

Public or municipal authorities manage most of the waste generated. Interms of origin, about half of the sewage is generated from households while the remaining half is of industrial origin. The sewage network is of two types: combined sewer (rainwater and sewage combined) and separated sewer systems (rain and sewage separated). Treatment is done in plants which discharge treated effluent in to surface water bodies. Excluding very small ones about 1600 treatment plants take care of the sewage treatment in Denmark. Out of these, the local authorities own about 1400 while the remaining are large industrial treatment plants (DWWA). The small treatment plants are being replaced by large treatment plants equipped with advanced technology due to the increasing requirements of effluent quality as per the new environmental regulations. According to DWWA, it is estimated that the treatment plants treat about 600 – 800 Mm^3 of sewage every year.

Leaching of nitrates and pesticides from cultivated land and more restricted contamination from point sources such as waste from chemical deposits, landfills, oil tanks and contaminated sites are among the major sources of contamination. Moreover, the presence of salt in deep ground water and in sources located near the cost can restrict abstraction of water for drinking and if abstraction is excessive, salt intrusion can become a problem. Salting of roads during winter also increases local concentration of salt. Inaddition to sulphates and fluorides, which occur in some areas, depending on the soil type inorganic trace elements including metals also occur in ground water in a high or low-level concentration among which are nickel, zinc & aluminium (NERI, 2001).

Human impact on the environment and specifically pollution of ground water caused by industrial wastes, sewage from households and agriculture has been significant through out the previous century, which has affected the availability of ground water resources. Due to efforts made during the last couple of decades however, it has been possible to reverse this situation. Improved water treatment and reduced use of fertilizers have led to significant improvement of the quality of water resources. The Danish ministry of the environment has launched a number of initiatives to protect the water bodies and tackle the pollution that threatens the quality of water. As a result not only has water quality improved but also consumption has decreased to the extent that Danish households

currently use only about three quarters of the water they used about a decade ago (Danish ministry of environment, 2004).

Danish environmental policy considers clean water as an important policy issue and gives due attention to prevention and protection measures. This can be witnessed from the budget allocated every year where about 25 % of the total expenditures on environmental initiatives is spent on activities related to water management (ministry of environment, 2004). According to the ministry, since almost all drinking water comes from groundwater sources, there is a strong commitment to protect it both by limiting consumption and by protecting it against pollution. In the future, the WFD, which was transposed in to the Danish law in 2003 will play an important role in reinforcing these efforts and thus protecting the environment.

5.2.2 Water conservation in Denmark

In the 1990s, Denmark had an average yearly consumption of about one billion m^3. With in a period of about a decade the consumption had decreased to a yearly consumption of about 650 Mm^3 in 2002 where households, industry and agriculture consumed about one-third each (Danish EPA, 2003). According to DWWA (2001) out of the total public water supply consumption households consumed about 61 %, industry 26 % and institutions 7 % while the remaining 6 % was UFW. However, around big cities, the volume of water abstracted still exceeds the safe limit. Practical examples are northern Zealand and Copenhagen area where ground water over-abstraction is estimated to be 80 M m^3/y (ministry of environment, 2004; GUES).

Water consumption has fallen by about 40 % since 1989 due to water conservation initiatives (Danish EPA, 2002). The impetus for these efforts was the increasing contamination of the ground water and excessive abstraction, which in some areas has been lowering the water table. Efforts were thus needed to protect the water resources and influence consumption including minimization of water losses. In this regard, a number of measures have been taken. As a result of the different measures significant reduction in consumption has been achieved. For example during the period from 1992 to 2001, a reduction of total consumption from 101.2 m^3/c/y in 1992 to 77 m^3 /c/y in 2001 has been achieved, the large part of the reduction being as a result of a decline in household consumption (DWWA, 2001). According to DWWA, despite the overall reduction in consumption, industrial consumption has risen from about 21 % in 1992 to 26 of the total production in 2001.

Table 5.1 shows some of the achievements made in water consumption in a period of about a decade.

Water use category	Water consumption		Reduction in consumption	
	1992	2001	Volume	%
Total consumption (domestic, industry and agriculture)	101.2 m^3/c/y	77m^3/c/y	24.2 m^3/c/y	24%
Households	158 l/c/d	128 l/c/d	30 l/c/d	19
Institutions	8 m^3/c/y	5.6 m^3/c/y	2.4 m3/c/y	30

Table 5.1 Achievements in reduction of consumption at national level
Source: DWWA (2001)

Green taxes and the instalment of meters at individual houses have created an enabling environment to monitor and reduce losses. Since the legalization of the instalment of water meters in individual houses in 1998, a large number of meters have been installed. The green tax on drinking water is a uniform rate, while the amount of green tax on wastewater depends on the degree of treatment required. Green tax is serving as an economic incentive for the utilities to make utmost effort to reduce losses while the installation of meters helps to monitor and locate losses. As a result, according to DWWA (2001) water loss has declined from 7.9 m^3/c/y in 1992 to 5.2 m^3/c/y in 2001, which is a decline from 8.4 % to 6.4 % during this period.

5.2.3 Water service fee

The price for drinking water is determined on cost recovery basis while wastewater fee is influenced by the cost of treatment. As a result, water service fees vary from place to place or from supplier to supplier. For drinking water usually a variable and fixed fee is paid. The average variable drinking water fee was DKK 4.37/m^3 and DKK 4.50 /m^3 in 2001 and 2002 respectively while the fixed water fee was on average DKK 315 in 2001 and DKK 329 in 2002 (DWWA). For the sewage normally a variable fee is paid. However, according to DWWA (2001) a fixed fee was also introduced in 2001, which is being applied by more and more utilities and the mean variable waste water fee in 2002 was DKK 15.39 /m^3.

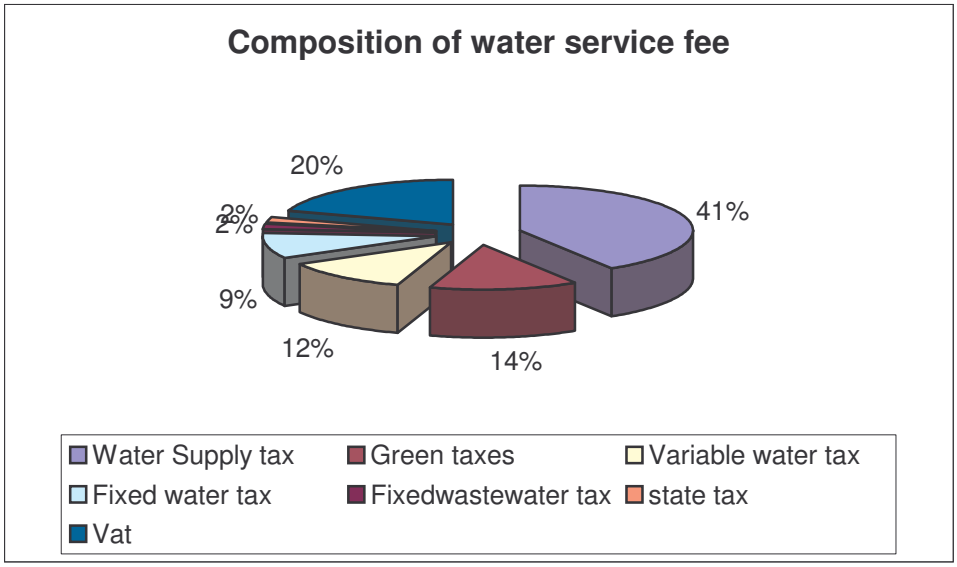

Figure. 5.1 Composition of water service fee in 2002
Source: Danish EPA

Consumers receive one bill for drinking water, wastewater, green tax and VAT. According to KE & DWWA, in total the average water price has increased form DKK 30.16 /m^3 in 1998 to DKK 34.41/m^3 in 2006 and the maximum and minimum values observed in 2002 were DKK 65.66 /m3 and DKK 24.95/m3respectively. In 2002, the composition of the water price was as shown in figure 5.2.

5.3 Summary

Ground water is the main source of public water supply in Denmark and inaddition to the different taxes, the price of water is determined on cost recovery principle. The country has a highly decentralizred administrative as well as public water supply service delivery system. Appropriate laws and regulations required to protect and manage the water in a sustainable manner are in place. Water conservation efforts have been going on for some time and as aresult the total water abstraction and consumption has been declining. In this regard the WFD which is an important water policy frame work in the EU and which has been transposed in to the Danish law in 2003 will strengthen ongoing efforts.

CHAPTER 6 - DSM in Copenhagen water supply

This chapter introduces the case study area and describes the DSM activities, which are considered for investigation. It is based on the interview made with Jens Peter as well as information obtained from KE's annual reports and other relevant sources. After a brief introduction to the case study area, it highlights some water management aspects followed by a brief description of the different components and activities of the water saving campaign implemented in Copenhagen. It also tries to summarize the major achievements made so far and the challenges and barriers faced in the process. In so doing it tries to highlight important issues that will be used in the analysis.

6.1 The city of Copenhagen

Copenhagen is the capital city of Denmark, which was founded in 1167. The city currently covers an area of 91 km^2. It has about 502,362 residents while the greater Copenhagen region has a population of 1,827,239 and covers an area of 2865 km^2 (Copenhagen in figures, 2005). As shown in figure 6.1, the population had been steadily increasing up to the 1950s. The population of Copenhagen then declined until 1980 while that of the Greater Copenhagen continued to grow. Since the 1980s the population in Copenhagen seems to have stagnated where as there is a steady growth in the Copenhagen region.

Copenhagen has a temperate coastal climate with an annual average rainfall of 613 mm. Temperature in January is about 0 c^o on average. But it can be as high as 17 c^o at other times. The air quality in Copenhagen is highly affected by increasing traffic. Eventhough it has been possible to reduce the emissions from sources such as power and heating plants, emission from traffic is still a problem. The introduction of innovative devices to reduce emission has not brought significant change so far due to increasing diesel traffic. Electric energy consumption has been steadily increasing over the past decade while gas and water consumption have decreased significantly. The two biggest economic sectors in the city are the finance and public and private services.

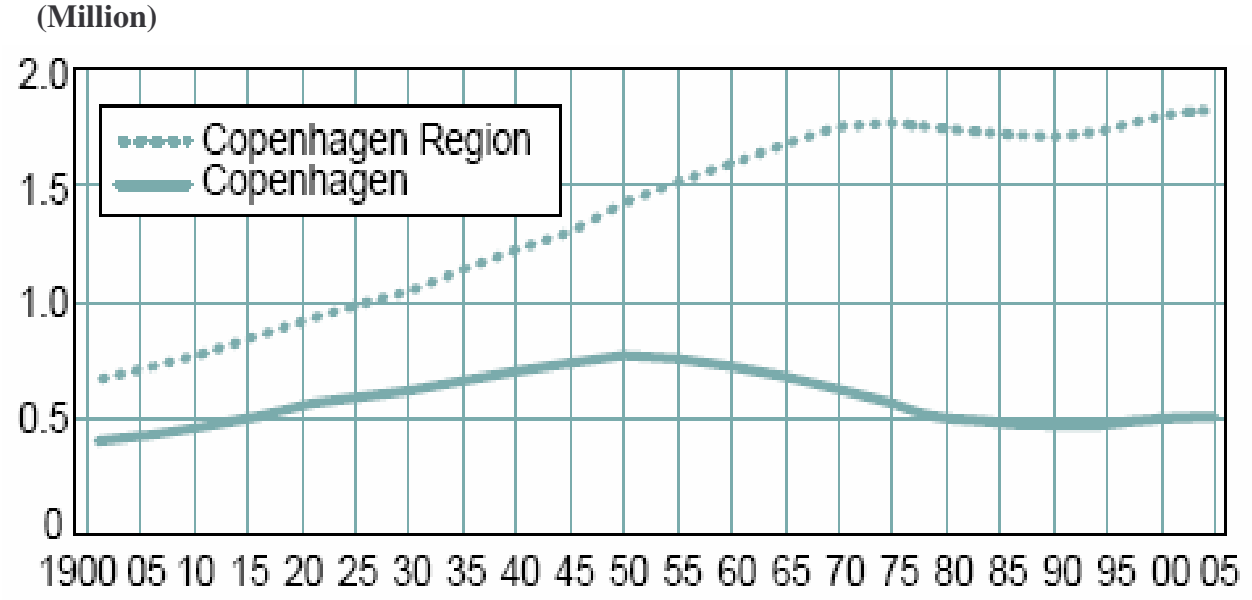

Figure. 6.1: Population growth in Copenhagen
Source: Copenhagen in figures, 2005

Since the reform of the 1970, Denmark is constitutionally divided in to 13 regions (counties) containing 271 municipalities where municipalities such as Copenhagen and Frederiksberg have a special status. Together with the surrounding counties they form the greater Copenhagen area in which a superior regional council decides on matters of common issues such as the utilization of water resources and planning of public transport. The greater Copenhagen area comprises 52 municipalities with approximately 1.83 million in habitants. In a recent development, the Danish parliament has approved a reform of the framework for public tasks and public service, which will be implemented in 2007. Based on this public sector reform, the counties will be dissolved and five regions will be established (see annex II). Larger and more sustainable municipalities will be given the responsibility to handle most of the citizen-related tasks.

6.2 Water Supply in Copenhagen

6.2.1 Historical background

Modern style of water works started in Copenhagen in 1859 with the replacement of a primitive system of bored wooden pipes. The water, which came from a stream and the springs along it, was treated with sand filters and pumped to the city through cast iron pipes. Since then water consumption continued to increase and reached approximately 11 Mm^3/y in 1900 (CW, 1989). It was thus found necessary to augment spring sources with water pumped from the Søndersø Lake, which later was replaced by borehole sources due to algae, and bad taste problems. Water consumption continued to increased after 1900 due to different factors among which were: Population growth, change in life styles, incorporation of new areas in to the city and agreement with the municipality of Frederiksberg on water delivery. In 1939 the water consumption reached a level of approximately 56 million m^3/y and new water works as well as expansions were carried out (CW, 1989).

Like many other parts of Denmark the source of water supply for Copenhagen is ground water. The first legal provision for the management of ground water was given by an Act of parliament in 1926. By this act ground water resource was nationalized and apart from the private landowner's right to abstract and use ground water for domestic purposes, permission to abstract and use ground water for public water supplies, industrial uses etc became mandatory. Inaddition, this Act included regulations for expropriation of property, building of water works and protection of ground water against pollution (CW, 1989).

The period between 1939 and 1972 was characterised by rapid growth in water consumption as well as expansion and growth of water works including surface water abstraction. Not only water consumption continued to increase after the Second World War but also the population in the city reached 756,000 in the1950s. Moreover, Development and population growth in the surrounding municipalities increased pressure on Copenhagen water supply to increase the water delivery. As a result, total consumption drastically increased to a level of approximately 100 M m^3/y in 1971 of which Copenhagen's requirement was 64 million m^3/y (CW, 1989). The distribution to all

consumers in the city was run by Copenhagen water (CW), while in the other areas the municipalities themselves managed the distribution.

Significant changes also took place in the working conditions of the utility during the period 1972 to 1984. The energy crisis that was encountered during this period made energy conservation a necessity and led to general economic stagnation and population decline. As a result, there was a substantial decrease in total water consumption. On the other hand, the 1974 environment Act put the responsibility of the management of water resources and the environment in the hands of the political authorities that were also mandated to do the planning for the proper utilisation of water resources.

This was later replaced by the water supply Act, which came in to effect on 1 April 1980 and gave the municipal authorities the responsibility to prepare plans for the organization of the water supply systems with in their respective territories. It also mandated the regional authorities to produce plans for water abstraction. Regional plans however needed the approval of the minister of the environment. The regional authorities were given the freedom to extend existing water works, regroup their areas of supply and create an environment of cooperation among the water works irrespective of whether they are private or municipal (CW, 1989). On the political arena, environmental concerns continued to gather momentum through out Denmark during the 1980's as a result of which issues related to water pollution and over-abstraction were brought to the attention of the general public (Andersen, 1994).

6.2.2 Institutional set up

Based on the existing administrative set up, the national government sets the overall guidelines for the activities of the local and regional authorities and approves regional water development plans. The regional authorities on the other hand are responsible for the overall management of the ground water resources and approval of municipal water supply plans taking into account their regional water development plans. The local authorities are responsible for supplying water and preparing detailed water supply plans, in which they describe how water is to be supplied to the consumers, which water works shall operate, etc. Their responsibility also includes assessment of the future consumption of water broken down into user categories; such as private households, industry and agriculture. (Napstjert, 2002)

CW, which was a public utility under the city council of Copenhagen, had been responsible for the supply of Water to the city and many of the surrounding municipalities until very recently. The merger between Copenhagen sewer and CW became effective in 1999 while Copenhagen energy (KE) was reorganized after the electricity Act. KE, which is also owned by the municipality, has been responsible for the operation, maintenance and expansion of the city's district heating, electricity and gas supply systems. Both companies had been accountable to the city council through the Energy, Water and Environment Committee (Copenhagen commune). In June 2000 merger between KE production units was made. Further more, a decision to merge KE and CW was implemented in March 2001 under the name KE. This company has since then emerged as a multi-utility public entity taking care of electricity, town gas, district heating, water, sewer and telecommunications (Napstjert, 2002).

6.2.3 Water demand management in Copenhagen

6.2.3.1 Water abstraction and consumption trend

KE owns seven waterworks with related well fields for water abstraction and treatment namely: Copenhagen, Regnemark, Thorsbro, Lejre, Marbjerg, Sonderso and Slangerup (see Annex - III). Currently KE supplies water to Copenhagen city, Frederiksberg and 18 other municipalities in the surrounding. Water is extracted from 700 wells located on 55 well sites in Zealand. The water is pumped to the seven water works where it undergoes aeration and filtration before it is delivered to consumers. An additional supply of about 2 to 4 % of the total annual water requirement is obtained from Haraldsted and Gyrstinge lakes in central Zealand, which is treated at the waterworks in Regnemark (Environmental profile, 2002). According to Napstjert (2002), water is supplied through a pipe system consisting of approximately 366 km transport network and 1084 km town network.

KE Supplies water for household, business and industrial consumption in Copenhagen and the surrounding municipalities. Water abstraction and delivery data obtained from KE indicates that after a long trend of increase, Water consumption in Copenhagen and the surrounding municipalities has been decreasing almost every year for the last couple of decades. Correspondingly, the total water abstracted and delivered to consumers has been decreasing. In 2004, the total amount of water produced was 59 Mm^3. Out of this amount, 32 Mm^3 was delivered

to consumers in Copenhagen city. The remaining 27 Mm^3 was supplied to Frederiksberg and the other municipalities (KE).

Households consume much of the water supplied to Copenhagen. The next major consumer is industry followed by institutions while the water loss is small compared to other EU countries. Concerning the household consumption, based on empirical assessment made by KE, water used in the bathroom i.e toilet flushing and bathing, accounts for more than 60 % of the household consumption (KE).

The decline in total water consumption is primarily attributed to a substantial reduction in household water consumption. In 1991 and 2000 the household consumption amounted to 164 and 134 l/c/day respectively, which shows a decline by approximately 20%. The consumption in institutions has been reduced by 31 % in the same period while that of industry has risen from 20.6% in 1991 to 24.2 in 2000 (KE). The change in industrial structure, which has resulted in a number of relocations outside Copenhagen, had its own impact on the general trend of the water demand. Napstjert (2002) has indicated that the water works themselves have also reduced their water consumption from 3 % in 1991 to 2.4 % in 2000 by implementing a water treatment system for the reuse of water.

6.2.3.2 Water price

Water and wastewater fee is determined on cost recovery principle where the consumer is made to pay a fee for the water supply and the wastewater services. It is periodically reviewed and implemented after approval by the regional authorities. The consumer receives one bill for drinking water and wastewater including tax and VAT. The water price has been increasing continuously for a long time except for slight decreases in 1996,1997 and 2003 as shown in figure 6.2.

Components of water price	Cost per m^3 (DKK)			
	2003	2004	2005	2006
Water cost	6.86	7.07	7.35	8.09
Ground water protection	0.50	0.50	0.50	0.50
Water service fee	5.00	5.00	5.00	5.00
Waste water treatment cost	10.70	11.20	11.28	13.54
Wastewater service fee	0.40	0.40	0.40	0.40
Tax	5.87	6.00	6.13	6.88
Total	29.33	29.99	30.66	34.41

Table 6.1 Composition of water service fee in Copenhagen (2003-2006)

Source: Copenhagen Energy

All water supplied by KE is charged based on meter reading on a group or individual level, since not all households have individual water meters. In 2004, KE had 33,000 billing customers in Copenhagen (KE annual report, 2004). Table 6.1 gives detail information on what costs constituted the water bill during 2003 - 2006. Comparing the price of water in 1988 with that of 2004, it has increased by more than 200%. High standard treatment requirement of wastewater, which led to increase in treatment cost of sewage and the addition of state taxes are some of the explanations given for the continuous increase of the water price in Copenhagen

Currently, household water consumption is taxed uniformly through out Denmark. However, as described in the English summary of 'The Danish Economy, Autumn 2004' there is a proposal to introduce taxes that are differentiated in such a way that the highest taxes are levied upon consumers in areas of greater water scarcity such as Zealand (Danish Economic Council). This document also indicates that tradable extraction permits could be considered. Eventhough it is not easy to predict the effect of this proposals before undertaking a detailed analysis of the over all price structure, the implementation of a differentiated tax may imply that water price in Copenhagen region will remain high, as this is the region currently experiencing overabstraction

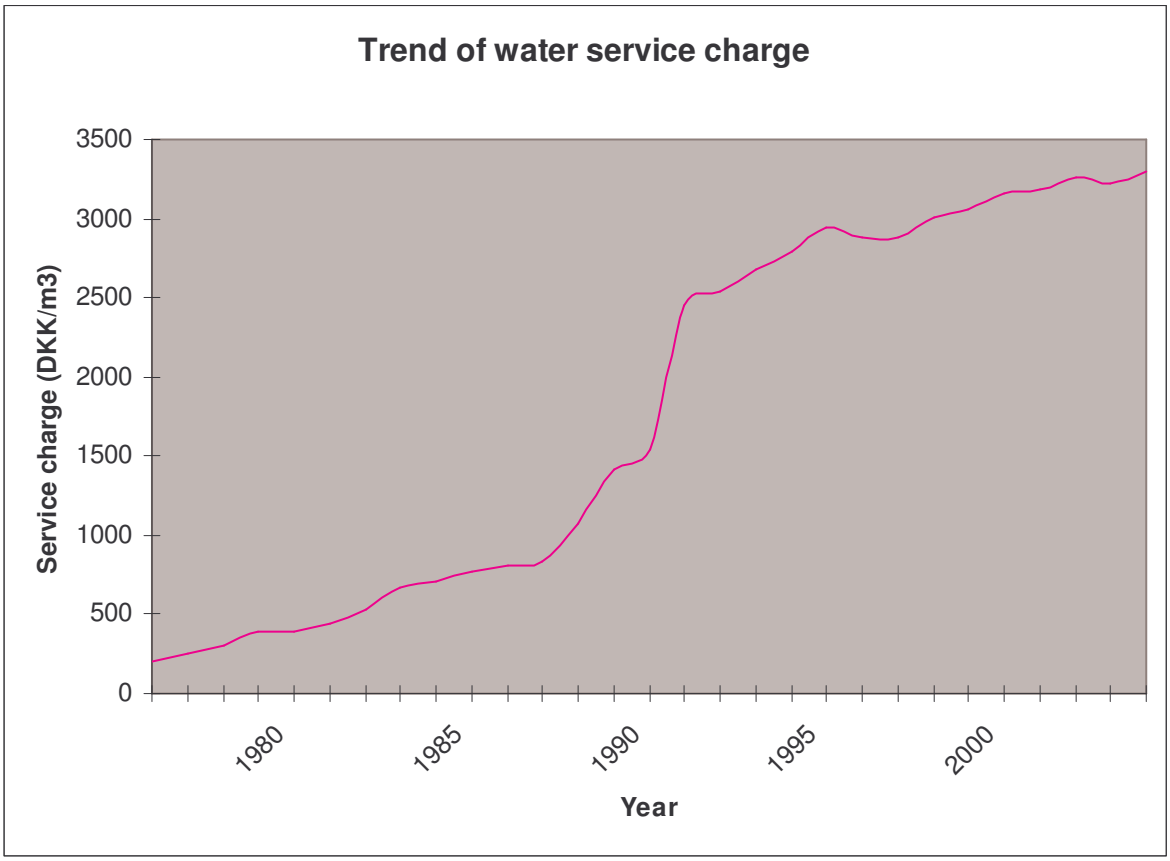

Figure 6.2: Trend of water service charge in Copenhagen

Data source: (KE annual reports; Schroeder, 1995)

6.2.3.3 Water saving campaign

Since the time when water pollution emerged as a priority issue in the Danish political agenda, pressures had been increasing on the water supply and sewage utilities of the city. EU Directive as well as national regulations adopted required higher quality standards for drinking water & effluents. Among such pressing regulations was the "Action Plan on Nutrient pollution of the Danish Aquatic Environment" which came in to effect in 1987. The city had therefore to develop and implement water supply plans and strategies to meet the requirements and ensure sustainable water management. Accordingly, a number of measures have been taken during the last couple of decades to conserve water in Copenhagen one of which is the water saving program commonly referred to as the 'water saving campaign', which has been going on since 1989.

The water saving campaign thus came as a response to the growing pressure on the city from different directions. There had been a growing concern not only about the over-abstraction of ground water resources that led to negative ecological effects in the localities of the well fields but also the shrinking potential of ground water resources due to pollution. The effects of over-abstraction on nature had already become visible in the well field areas and the issues had been linked to the renewal of licence for future ground water abstraction for Copenhagen water supply. The water saving program thus evolved as a strategy from the sustainable water management plan of the municipality and was conceived primarily to respond to these concerns and ensure the sustainable use of water resources.

The main objective of the water saving campaign is thus to reduce the water consumption in Copenhagen through the implementation of various initiatives that can lead to change in consumers' attitudes and habits with regards to water consumption so that adequate and clean water supply can be secured to the public in a sustainable way. The main targets of the program are households due to the fact that they account for not less than 60 % of the total water consumption. Water consumption per day per person (l/c/d) was chosen as an indicator to define the baseline, set goals, monitor implementation and evaluate the process as well as the outcome of the water saving campaign. This indicator was also found to be a simple tool for communication with the target groups in the process of undertaking the different initiatives, which are described below.

6.2.3.3.1 Public awareness creation & information communication

The overall objective of this component is to create awareness among all consumers on the efficient use of water and to promote water saving practices and devices by undertaking different campaigns through advertisements on newspapers, taxis, buses and trains; radio; TV - spots; leaflets sent to households; exhibitions etc. Numerous campaigns have been carried out since 1989 to educate consumers on water savings and the water cycle in general. These component also includes provision of consultancy services on water saving and demonstration of alternative ways of using water locally.

The communication methods used are diversified. For example, posters are put on appropriate places in apartment blocks with fact sheets about water consumption and advice on how to save water. Moreover, in cooperation with the municipalities, which get their water supply from Copenhagen, a program known as capital area program has been implemented. This program focuses on major campaigns on the 20th and 21st week every year and uses the distribution of T-shirts, leaflets, and slogans on water conservation to achieve its objectives. A documentary film on the water cycle has also been produced for promotion purposes. The main theme of all the campaigns is the need and justification for reducing the prevailing water consumption

The Internet is another media through which information on water saving is provided to the public. The Copenhagen commune home page provides some information and messages on water saving. It is however the KE home page, which provides information on different aspects of water saving. It gives basic lessons on the different household uses of water and indicates where the potential of saving much water lies. Inaddition to the messages and advice on why and how wastage and overuse should be avoided, it provides with a facility, which helps households with out individual meters to have an idea of how much water they consume. By inputting data on household size and water use habits the program enables the customer to have an idea of her/his daily consumption. By comparing it with an average consumption in the city the facility gives advice depending on the out come of the comparison. The web site does not have a counter to record the number of visitors and there is no data on how many people visit it in a given period.

6.2.3.3.2 Consultations

Consultation is another component of the water saving campaign, which was set up in 1994 with the main task of providing advice to companies & housing associations; participating in various committee works and exhibitions; and publishing information on water conservation. So far this section has provided consultation to housing cooperatives, tenants associations, companies, institutions and households. To make the service more effective surveys have been carried out in some areas to obtain information about the water consumption in single states. This helped the program to identify blocks or districts with significant consumption larger than the average district or block consumption. The identified areas were then considered for priority attention and

discussions were held with owners and consumers. Advice was also given on how to reduce consumption depending on the outcomes of the discussions.

6.2.3.3.3 Program for school children

School children are among the target groups of the program. In 1997 a school unit was established in CW to work with schools. The primary objective was to reach out school children with information on water saving. The unit started its task by contributing educational materials to the school curriculum. Initial efforts targeting school children focused on campaigns and teaching material on water saving specifically prepared for schools. In cooperation with other utilities a new program has been designed to reinforce the school curriculum on natural science education and will be launched in August 2006. The efforts towards school children have been further strengthened through the establishment of an independent education and exhibition centre where children can go on excursion and learn more on water and water saving. This was made possible by changing a decommissioned old water plant located in Valby in to an exhibition and experimental school (Energi og Vand værkste-Det) for school children.

The school started its service with indoor activities and later added outdoor space. Recently a new building with a laboratory and office facilities has been added. The laboratory facility was required inorder to use the near by lake for teaching and experimental study for the children. An old sewer line in the basement of the buildings has also been changed in to a sewer tunnel where children are taught about sewage. The major facilities available in the water and sewage section are: a place where students measure how much water they use while brushing their teeth; a toilet model; computers to play water saving games; a model showing the uses of water, sewage generation, wastewater treatment and discharge to surface waters; ground water laboratory with computers and video film; and a model of the water cycle.

The school is currently organised in such a way that students can learn not only about water saving but also about energy and other environmental issues. It consists of sections with facilities for teaching on water, sewage, electricity, gas, heat and renewable energy. It is managed by a board composed of two members from Copenhagen energy and two from the finance bureau of the commune and has its own chairperson and secretary. Its budget comes from both KE and the commune.

The school has now become an interesting excursion site for school children because of its exciting indoor and out door space including the laboratory facilities. It has been attracting many schools in Copenhagen area and this has created a wide opportunity for the program to reach more children with environmental awareness and water saving messages across the region. The school can host upto 10,000 students in a year and has developed a web based booking system where schools can easily book to use the facilities according to their annual academic schedule. About 3500 children have visited it in 2005 and it is already booked for 5000 students in 2006. The general trend shows that the number of students visiting the school is increasing from year to year.

6.2.3.3.4 Support program

One of the basic factors that affect the progress of water conservation efforts is the existence of water meters at individual household level. In Copenhagen, not all consumers have water meters on individual household level. For this reason, inaddition to provision of information and consultation, the water saving program encourages the installation of water meters. An incentive mechanism known as the support program has been designed to enhance the installation of water meters, which is being implemented with an annual budget of DKK 1 Million. Any customer wishing to install a water meter is supported with about DKK 500 - 1000 to cover some portion of the installation cost as an incentive. KE estimates that the water saved by customers who have benefited from the support program could be about 25%.

6.2.3.3.5 Cooperation & collaboration with Stakeholders

One task under this component is cooperation with intermediaries such as groups or organizations, which have contacts with households because of their service and may influence the household consumption of water. Activities in this regard include meetings with plumbers association, which aim at informing them about possible water loss in households and about the technical possibilities to reduce water consumption. Similar cooperation has been established with home-helpers who can give information on leaks in households, which they discover in the process of their service. They assist in reporting on leaking taps or toilets to KE who would contact a caretaker.

The effort to establish local water collaboration partnerships with private waterworks and municipalities in Copenhagen Energy's service area has resulted in many partnerships such as the ones in Hillerød, Slangerup, Skævinge, Greve, Skovbo, Vestegnen and Stenløse. Copenhagen Energy also participates in Hovedstadsområdets Vandsamarbejde (the metropolitan region's water cooperation partnership). The purpose of these collaboration & partnerships is to protect the ground water, which is the main source of water supply (KE).

6.2.3.3.6 Pilot projects on water conservation

A number of pilot projects on water conservation have been implemented. Considering several mechanisms that enhance the water saving effort in a package in selected buildings was one of them. This water saving option included minimization of leakage, information and consultation as well as individual meter installation. The outcome was a significant reduction of total water consumption, which indicated that there is some potential in the approach. Besides, activities related to the creation of additional capacity from other sources as well as recycling have been considered on pilot basis. One major action in this regard, which was implemented in 1993, is the artificial ground water recharge from a lake.

KE has also piloted other initiatives aiming at exploring various options for water management. Collection and use of storm water for toilets and washing machines as well as re-use of grey water have been implemented on pilot scale. So far Water recycling and rainwater harvesting, which is used for toilet flushing and laundry purposes, is practiced to a limited extent and there are only about 32 water plants in Copenhagen, which are inspected once a year (Napstjert, 2002).

6.2.3.3.7 Water saving technology

The total water saving achieved in Copenhagen over the past couple of decades is a result of the combined effect of the various measures taken targeting mainly households, industries and institutions. In all of this sectors technology has played some role in increasing water use efficiency. In this regard, there is no doubt that the Danish water sector has benefited from the research & development that has been going on for a long time. It is obvious also that much of the innovation that relates to the industrial sector has been initiated and supported by the sector itself in its effort to be cost effective and environmentally friendly.

When it comes to the technology used by households & institutions, there is no information on what kind of research on water efficient technologies has been going on since the launch of the water saving campaign in Copenhagen. Infact, information obtained from KE indicates that the water saving program has not been involved in any research & development on water saving technologies for households, institutions or industry. The program only promoted water saving technologies that were available in the market even though there is no data as to how widely they are used in Copenhagen. The major products promoted were, water-efficient bathroom appliances, water taps and washing machines and there is no information which agency did the research and development on these technologies.

6.2.3.4 UFW

Leakage control is another important area, which has been given due attention in KE. The section that is primarily responsible for this task focuses on the maintenance of the public network as a whole and its activities cover household plumbing as well as the whole pipe network in the city. Accordingly, a renovation program has been going on to minimize leakage in the network. The section carries systematic leak detection and uses modern technologies for renovation works. It has so far managed to complete one round of check for the whole network and the process is repeated once in 4 years. Inaddition to this the leakage control section assists customers in leakage detection when the symptoms are reported to it and advises on appropriate measures. The reduction in leakage as a result of this undertaking has been satisfactory and in general, it has been possible to minimize water loss substantially. A target was set to contain leakage below 4 % and KE has achieved this target, as it can be seen from the chart in figure 6.6.

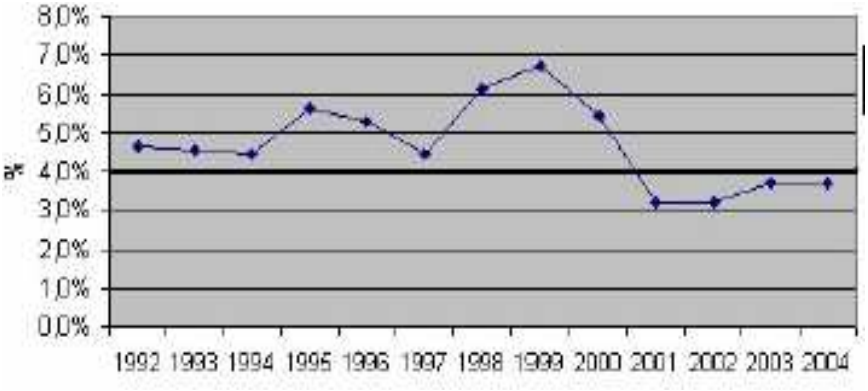

Figure 6.3: water loss trend in Copenhagen

Source: KE

6.2.3.5 Achievements

As briefly discussed so far, Price and non-price measures have been taken to conserve water in Copenhagen. Water price has been under continuous revision for a long time and it has been increasing continuously. The water saving campaign and leakage reduction measures, which are among the major activities undertaken under the non-price measures have been under implementation since 1989. The leakage reduction measures got greater attention at a later stage. Many of the activities have produced positive results and the ultimate objective of reducing water consumption has been achieved as per the targets set. Not only the household per capita consumption has decreased significantly but also the total water consumption in Copenhagen has been reduced to substantial extent.

The school program that started with producing teaching material for school children has expanded to a level where it runs a well-established school. The print and electronic media have been used to disseminate information and create awareness with in the general public. Consultation and support services have also been provided to many customers and cooperation platforms have been created with a number of stakeholders. The leakage detection and network renovation program has also led to a significant reduction in UFW.

The water saving campaign has basically relied on the water consumption rate (l/c/d) for planning and evaluation purposes. The water consumption that prevailed at the start of the program was

taken as a benchmark and objectives and goals were set to reduce the consumption rate to a certain level with in a given period of implementation. Internal evaluations were then made with a focus mainly on whether the water consumption had been reduced according to the goals set or not. For example the goal set in 1994 was to reduce the consumption to 110 l/c/d in 2001. This was not achieved and a revised goal was set in 2001, which was to reduce the consumption to120 l/c/d in 2005. This has been more or less achieved. The goal set for 2010 is 110 l/c/d (KE). Based on the reduction in water consumption that has been achieved so far KE asserts that the water saving campaign has been a major success.

6.2.3.6 Challenges and barriers

The interview and the annual reports of KE or CW do not indicate whether major challenges & barriers were faced during the implementation of the program or not. It is obvious however, that a program such as DSM cannot be realized with out facing some challenges. One major source of challenge is the institutional dynamism that is observed within the utility itself. There is some indication that the changes & merges that the water utility has undergone, which required some reorganization and reorientation could have affected the program implementation at least interms of organizational setup & resource allocation. Other challenges or barriers might have been faced in the area of promotion of water efficient technology and water saving habits. In this regard the relatively high cost of water saving technology, the effect of the water saving achievement on the existing network and slowness of attitudinal and behavioural changes might have surfaced as challenges

Some challenges pertinent to the implementation of price related measures are also obvious. One obstacle in this connection that existed from the outset is the lack of water meters at individual household level. Effort has been made to tackle this barrier through appropriate legal support and incentive mechanism designed to encourage the installation of water meters. Besides, since water is generally a politically sensitive issue, it can be said that price review & implementation has not been a smooth process for the utility. Moreover, relocation of some major water-intensive industries has been observed. If this has happened partly because of high water prices in Copenhagen, it may be considered as one negative side effect of the program, which challenges its acceptance as a strategy in water conservation.

6.3 Summary

KE, which is a public utility supplies water for household, business and industrial consumption in Copenhagen and the surrounding municipalities. After a long trend of increase, water abstraction and consumption in Copenhagen has been decreasing since the last couple of decades. During this period price and non-price measures have been taken to achieve water saving objectives. The water saving campaign and UFW reduction measures, which are among the major activities undertaken under the non-price measures have been under implementation since 1989. Many of these activities have contributed to some degree to the ultimate objective of reducing water consumption. As a result not only the household per capita consumption has decreased significantly but also the total water consumption in Copenhagen has been reduced substantially.

Based on the reduction in water consumption that has been achieved so far KE asserts that the water saving campaign has been a major success. There were not any major obstacles faced in this endeavor except for some minor issues of concern. Some of these issues were the institutional changes and merges that the water utility has experienced which might have affected the overall capacity of the water saving program, the difficulty in promoting water efficient appliances and individual household water metering and the effect of increasing water price on water-intensive industries.

CHAPTER 7 - ANALYSIS

The discussion in this chapter focuses on exploring the DSM program implemented in Copenhagen with the main objective of investigating the role of the various DSM components in water conservation. Effort is made to examine to what extent the different strategies have been helpful and how much they have contributed to what has been achieved so far interms of reduction in water consumption. The discussion is presented in three sections where a brief theoretical analysis is given followed by an empirical discussion. It also includes a brief analysis of the barriers and challenges faced in the process of implementation of DSM strategies. The analysis is framed with the major themes high lighted in the previous chapter: water price; non-price measures (mainly UFW, water saving technology, water saving campaign and enabling environment) as well as barriers and challenges

7.1 DSM as an approach to water conservation

DSM in the classical economic theory is a means to limit demand in a situation where there is an imbalance between supply and demand in a competitive market. It is employed with the main objective of overcoming an economic crisis & its administration, as a cure is a temporary one. This theory states that economic instruments such as price and taxes have a significant influence on economic decisions of consumers & thus limiting demand. One drawback of this strategy is that by employing economic instruments to restrain demand, the consumer is made to forgo some benefits interms of goods or services.

The objective and the way it is adopted in the energy sector are a bit different. The strategy is employed as a response to an energy crisis as well as associated environmental concerns & scarcity of capital resources. The basic objectives in the energy sector are: to ensure optimal use of existing capacity, conservation of energy sources & minimization of energy losses & environmental

impacts. To achieve these objectives different measures are implemented to influence demand for energy. However, unlike the way DSM objectives are pursued in economics, the consumer is not made to loose amenities due to DSM program implementation. The objectives are rather achieved by promoting energy efficiency & wise use habits mainly through the use of energy efficient technology & public awareness creation.

DSM in water management is also based on the assumption that demand can be altered with out making consumers loose basic benefits. It is a strategy adopted in response to the increasing demand for water and aims to ensure the conservation & optimal use of water resources. To achieve this objective it employs various strategies including: price measures, technologies that increase the efficiency of water use, behavioural change to ensure the long-term sustainability of water resources, and an enabling environment. The successful implementation of DSM highly depends on the proper planning and continuous evaluation of the program activities. In the following section the water saving program implemented in Copenhagen will be assessed with in this framework.

7.2 DSM in Copenhagen water management

7.2.1 price measures

Making water price reflect real costs including environmental costs is one basic step towards a successful implimentation of a DSM program since it enables utilities to signal a proper message for wise use of water. The cost components of water price in Copenhagen fall under the jurdsiction of the central and the regional government. The green taxes are levied by the central government to protect the environment & the utilities collect the revenues together with the service fees onbehalf of the government. The service fees are determined generally on cost recovery principle and all water supplied to consumers is charged based on meter reading. All efforts are thus made to make water price reflect real costs. As a result water price in Copenhagen has been under continous review and has been continously increasing for the last couple of decades. This indicates that water price as practiced in Copenhagen encourages water conservation & has been employed in an effective way.

7.2.2 Non-price measures

Various non-price measures have been employed in water conservation efforts in Copenhagen, which can be categorized under promotion of water saving technology, public awareness creation and UFW minimization. Since the launch of the water saving campaign, different activities that fall under these major categories have been implemented to influence the water consumption. These activities are briefly assessed in the following section.

7.2.2.1 Water saving Technology

Water saving technology helps improve the efficiency of water use in all sectors. It however requires great effort in encouraging the take-up of existing products as well as research and development for new technologies or the refinement of existing ones. Research and development demands a significant amount of resource. Besides, public research on areas such as the environment needs to be initiated and coordinated by a mandated body before the market forces can pick it up.

Neither CW nor KE have been involved directly or indirectly in research and development of water saving technology in connection with the water saving program. As the focus is on reduction of household water consumption, the program has been promoting water saving appliances already available on the market such as showerheads, low-flush toilets as well as water saving faucets & washing machines. However, information on studies made so far on the extent of the use of these technologies in Copenhagen was not available for this study. With regards to industrial water use, there are indications that they have been taking their own initiatives to ensure water use efficiency and remain cost-effective.

The Danish institutional framework for the promotion and development of research on innovative technology as well the mechanism for initiating, encouraging and promoting innovative technology such as water saving appliances is not clear. There is no doubt that research on technological innovation in the environment field in general and the water sector in particular has been going on in industries as well as in different organizations. When it comes to the initiation, coordination & encouragement of research as well as promotion of innovations in the environment sector such as water conservation, there has been no formal institution except the Danish EPA itself and in the

authors opinion, apart from the promotion of existing technologies this task this has not been given due attention.

This assumption is supported by recent actions of the Danish ministry of environment, which give clue to the ministry's realization that such a need exists and its decision to reinforce its coordination & information dissemination effort. One of these actions is the launch of a web site on eco-innovation in 2006. The purpose of this site is to disseminate knowledge on the comprehensive environmental innovation efforts being made by industries & other institutions in Denmark & promote the potential use of environmentally efficient technology. It also hopes that this web site will serve as a discussion forum for the business, researchers & other stakeholders (Danish EPA).

The second action is the creation of a new agency known as the Danish Agency for Science, Technology & Innovation (DASTI), which was officially established on 1 May 2006. The objective of DASTI is to promote research & innovation for the benefit of the Danish society. This agency will deal with activities such as public research funding; researcher mobility; dialogue on priorities in research & technology initiatives; regionalization of research & innovation, commercialization of research; interaction between knowledge institutions & the business community; innovation policy; research dissemination as well as statistics & documentation of Danish research & innovation (DATSI).

7.2.2.2 Awareness creation and information communication

Increasing the knowledge and awareness of the society to bring behavioral and attitudinal change is one way of tackling environmental issues such as water management problems. Lack of awareness, which may result from inadequate knowledge or information on the status of water resources in general and water consumption in particular, may hinder the efforts being made to ensure sustainable water management. Education, awareness raising and information communication activities are therefore necessary to disseminate information, increase public awareness on water management issues, raise public interest in conservation efforts and mobilize society to join in the conservation endeavor to ensure sustainable water resources management.

This strategy has gained significant attention in Copenhagen especially since the launch of the water saving campaign in 1989. Education, awareness raising and information communication

activities have been carried out using all available media including the Internet. Information and advises have also been provided through consultation & other mechanisms. Above all, due attention has been given to schoolchildren by establishing a permanent environmental school with the main objective of creating a water conscious society and making water conservation a culture. Eventhough it is not easy to judge its immediate effect, its impact on the next generation can not be undermined since today's children are tomorrow's customers in the society, responsible for water consumption as well as its management. Not only does this facility give the opportunity to reach children with the proper knowledge on water but also enables the children to take water saving messages to their families. It is therefore the author's opinion that the strategy has been employed to a substantial degree in Copenhagen.

7.2.2.3 UFW

UFW minimization is an important strategy for water utilities and effectiveness in its management brings them a number of benefits. First, it helps them to conserve water and serve additional customers with existing infrastructure. Secondly, it helps them increase their revenue and save them from costs due to additional pumping, treatment and operational costs. Thirdly, this helps them to avoid wasteful abstraction and defer the development of new sources, thereby protecting the environment. Most important benefit is however, the message that is conveyed through the endeavor to minimize loss. If utilities demonstrate firm determination to tackle water loss, the public is encouraged to join the water conservation effort.

According to EEA (2003) the water loss in Denmark during the 1990s was estimated between 4-16% of the water supplied, which is the lowest in Europe. This shows that UFW management has been effective in Denmark. Leakage detection and pipeline renovation has received greater attention in Copenhagen since 1989. In an effort to tackle water loss, modern technological products & innovative methods have been applied to detect, locate, and maintain leaks. As a result, it has been possible to bring down the leakage to less than 4 % and maintain this achievement for a number of years since 2001. Based on this, it is fair to conclude that UFW management in Copenhagen has received due attention and it has been effective.

7.2.2.4 Enabling environment

For DSM to be effective in water management, it requires a conducive environment interms of appropriate policies that set the objectives for water conservation, legislative framework that establishes the laws and regulations and institutional capacity to plan and implement the program. Institutional capacity is important because, DSM implementation will require not only financial resources but also committed and skilled people responsible for planning, implementing and evaluating the different strategies. Such an environment can be created if there is a political will at the highest level of decision-making bodies. Another important aspect of creating a conducive environment is mobilisation of all stakeholders to get their cooperation & collaboration.

National as well as local conditions are generally favourable for DSM in Denmark. At national level the country is determined to ensure the efficient use of its water resources. The political will has been there since a long time. Accordingly, appropriate policies as well as clear and consistent legislations are in place. The local conditions in Copenhagen are not different. Regional water resources plans are prepared & implemented with in the framework of the national environmental policy and legislations. Therefore, interms of policies and legislation, there has been a favourable condition for DSM in Copenhagen

However, there were some limitations when it comes to the implementation capacity. The human resource assigned for the water saving campaign was not enough. Infact it fluctuated during the program life from about five employees to only one. This has been reflected in a number of drawbacks in the program. The first one is the absence of any kind of evaluation study on the different strategies to check whether they are effective or not and whether they need a modification of approach or not. Second, no cost benefit analysis was made to determine whether the activities are worthwhile. A third reflection of capacity limitation is the absence of diversified incentive mechanism to enhance the progress of DSM except the one implemented with the support program to encourage the installation of water meters. This could be due to the inadequate attention given to the program in financial terms.

7. 3 Contribution of DSM strategies in Water conservation

7.3.1 Water conservation at national level

At national level, water consumption has generally declined since the 1970s. It had been relatively constant during the 1980s and since then it has been falling. As shown in figure 7.1, the total amount of ground water abstracted for various uses during the period between 1989 and 2000 has been decreasing to various degrees with the exception of some periods of increase in the agricultural consumption, which can be attributed to draught periods. Eventhough a slight increase is observed in the industrial sector due to industrial expansion, total water abstraction has decreased by 40 % during this period (Danish EPA, 2003). According to them the total abstraction has decreased from about one billion m^3/y in 1989 to 653 M m^3/y in 2002.

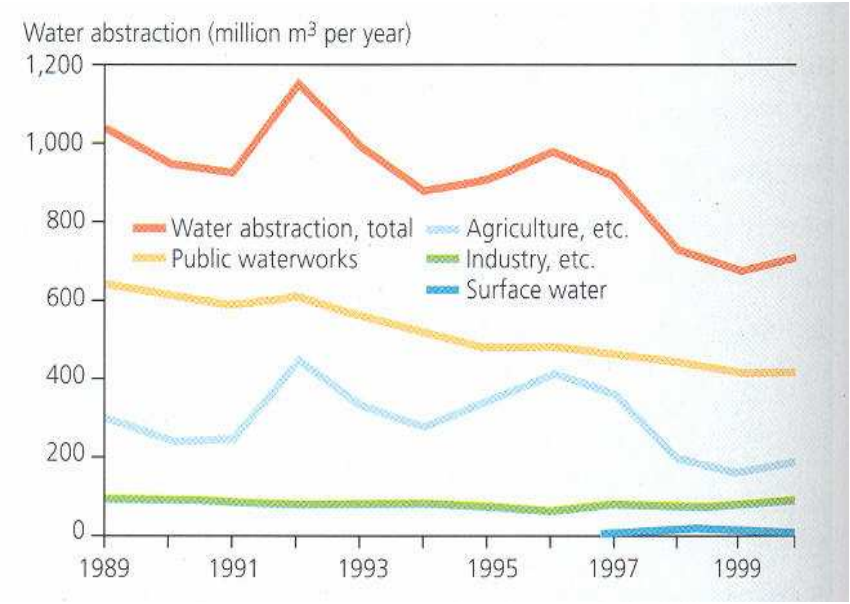

Fig. 7.1 Water abstraction trend in Denmark

Source: Danish EPA, 2001

When the total water abstraction of 1989 is disaggregated in to the different sectors, public water supply consumed about 600 Mm^3/y, agriculture used about 350 M m^3/y while the share of industry was not more than 60 Mm^3/y (Danish EPA, 2003). According to this report the total abstraction in 2002 was 653 Mm^3/y out of which public water supply consumed about 410 Mm^3/y while agriculture and industry consumed 180 Mm^3/y and 60 Mm^3/y respectively. This clearly shows that

there has been a significant decline in water consumption especially in the public water supply and agriculture sectors.

A number of factors could have contributed to the decline in total abstraction as well as sectoral consumption. One of them is the conservation effort that has been undertaken at national and local levels using non-price measures. The most important factors are however the price-measures, which include the green taxes, the wastewater fee and the water fee. Based on the analysis of the effect of price on consumption, which I will dwell in more detail in the following sections, the reduction in water abstraction at national and local level are mainly due to the implementation of the price measures.

7.3.2 Water conservation in Copenhagen

Data obtained from annual reports on water consumption in Copenhagen since 1989 indicates that the water consumption has been dropping continuously. Decrease in water consumption has been achieved in all consumer categories except in industry where a slight increase has been observed. Considering the total consumption, it has declined from 268 l/c/d in 1989 to 181 l/c/d in 2004, which is a decrease by 32.5 % in about 15 years. The decline in water consumption is primarily due to a significant reduction in household water use, eventhough institutions and industries have also played a role in lowering the total consumption. The consumption by institutions decreased from 8 m^3/c/y in 1992 to 5.4 m^3/c/y in 2002, while industrial consumption has increased from 20.8 % in 1992 to 25.6 % in 2002 (DWWA, 2002; 2001).

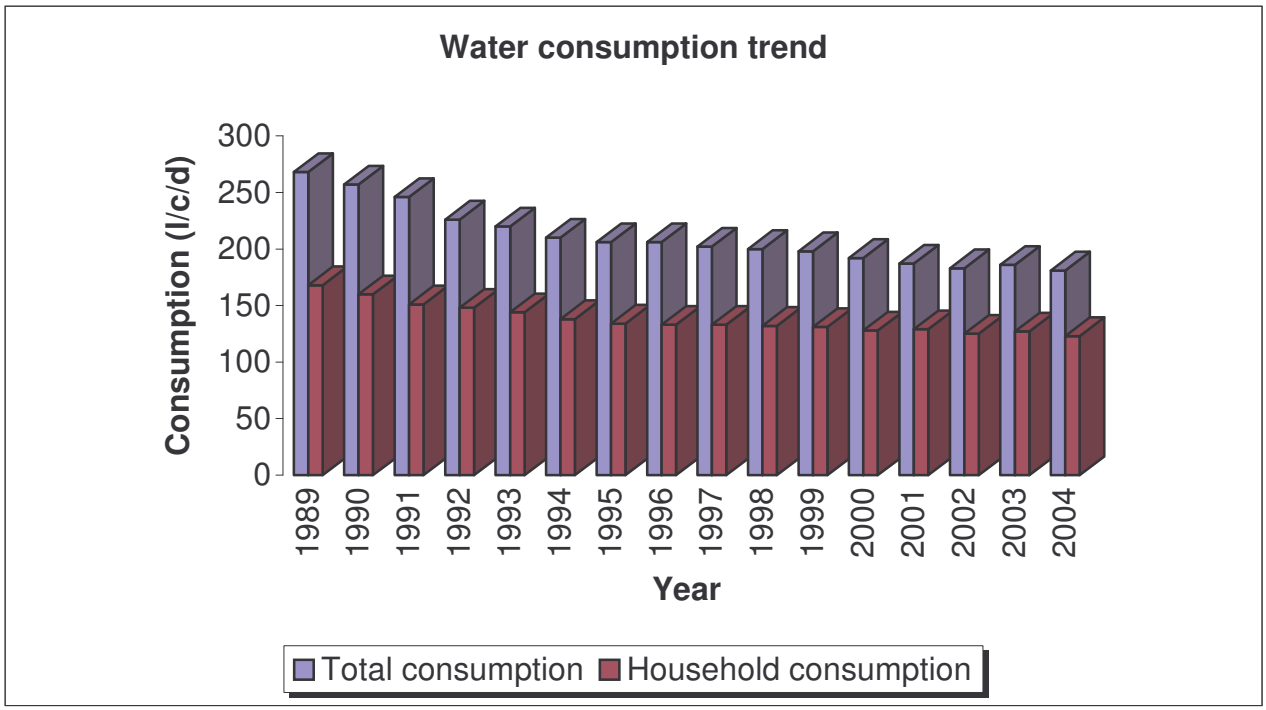

Fig. 7.2 Water consumption trend in Copenhagen

Data source: Copenhagen in figures (1998; 2005)

Household consumption, which is a major part of the public water supply, has declined from 181 l/c/d in 1989 to 123 l/c/d in 2004, which is a reduction by 32 % or an average decrease of about 4 l/c/d/y. This shows that there has been a considerable reduction in household consumption in Copenhagen. The extent of saving with in the different household uses may vary to a certain degree depending on the water requirement of each activity and the water use habit as well as the technology in place. However, data on the trend of water consumption in the different household activities was not available for inclusion in this analysis.

7.3.2.1 The role of price on water conservation in Copenhagen

The significant achievement in reduction of water consumption indicates that DSM has been effective in Copenhagen. A number of DSM measures have been operating before and after the launch of the water saving campaign, which has been going on since 1989. This part of the analysis focuses on answering the question with regards to which measures were primarily responsible for this achievement. In many of the annual reports of CW and KE it is claimed that the achievement

made in the reduction of water consumption in Copenhagen is due to the water saving campaigns. Different groups and individuals (SURBAN; DWWA; WATERSAVE; Napstjert, 2002;) have also made similar assertions.

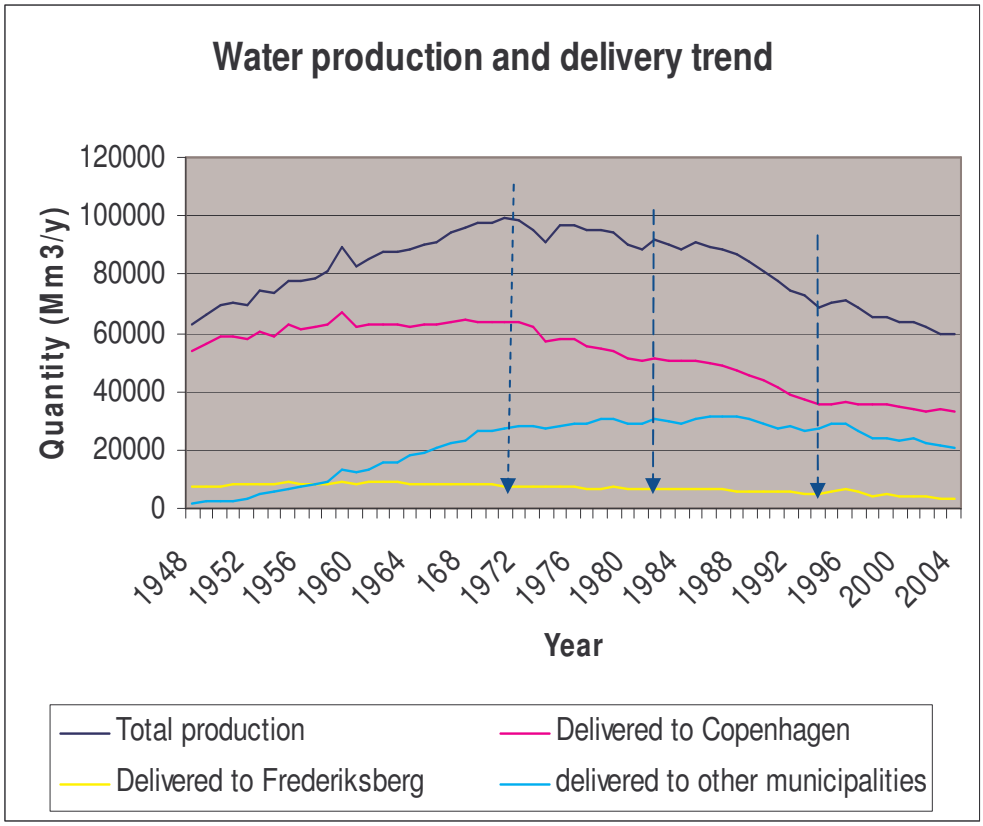

Fig 7.3 water production and delivery trend

Source of data: (KE & CW annual reports; Schroeder (unpublished))

Based on my analysis that follows, I hold the opinion that the price measures have been playing the primary role in the water saving effort. The chart shown in figure 7.3 depicts that there are four distinct trends in the water production and delivery trend in Copenhagen. I have found it convenient for analytical purposes to divide the time span in to four periods following those distinct trends: the period before1971, from1971 to 1984, from1984 to1995 and 1995 onwards.

Considering the total water production, it had been continuously increasing after the Second World War. The chart shows that there had been a sharp increase since the 1950s until it reached a

maximum in around 1971. However, the water delivered to Copenhagen & Frederiksberg had remained almost constant during the 1960s while the portion that was delivered to other municipalities was increasing. As discussed in the previous chapter the major factors, which contributed to the increase in total production, were the changing life style of urban life and the increase in demand from the surrounding municipalities.

The trend between 1971 and 1984 however indicates that water production as well as consumption in Copenhagen had already been declining before the water campaign program was launched. Consumption in Frederiksberg remained constant while that of the surrounding municipalities continued to increase. During this period water production had decreased from 64.1 Mm^3/y in 1971 to 50.6 Mm^3/y in 1984, which is a reduction of 21 % or an average of 1 Mm^3/y. The decline in water consumption in Copenhagen could be attributed to a number of factors. One of them is the energy crisis that resulted due to the oil embargo of the 1970s, which led to an economic stagnation and initiated energy conservation. Environmental concerns also begun to come to the surface and it was during this period that the environment Act (1974) and Water supply act (1980) came in to effect.

The decline of water production as well as consumption in Copenhagen becomes sharper during the period between 1984 and 1995 while the delivery to other municipalities seemed to have stabilized. The major reason for the decline in total production is the sharp decline in consumption in Copenhagen. During this period water production had decreased from 50.6 Mm^3/y in 1984 to 35.6 Mm^3/y in 1995, which is a reduction of an average of 1.36 Mm^3/y or about 30 %. This could be attributed to a number of measures, which were taken during this period. The first important measure is the introduction of economic instruments in the mid 1980s, which resulted in sharp increase in water service charge. The Plan for the aquatic environment, which requires mandatory measures to protect the aquatic environment, also came in to effect in 1987. Another important action taken is the launch of the water saving campaigns in 1989. After 1995, eventhough water production and consumption in Copenhagen continues to decrease, the rate of decline is insignificant compared to that of the previous years.

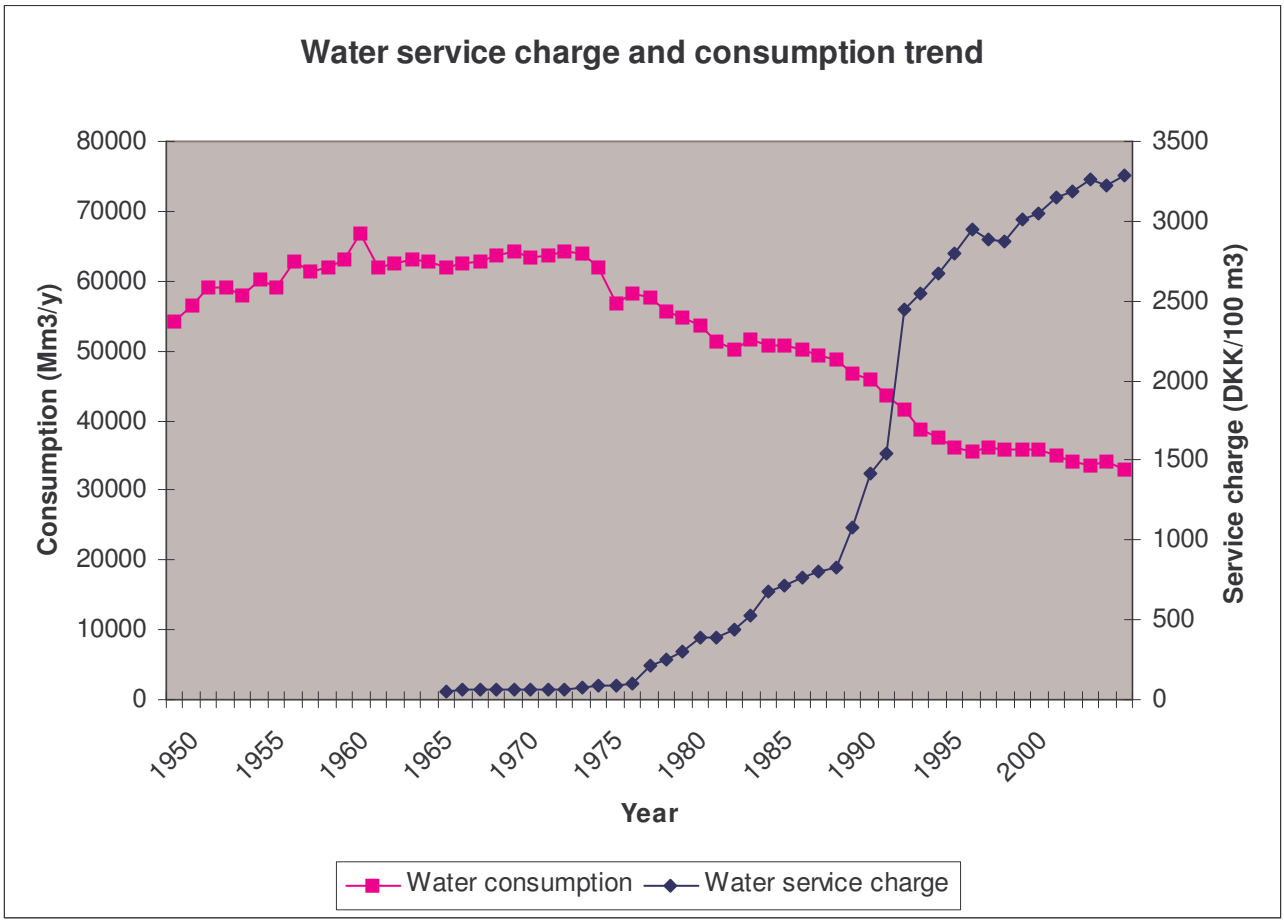

Figure. 7.4 Water service charge and consumption trend

Source of data: (Copenhagen in figures 1998 & 2005; Schroeder, 1995; KE annual reports)

Since reliable data on the impact of the different components of the water saving campaign on water consumption was not available, the analysis focuses on the role of water price only. To aid the analysis, data on water service charge and water consumption have been plotted together as shown in figure 7.4. The Chart depicts that there is a relationship between the two in such a way that price related measures produced responses in the form of immediate significant reduction in consumption. The trend shows that there was a steady increase in water price during the 1980s as well as sharp increases after 1990. This is mainly associated with the introduction of green taxes in the 1980s, the tax reform of 1994, which increased the level of green taxation as well as the introduction of the wastewater tax in 1998. These trends indicate that water price which kept

increasing due to the implementation of price related measures played a major role in the reduction of water consumption.

Eventhough water price has been continuously increasing; the chart indicates that the corresponding reduction in water consumption after 1995 is insignificant when compared to that of the previous years. In other words, as a water conservation measure, price is no more elastic after this period. This situation reveals two important issues. One refers to the fact that KE needs to evaluate its conservation strategies and identify those mechanisms, which can enhance the conservation effort. The second one concerns the increasing price of water. As long as there are no increments in taxes, the main justification for keeping the price of water increasing in Copenhagen is the operational cost of KE, which has monopolized the public water supply service.

As indicated by the Danish Economic Council (2004), different studies indicate that large private suppliers are more efficient than public ones and if public water utilities were as efficient as the private ones, their costs could be reduced by 15 – 20 %. Currently KE charges for water service based on cost recovery principle. However, it is often argued that the cost recovery principle provides utilities with little incentive to minimize their costs. The Danish Economic Council therefore recommends that the cost recovery principle be replaced with a yardstick competition, which protects the consumers while at the same time creates incentives for greater efficiency in public utilities. In my opinion the implementation of the yardstick competition as per the recommendation of the Economic Council will enable KE to re-examine the cost structure of water in Copenhagen and will open room for greater efficiency.

7.3.2.2 The Contribution UFW management

Inaddition to Price other conservation measures have been implemented in Copenhagen one of which is the minimization of UFW. In this regard the leakage detection and network renovation is a major task, which has received greater attention since 1989. According to EEA (2003) the water losses in Denmark during the 1990s were between 4-16 % of the water supplied, which is the lowest in Europe. As shown in figure 7.5 it has been possible to bring down the leakage to less than 4 % in Copenhagen and maintain this achievement for a number of years since 2001.

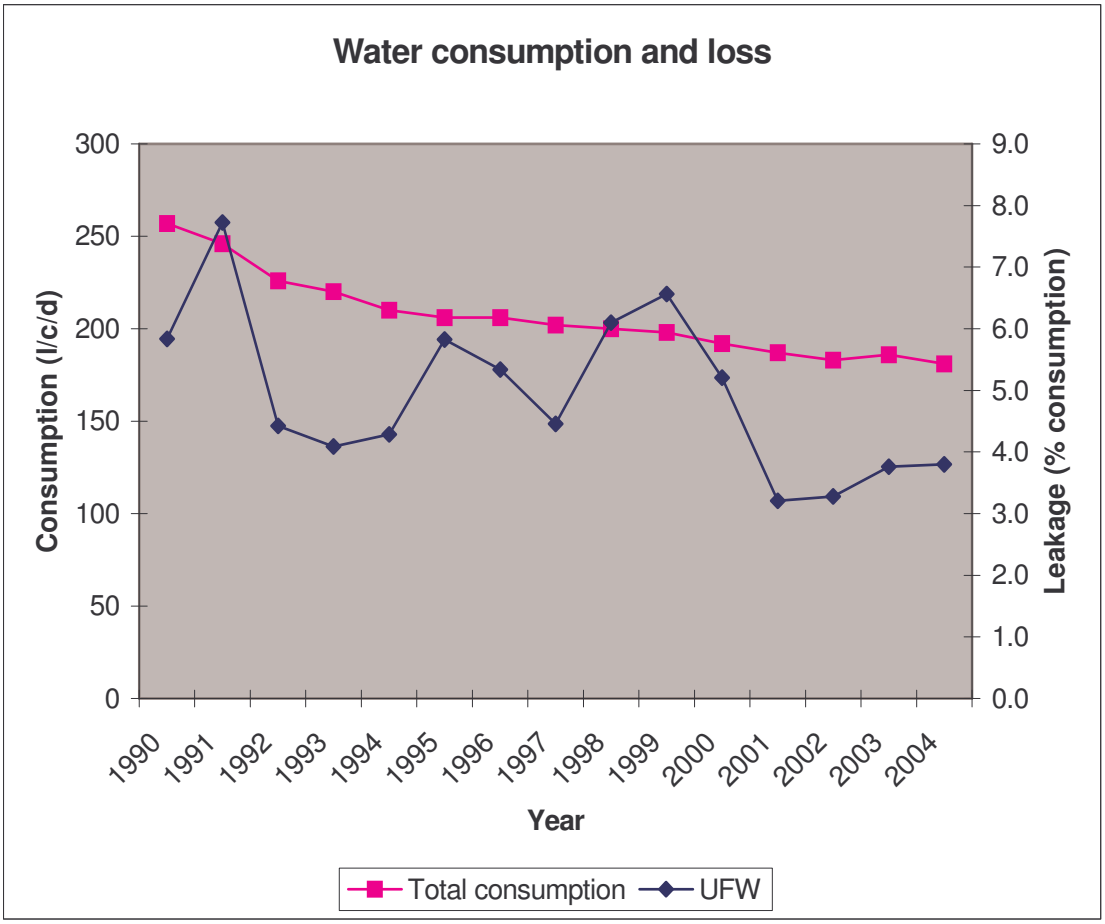

Fig. 7.5 Total water consumption and leakage

Data source: Annual Reports of KE

The chart shows that there has been a declining trend, eventhough there were fluctuations until 2001 after which the loss has more or less stabilized. During the period between 1990 and 2004 a maximum water loss of 7.7 % and a minimum of 3.2 % was reported in 1991 and in 2001 respectively. This shows that a total decrease of 4.5 % has been achieved, which is equivalent to an average yearly decrease of 0.3 %. In other words a loss that was estimated to be about 3 Mm^3/y has been reduced to about 1 Mm^3/y. In monetary terms considering 24 DKK/m^3 as an average price of water (average of 1991 & 2004 prices), the utility has been able to reduce the resource loss from 72M DKK to 24M DKK, which shows that a significant amount of saving has occurred as a result of water loss minimization.

Therefore, UFW management has been effective and has contributed significantly to the reduction in water abstraction in Copenhagen. Besides the Environmental concerns that have been pressing for the reduction of water abstraction, one important factor that has encouraged loss minimization and contributed to this success is the economic incentive that the green taxes have come up with. This assumption is supported by the trend of water loss as clearly shown in the chart (figure 7.6) made by Napstjert (2002). It is clear form this trend that Copenhagen has been doing well in UFW management almost a decade before the water saving campaigns were conceived.

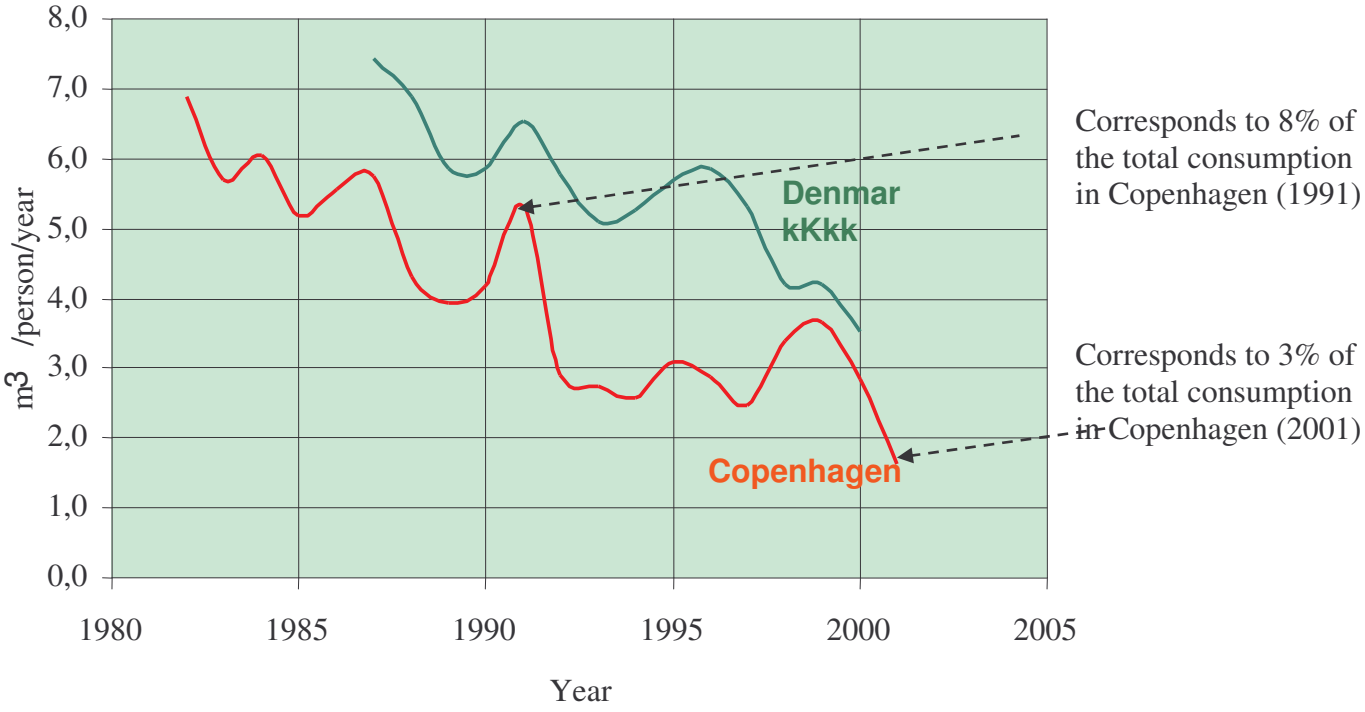

Fig. 7.6 Water loss trend in Denmark and Copenhagen

Source: Napstjert, 2002

7.3.2.3 The role of Water saving Technology

The water saving program focuses on households in its effort to conserve water in Copenhagen. This is appropriate as households consume more than 60 % of the water supplied and industries, which consume about 20 %, have the incentive to find ways for themselves for conserving water inorder to be cost-effective and respond to the increasing water price as well as effluent quality standards. Household water saving technology mainly refers to appliance and fittings used in the kitchen, bathroom, washing area and garden. In this regard the Water saving program has been

promoting among others, low flush toilets, water saving showerheads & faucets, water efficient dishwashers and washing machines. However, as water saving appliances have relatively higher prices, no incentive mechanism was developed to encourage households and manufactures. It was simply left for the market forces to work out the meeting of the innovator with the supplier and the buyer. More over, eventhough it is undeniable that water saving has occurred due to the promotion of these appliances, research based data as to what extent they are used in Copenhagen and how much they have contributed to the water conservation that has occurred in the city was not available.

When it comes to technology that concerns the industrial sector, the water saving program did not have any significant intervention. Taking in to account the development and expansion that might have occurred in the industrial sector over the years and the fact that it has been possible to suppress the industrial water consumption with a minimum increase over a long period, it is reasonable to assume that industries have taken initiatives to conserve water inorder to be cost effective and environmentally friendly.

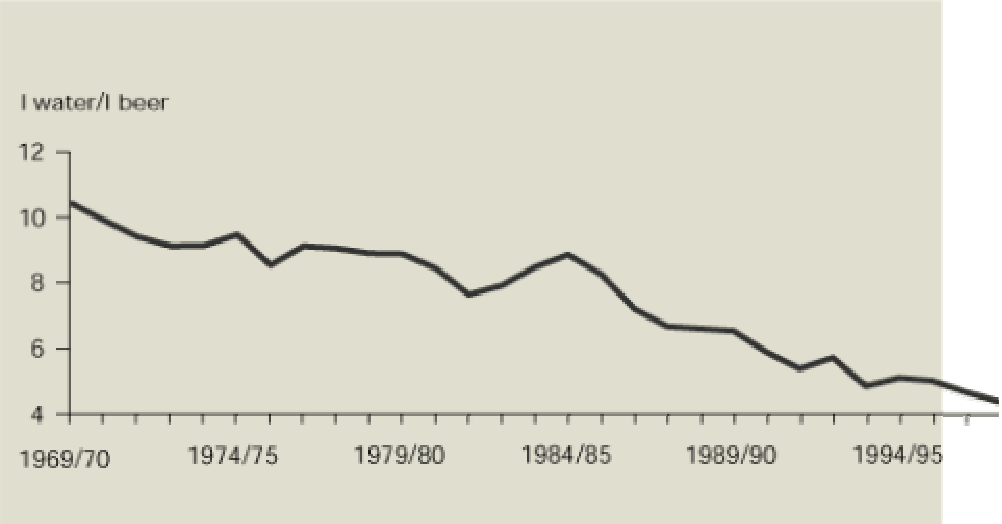

Fig. 7.7 Water consumption in Carlsberg
Source: Environmental signals, 2000

One good example that supports this assumption is Carlsberg, which is a large beverage industry and which has achieved remarkable water conservation in its production process. In 1977 Carlsberg set a water saving target to reduce the amount of water required per litre of beer produced at its Copenhagen brewery by 50 %. To achieve this target washing, pasteurization and bottling machines

were modified to recycle water. Inaddition, the production processes were revised and modified to introduce water saving. These initiatives enabled the industry to save about 235,000 m^3/y Environmental Signals, (2000). According to this source Carlsberg not only managed to save a significant amount of water but also enjoyed additional benefits in the form of energy saving to the extent of 25 % per litre of beer produced as a result of the reduction in water consumption. This is an indication that water intensive industries have taken similar initiatives to reduce their water consumption.

7.3.2.4 The contribution of other components of the water saving campaign

The water saving program has also been working on water conservation through a pilot package initiative, which includes an incentive mechanism in the form of financial support for the installation of water meters at individual household level, consultation and provision of information. Eventhough it is implemented on pilot basis, in addition to the immediate result in the increase of the number of water meters installed, there has been some indication that household water consumption has decreased significantly in the piloted areas. However, beyond indicating the potential for water saving in the household use, the reported outcomes do not give a clear indication as to whether the saving was induced by the individual water bills due to the introduction of the water meters or the awareness and hence the change in water-use habits that has occurred as a result of the program.

Cooperation and collaboration with different groups might have also enhanced the awareness raising and the water saving efforts in different ways. Cooperation with plumbers associations, home-helpers etc. might have resulted in the reduction of leakage & water consumption in some households. Moreover, the effort to establish local collaboration partnerships with different municipalities and localities might have played a role in enhancing the spread of the message of the water saving campaign to reach a wider community in Copenhagen. However as reliable data on the outcomes of these activities were not available, it is difficult to tell how much they have contributed to the water saving effort.

Public education and information communication is a major activity of the program. Efforts have been made to utilize all media outlets: print, electronic, Internet as well as advertisements on trains, buses and taxis. It is obvious that these mechanisms can help KE to reach the general public with

the water saving messages. However, data was not available on how many people have been effectively reached with individual program activities or in total. Information was also not available on whether the activities have been effective in terms of leading to change in water use habits or not. For this reason it is difficult to judge the effectiveness of this activities and their contribution to the water conservation effort. Another activity, which was given greater attention in this regard, is the one that targeted children. Besides contributing to the school curriculum, the program has managed to establish a permanent school with appropriate facilities for children. The establishment of such a school is a significant achievement by itself. Not only will this facility help school children (tomorrows customers) to grow up with the knowledge of the value of water, but also will enable them carry the message of water saving to their homes.

7.4 Barriers and challenges

The implementation of water demand management strategies is not a smooth road. A numbers of challenges and barriers, which appear in various forms under different contexts, may be faced before or during implementation. Their extent and magnitude may vary depending on the type of the strategy and the environmental as well as socio economic context in which DSM is implemented. They may be associated with the existence of an enabling environment interms of legislative or regulation aspects and institutional arrangement, public awareness, communication, technology etc. The barriers and challenges faced in Copenhagen are not outside this domain as can be seen from the brief discussion that follows.

7.4.1 Challenges

Based on the information obtained from the interview and the annual reports, there were no major constraints encountered in DSM program implementation except for some minor challenges. The program has been able to reach out to the general public with clear messages on water saving using the percapita consumption as an indicator with which program goals and objectives were defined. A basic problem with this yardstick however is the fact that water consumption is influenced by various measures, which have a role in the water conservation effort. Measuring the individual contribution of these strategies, which are operating simultaneously, is not an easy task. For example in Copenhagen there is no indication as to what extent or level the awareness on the need

to save water has reached as a result of the program and how much the public awareness campaigns have contributed to the water conservation achieved so far.

In addition to the difficulty of measuring the contribution of the different components of the DSM program, it has not been possible to clearly state their costs and associated benefits. There is no evaluation done for each measure interms of cost benefit analysis, which could give a clue as to which measures deserve priority attention to enhance the water conservation effort and ensure cost effectiveness. For example, the achievement made on loss reduction is significant. As mentioned before, it can be assumed that the initiative that led to this achievement was induced by the incentive that emerged with the green taxes that made the utility to pay tax on the water it abstracts. In any case, it has been possible to bring down the water loss from about 8 % in 1991 to about 3 % in 2001 (Napstjert, 2002), which is a significant achievement interms of quantity of water saved. However, there is no information regarding at what cost this achievement has been made and whether this endeavour has been worthwhile interms of cost benefit analysis.

Institutional dynamism is the order of the day of which CW or KE cannot be exceptions. Due to the number of merges and changes that these utilities have undergone so far, the water saving effort has been affected both interms of organizational arrangement and resource allocation and the sustainability of the program seems to be under threat. Organizational structures have been changed a number of times and the amount of attention given to the water saving section has decreased to the extent that currently it is a one-person unit. This is a great reduction when compared to the situation where there were more than 4 employees responsible for the water saving activities during the 1990s. The challenge is that changes will continue to occur and affect DSM as clearly reflected in one of KE's annual reports. "…Those days are over when staff would have the same function for 40 years and it seemed like the end of the world if you were separated from your gang. Copenhagen Energy needs mobile staff – physically as well as mentally – who accept change as one of life's constants. If an organisation is stationary, the changes actually required will just pile up until, all of a sudden, they will sweep through and over the company…" (Petersen, 2001: pg 10).

One of the objectives of DSM is to bring attitudinal and behavioural change in water management in Copenhagen. Experience shows that this takes time to happen as it is influenced by a number of social and economic factors. The progress to wards achievement of behavioural changes may be

affected by among others the level of income and education as well as cultural and environmental contexts. As a result it is difficult to give judgement based on the immediate results. Inaddition, measuring the progress made interms of the level of awareness reached and the contribution of the endeavour to the achievement in water saving is not an easy task.

Another challenge is related to the sensitiveness of the water price issue. Increasing water price may affect the competitiveness of water intensive industries such as food and beverage. In the absence of uniform water prices in a country or region relocation of such industries may be considered as a cost-effective measure to ensure competitiveness. This may bring social and economic consequences, which politicians do not want to happen. This scenario might have occurred in Copenhagen even though detailed analysis was not possible in this study due to lack of adequate information. Effort was made to explore the reasons behind the decision made by two big industries namely Carlsberg and Novonordisk to relocate the industries outside Copenhagen. Carlsberg provided brief information stating that water price had no role in the decision, while Novonordisk was not willing to give information. Studies made by Schrøder (1998) as well as Environmental signals (2000) however, indicate that increase in water price might have had a role in making the management of theses industries consider the issue of relocation.

Technology is also a challenge in DSM implementation. It not only requires time and money for its development and refinement but also its promotion is not an easy task since it requires the dissemination of adequate information about the products to the general public. Ensuring coordination and collaboration among stakeholders is also a difficult job, which in the author's opinion should be assumed by the government. Moreover, the cost of the water saving appliances is usually relatively high. It therefore requires the design of appropriate incentive mechanisms in cooperation with a number of stakeholders. Copenhagen water saving program did not have any initiative in this regard, except for the promotion of those already available in the market. This issue was left for the market forces and it is difficult to tell how the market forces have been responding to the need for the enhancement of water saving technology, as there is no information available regarding the extent of use of these appliances.

The effect of reduction of water consumption on the existing water supply network is another challenge. This issue is of especial relevance to the case study as large part of the network system is

over 50 years old and the achievement in water saving is significantly high. This primarily refers to the decrease in network pressure and associated problems have been experienced in Copenhagen. Pressure related problems were overcome using booster pumps. However, information on the cost of additional boosting as well as the cost of adjusting the size of the pipes was not available. As per the information obtained from KE, there was no serious problem with regards to water quality except slight increases in water temperature.

Backsliding, which can be seen from what I call a water comfort syndrome is also a challenge. In 2003 the water consumption in Copenhagen showed a slight increase in comparison with the previous year, which was not in conformity with the general trend that has been observed over a long period. A number of explanations have been given among which is the possibility of residents going back to old water use habits and installing appliances that do not save water. This added to the belief that water is abundant in Denmark may ultimately lead to backsliding. This shows the need for continuous awareness creation and information communication as well as the promotion of water saving devices.

7.4.2 Barriers

Based on the information obtained from KE, there were not any major barriers that were faced while implementing the DSM activities, eventhough a couple of obstacles, which were identified in this study, are worthy of mention. One of them concerns water meters, which play a facilitating role for the other DSM measures. In Copenhagen, in a city of a population of about half a million there are only less than 35,000 meters. This situation has been realized as an obstacle to the water saving endeavour and efforts were made to address it using the support program where a grant is provided to cover part of the installation cost. This incentive mechanism has proved to be effective since it has produced positive results in the water saving effort.

Institutional bias is one obstacle that hinders the successful implementation of DSM in water utilities. Water utilities by their nature most often have a bias to wards the supply side management and hence focuses on the engineering profession for the management of water supply. The role of other disciplines in water supply management especially the demand side management is not given enough attention. The fact that the water saving unit, which started with about five employees have

now diminished in to a one-man unit indicates that there is such a bias. The situation may have also been aggravated due to the latest merge between CW and KE where it seems that KE has the upper hand as it appears in the new name of the company.

CHAPTER 8 - CONCLUSION

It has been realized since recent years, that fresh water is a scarce resource that needs to be efficiently used. Experience shows that the traditional supply side management approach to water governance has proven to be inadequate in meeting water demands of urban areas in a sustainable manner and protecting the environment. This reality has made water conservation an imperative. Conservation in water governance recognizes that developing new water sources to meet urban water needs may be costly whereas influencing consumer demand is more cost-effective. This is particularly true when environmental, social and economic costs of new urban water schemes are taken into account. It is therefore better to manage the resource at hand efficiently before going out to invest in the development of new sources. Above all, the water that is inefficiently used is a resource or a capacity, which if conserved may enable a utility to extend its service to others who are in need of the service. Conservation is thus justifiable interms of logical, economic and environmental considerations.

Considering the fact that urban centers in many areas are growing fast & the current water use trend is unsustainable and inefficient, DSM has a substantial potential to reorient urban water management. By implementing simple and cost-effective price and non-price strategies it is possible to achieve significant reduction of water use with out substantially affecting the consumer's welfare. Institutionalized, well-designed, properly implemented and continuously evaluated DSM programs can enable utilities achieve water conservation objectives and coupled with the supply side efforts they can help ensure the sustainability of future water supply to urban areas.

However, since water is a multi-dimensional and sensitive issue, obstacles may be faced form various directions and the implementation of DSM may not always be a smooth process. Economic, social, political and institutional factors as well technology may affect the progress of a

DSM program. Therefore, in addition to the social and economic costs incurred in order to harvest the benefits of DSM, it may be necessary to overcome a number of challenges & barriers. Proper planning and evaluation as well as creation of an enabling environment are therefore decisive measures required for DSM to progress and bear fruit.

Moreover, public awareness raising and education as well as information communication should be enhanced using all available means so that all stakeholders can realize the need to conserve water & embrace DSM as a complimentary approach to urban water management. In this regard, the role of politicians and decision makers at various levels who can influence water use policy formulation and affect the promotion and in enhancement of water conservation must be recognized. Due attention should also be given to the creation of an enabling environment to involve all stakeholders in the planning and implementation process, so as to ensure a successful implementation. Inaddition to the focus on households which are the major consumers of public water supply, due attention should also be given to industries as well as institutions.

DSM has been adopted in Copenhagen and a number of conservation strategies have been employed for a considerable amount of time. The program has been assessed to investigate the extent of application of these strategies and the water conservation that has resulted for which two basic measurement criteria were set: reduction in water use and net increase in social welfare. It was also envisaged to evaluate the potential use of DSM as a complimentary solution to water scarcity and identify major obstacles or barriers faced in either adopting or implementing the strategies.

Based on the assessment, price and non-price measures have been employed to a substantial extent to achieve water conservation. The study shows that implementation of DSM strategies has led to a significant decrease in water abstraction as well as consumption before and after the launch of the water saving campaign in Copenhagen. The substantial decline is primarily due to decrease in water consumption by households. With regards to the water use by other categories, it has been possible to either get it reduced to some degree or contain it with minimum increase over the years. This shows that DSM measures have been successful in Copenhagen in terms of reduction in water abstraction and consumption.

The claim, which is reflected in many occasions that this success is as a result of the water saving campaign, however is overstated. This is because:

1. This assertion does not take into consideration the efforts and contributions made before the water saving campaign and the general trend that prevailed at the start of the program
2. It overlooks the contribution of the price-measures
3. It is not based on appropriate measurement of the contributions of the non-price strategies except the general indicator of reduction of water consumption

On the contrary, eventhough there is no doubt that price and non-price DSM measures, which have been operating in tandem, have contributed to the reduction in water abstraction and consumption achieved so far, based on the analysis of the general trend of water price and consumption in Copenhagen before and after the water saving campaign, it is the price-measures that have played the major role. On the other hand, since data on cost of implementation of the strategies or information on cost-benefit analysis results was not available for this study, it was not possible to judge the efficiency of each of the DSM measures currently under implementation and as a result it was not possible to ascertain whether there has been a success in conservation that meets the criteria of net increase in social welfare.

There were no major challenges or barriers encountered by the water conservation program in Copenhagen except for some issues of concern which are associated with program sustainability, institutional dynamism, program evaluation, meter installation, adoption of water saving technology and side effects of the program. Some of these issues have been addressed through a number of mechanisms while others still require appropriate actions in order to enhance DSM as a sustainable management of urban water supply in Copenhagen. The effect of water price on water-intensive industries was not possible to investigate due to lack of information eventhough it seems that some industries had taken water price in to account in their decision for relocation. The problem related to loss of pressure in the network as a result of significant reduction in total consumption was tackled using booster pumps and network renovation.

Copenhagen's source of water supply is still stressed and the city need's to conserve water. KE should therefore reinforce its ongoing conservation programs. Previous conservation efforts and experiences on water and energy can be combined to build synergy with in the current structure of

KE in order to build institutional capacity to ensure conservation of scarce resources. Price and non-price strategies should therefore be given increased attention. KE should also support research and development on innovative technology in the area of conservation. Besides emphasis should be given to the evaluation of the strategies in order to make sure that they are worthwhile and improve the overall outcome of the DSM program.

As clearly stated by Army Vickers (2002), "…as we peer into the twenty-first century, water conservation is looking far more like an imperative than an option…" Beyond its application to overcome a crisis in resource management in various sectors, experience has shown that DSM has a potential for the sustainable management of scarce resources. It can help in altering urban water demand and reduce generation of wastewater, thereby reducing environmental stress. All DSM strategies and mechanisms should therefore be given adequate attention with in the context of the objective conditions of the application area.

Experience shows however, that individual measures alone give limited or unsustainable results. Moreover, slowness of adoption of technology and change of human behaviour are major challenges which require persistent and continuous efforts as technology requires research and development for further refinement and innovation, while human behaviour and water use habits take time to change and become part of culture. For this reason all available and applicable DSM strategies should be used in a complimentary and coordinated manner in order to obtain sustainable results.

However DSM is not a cure-all solution for all urban water management problems. In fact, it is a complimentary effort to the supply side management. It is therefore integrating DSM with the supply side management that can ensure sustainable use of water resources and an efficient urban water management. For this reason, integrated urban water resources management should be pursued inorder to ensure efficient use of water resources and provide urban areas with sustainable water supply systems. To achieve this DSM should be embraced and mainstreamed in water utilities and water conservation should be treated in the context of an integrated water resources management approach, combining DSM and the supply side management.

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Annex I - Interview Questions

1. Questions prepared for KE staff

1.2 What was the rational for the water saving program?

1.3 What program and activities implemented to achieve water conservation?

1.4 Which sectors of society or economy is target and how much is the coverage?

1.5 What are the program out puts?

1.6 What is your overall opinion on what has been achieved by implementing the water saving program

1.7 How much is your saving per year interms of withdrawal, sewage disposal, operation & maintenance

1.8 Were there any unexpected or undesired results?

1.9 What specific activities are done to tackle water loss and what is the achievement?

1.10 How is research on water saving technology and dissemination coordinated and what is the role of KE?

1.11 To what extent are water saving appliances used in Copenhagen and what specific problems are faced in promoting them?

1.12 Has the working environment been a conducive one for water saving?

1.13 What is your opinion on the attention given to Water saving in KE?

1.14 Who and what determines the price of water in Copenhagen?

1.15 How reasonable is the current water price?

1.16 Is it easy to make a price adjustment when KE finds it necessary?

1.17 How much does each program cost KE every year?

1.18 How do you describe the benefits from the program?

1.19 What challenges and barriers have been faced and what mechanisms have been employed to overcome them?

1.20 If the water saving program was not implemented what would have been the scenario?

1.21 Is KE worried that less revenue is collected as a result of DSM and tax?

1.22 How has the environment benefited as a result of DSM?

1.23 What evaluation mechanisms are in place to evaluate the different programs and activities?

1.24 What is your view on the existence or absence of completion on water saving and cost efficiency in Copenhagen service?

1.25 How do you see the response of households, institutions and industry to water saving in Copenhagen?

1.26 Has increasing water price in Copenhagen led big industries such as Carlsberg and Novonordisk to consider relocation out side of Copenhagen?

1.27 In your opinion, what things went well and what did not?

1.28 What is the future plan with regards to the water saving endeavour?

1.29 Final comments

1.30 Request for figures

1.30.1 What is the current connection fee in Copenhagen?

1.30.2 What is the water price in 2006 in Copenhagen and what constitutes the price?

1.30.3 What is the cost of water meter installation for (single state, flat, block or apartment)?

1.30.4 How many people are reached every year through the capital area program during the 20th and 21st week programs?

1.30.5 What is the yearly budget or cost of the different activities of the water saving program?

1.30.6 How many people, cooperatives, associations, households get consultation services in a year?

1.30.7 How much money has been used so far for the support program and how many meters have been installed as a result?

2. Questions prepared for Carlsberg & Novonordisk

2.1 How significant was the contribution of increasing water price to the decision made by Novonordisk to relocate the industry outside Copenhagen?

2.2 How significant was the contribution of increasing water price to the decision made by Carlsberg to relocate the industry outside Copenhagen?

3. Questions prepared for DHI

3.1 How is research and development on water saving technology initiated, coordinated and disseminated in Denmark?

3.2 What does the current extent of use of water saving appliances/ technology look like in Denmark?

3.3 What is the effect of a significant reduction of water consumption (such as the case in Copenhagen) on existing network systems interims of pipe flow characteristics and water quality?

4. Questions prepared for DWWA

4.1 Who initiates, encourages or promotes innovation in environmental areas such as water saving devices for household uses?

4.2 Who initiated the development of the water saving appliances already in the market & who encourages and coordinates their further refinement and similar future innovations?

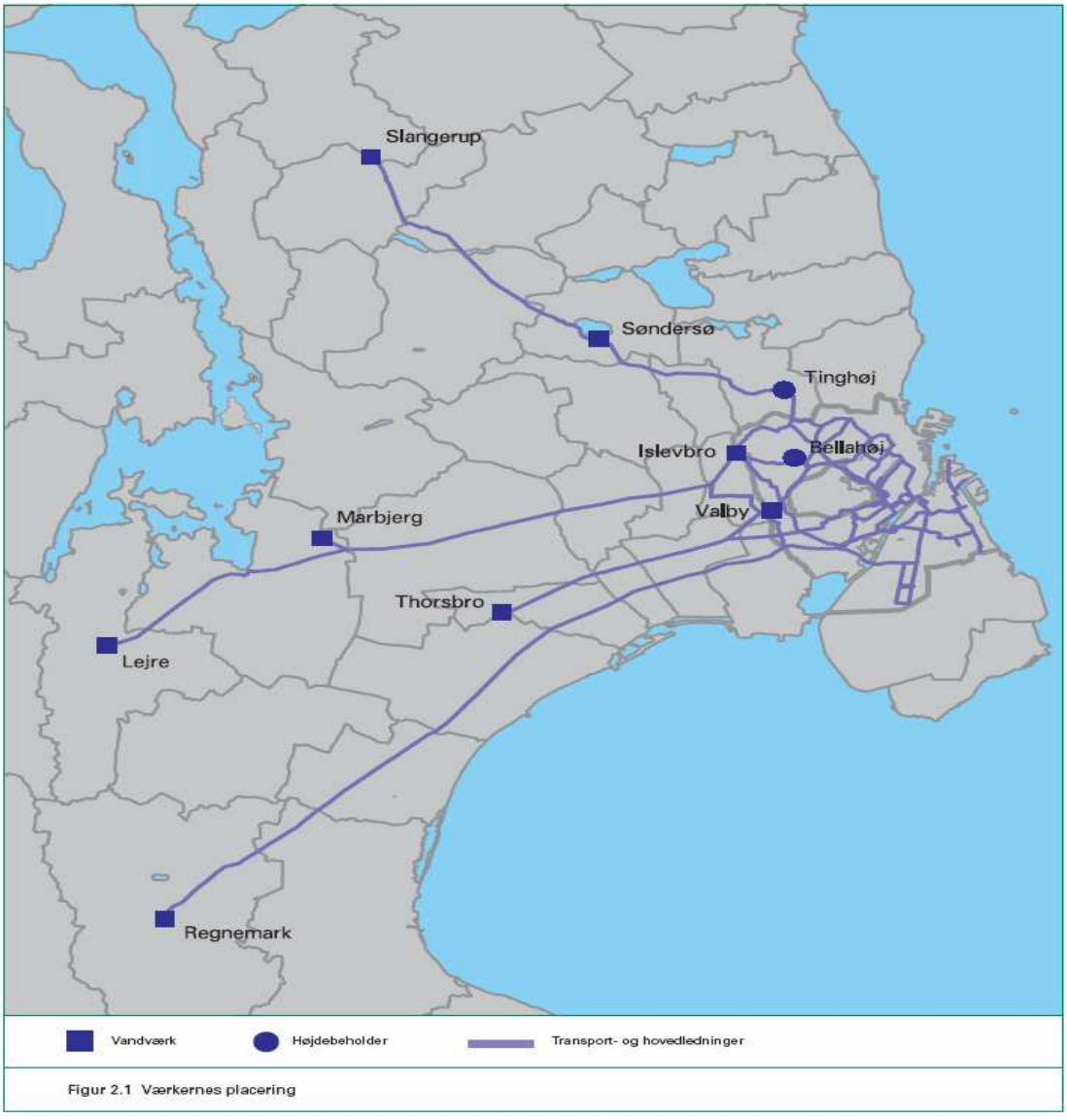
4.3 Who or What encourages profit-making institutions to invest on the manufacturing of innovative technology such as water saving devices?

Annex II - Map of Denmark

Copenhagen

Source: Wikipedia

Annex III - Location map of major water works of KE



Figur 2.1 Værkernes placering

Source: Københavens Kommunes, (Vandforsyningsplan 2001)