ANALYSIS OF THE WATER DEMAND MANAGEMENT

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Abstract: The paper analyzes management of water demand. It identifies and describes the factors defining management of water consumption in households, industry, and agriculture. Technological approach, pricing policy, and water use are discussed. Reduction of water demand in the long term program is between 10 and 20 per cent in the period of 10 to 20 years. For sustainability of the water system, the balance between water demand and its availability is essential. Integrated water management ensures sustainable management and development of water resources.

Keywords: water demand, avilable water, water demand management, technological approach, economic approach.

DIE ANALYSE DER WALTUNG DES WASSERBEDARFS

Zusammenfassung: Analysiert ist die Waltung des Wasserbedarfs. Die für das Definieren des Problems wesentlichen Faktoren sind angeführt und beschrieben. Es wird gezeigt dass man Wasser im Rahmen des kommunalen Verbrauchs ersparen kann, und zwar: durch Ausstatung und Einrichtung bis 40 Prozent und durch Einbau von Wassermessern 10 bis 25 Prozent. Durch Abminderung der Verluste im Netz steigen die verfügbaren Wassermengen. Hervorgehoben ist die Notwendigkeit eines Ausgleichs zwischen Wasserbedarf und Verfügbarkeit für die Erhaltbarkeit des Wassersystems. Die integrale Wasserwaltung sichert auch die Entwicklung der Wasserresourcen.

Schlüsselworte: Wasserbedarf, verfügbare Wassermengen, Waltung des Wasserbedarfs, technologischer Zutritt, wirtschaftlicher Zutritt.

1. Introduction

Water is a fundamental need for life and for development of human society. Sustainable management, protection and use of water resources is essential in conditions of population growth and increasing pressures on water and land resources, resulting from human activities aiming to meet the vital needs. Management of water demand ensures the balance between water requirements and water supply, balancing the demand and supply.

Reduction of available water quantities and increasing of water requirements or water demand of various sectors of economy increase the importance of economic analyses in water management.

In the economic theory, the supply and demand for commodity and services includes the relations of all participants in the market or exchange (Samuelson and Nordhaus 1992).

Demand is the quantity of commodity or services the buyers are ready to buy, at certain prices, in a given period.

The general law of demand shows the demand for commodity and services as the function of price and other variables on which the sale is dependent. The Slutsky-Hicks-Allen law describes this in the following way:

$$D = F(c_1, c_2, \ldots c_n, doh) \quad (1)$$

Where: c_1 = the price of commodity

$c_2 \ldots c_n$ = the price of other commodities
doh = income

Supply is the quantity of commodity or services offered by vendors, at certain prices, in a given period and on a given market.

Balance of supply and demand, on the market with full competition, is achieved at the price at which the supply and demand forces are in balance. The price and quantity try to remain in balance as long as other conditions are equal.

Water demand management is defined as application of measures and policies aiming at control of the quantity of consumed water. The concept refers to initiatives aiming to meet the existing water demands with smaller quantities of available resources. There is a number of measures and activities to achieve management of water demand. Table 1 gives examples of such measures. Other measures which are a part of water management have been omitted.

The concept of water demand-consumption management was discussed for the first time in late 70s and 80s when limitations in infrastructure became obvious. From the aspect of the distribution network, economic sustainability of reduction of leakage losses is practically non-existent, because investigations did not include economic assessment. From the aspect of water use in households or industry, economic sustainability may be easily proved by saving of considerable water quantities, even in cases when the pricing policy has not been applied (UKEA 1998).

Table 1. Management of Water Resources in the Context of Water Demand Management

Process	Option	Examples of measures
Resource management	Alternative sources of fresh water	Use of sea water for cooling
Production management	Technologies in production	Technology for improvement of water treatment
	Recycling of treated waste water	Recycling for various uses Reduction of water requirements

Distribution management	Efficiency of the mains network	Detection and elimination of leakages Pressure reduction
Management on the users' part	Water saving equipment	Water saving appliances (development etc.) Promotion of use of saving appliances Efficient irrigation material Alternative industrial processes
	Installation of water meters	Assessment of used quantities
	Reduction of leakages	For individual and collective users
	Water prices	Adjustment of prices to consumption Concessions for irrigation Sanctions for excessive water use in irrigation
	Water re-use	Use of rainwater for gardens Use of recycled water
	Education and information	General recommendations for water protection Tactical advice for irrigation Advice for reduction of losses

Note: measures which are not a part of water consumption-demand management are not given in the table

2. Technological Approach

2.1 Water saving equipment and appliances

Higher standard of living changes water consumption. This is reflected by increased water consumption in households. Research and development of water saving appliances enabled their application in households (Table 2).

Table 2. Typical Water Saving Appliances in Households

Equipment	Description	Saving
Tap - with airing addition	Introducing of air bubbles into water reduces the flow with the same effect	About 50%
- with thermostat	Maintains given water temperature	About 50% of water and power
- with infrared sensor	Water is available only when the appliance is in operation	Reduction 70 to 80%

- electronic tap	Water may run for a specified time
Lavatory	6 l / flushing
Double regulation	3 l / flushing

Application of new technologies in manufacturing of house appliances has a positive effect on water consumption, resulting in considerable water savings in the past 20 years. Washing machines' consumption per cycle was: in 1970 – 175 l, in 1980 – 142 l, in 1990 – 85 l, and in 1998 – 50 l. Dishwashers' consumption per cycle was: in 1970 – 59 l, in 1980 – 45 l, in 1990 – 24 l, and in 1998 – 13 l.

The influence of use of water saving appliances is variable and depends on the portion of water consumption in households in relation to the entire municipal consumption. Some studies show that for instance in The Netherlands, water saving in households of 10 to 70 per cent make between 6 and 40 per cent of the entire municipal consumption (57 per cent of municipal consumption pertains to households).

2.2 Metering

The influence of water meters or registered consumption on the size of consumption is difficult to separate from other factors, in particular water price. The fundamental question in metering is to work out the real balance between consumed water and unaccounted for quantities (losses). Losses may be assessed realistically if meters are installed both in water supply facilities and with the consumers. The savings achieved by installing of water meters are estimated to about 10 to 25 per cent of consumed water.

2.3 Reduction of leakages in distribution network

The issue of leakages which is the matter of network efficiency, is related to the issue of water quality, because pollution of drinking water is possible if the working pressure in the system is low.

Table 3 shows estimated losses in individual countries. There are large differences from country to country, which are partly due to the condition of networks as well as to application of different concepts in determining of losses.

Table 3. Estimated Leakages from Water Supply Network

Country	Leakages (% of supply)	Source
1. Bulgaria	over 60	(IWSA 1999)
2. Croatia	30 – 60	(Ostojić 2001, 1)
3. Czech Republic	20 – 30	(IWSA 1999)
4. Denmark	up to 16	(IWSA 1999)
5. France	average 30	(IWSA 1999)
6. Germany	average 8,8	(IWSA 1999)
7. Hungary	30 – 40	(OECD 1998)
8. Italy	average 15	(OECD 1998)
9. Slovakia	27	(OECD 1998)
10. Slovenia	40	(OECD 1998)

To get the data on leakages that may be interpreted and compared, it is necessary to analyze a larger number of factors characterizing the network. A comprehensive assessment of the network is shown in Table 4.

Table 4. Description of Losses by Leakage for 2 Water Supply Systems

Description	Essex and Suffolk United Kingdom	Dijon France
NUMBER		
Population	1,662,200	151,000
Connections	586,850	20,580
Housing and other units	733,560	20,580
Mains (km)	8,250	550
Network pressure – night (m)	45	40
Network pressure – day (m)	35	40
Quantity of water in network (10^6 l/day)	498	32,5
Total leakage (10^6 l/day)	85	3,6
Households	686,200	20,324
Consumption in households (10^6 l/day)	269,3	23,3
Maximum source yield (10^6 l/day)	540	100
LOSSES BY LEAKAGE		
l / connection / day	145	175
l / number of units / day	116	175
l / inhabitant / day	51	24
% of water quantity in network	17	11
cu. m / km / day	10	7
mains / connections	14	27
mains / housing units	11	27
water price (pence / cu. m)[1]	110-200	120
marginal costs (pence / cu. m)	10	8
consumption per capita (l/day)	162	154

[1] – GBP 1 = 100 pence = 11,70 KN
Source: (UKEA 1998)

2.4 New technologies in industry

In the industrial sector considerable progress has been made in reducing energy consumption to reduce the costs. In 1990s a lot has been done to improve efficient water use in order to reduce the costs. Water saving measures result in saving of consumed water between 25 and 50 per cent. Saving technologies give the best results in cooling, cleaning and washing processes. By application of closed cycles, water savings up to 90 per cent are achieved.

3. PRICE OF CONSUMED WATER

The complex structure of water price causes difficulties in assessing the impact of water price on reduction of consumption-demand, also, it is difficult to compare water tariffs in different countries. Water bills usually contain a part referring to costs of water supply, and a part referring to other costs – taxes, fees, etc. (Ostojić and Lukšić 2001, 3, 4,5).

In the Republic of Croatia, the price of water supply and sewerage consists of several elements:

1. *The basic price* or price of municipal services is the revenue of the municipal company. The price includes all costs of production and services, repayment of loans for construction of infrastructure, etc. (9).
2. *Water use charge* is the source of revenues at the national level, meant for financing of a part of public services in water management providing the supply of water for specified purposes (5,8).
3. *Water protection charge* is the source of revenues at the national level, meant for financing of public services in water management referring to water protection and for participation in financing of construction of new treatment plans (6).
4. *Concession on waters and water related estate*: the concessionaire is entitled to use water and public water related estate and perform economic and other activities on waters and water estate (2, 7, IWSA Cong.1999). The concession is the source of revenues at the national level, payable to the national budget.

Table 5 shows the basic prices of water, use and protection charges, and concession charges in Croatia.

Table 5. Water Tariffs, Use and Protection Charges, and Concession Charges in Croatia (May 2002)

Item	Price Minimum HRK/cu.m	Arithmetic Mean HRK/cu.m	Maximum HRK/cu.m	Mean EUR/cu.m

A. PRICES OF MUNICIPAL COMPANIES				
1. Households				
- basic price	0.70	3.02	9.80	0.403
- total price	3.06	6.10	13.66	0.813
2. Industry				
- basic price	1.80	5.42	14.92	0.723
- total price	3.70	9.31	20.08	1.241
B. AGRICULTURE				
- irrigation	In accordance with decision of administration bodies water consumption and charges are not paid for			
- fishponds	In accordance with decision of administration bodies, 20% of water use charge is paid until 2005			
C. CHARGES				
1. Value added tax	-	22%	-	-
2. Water use charge				
- category I (public water supply)	-	0.80	-	0.106
- category II (other uses)	-	0.72	-	0.096
- category III (other uses)	-	0.56	-	0.075
- categories IV and V (other uses)	-	0.32	-	0.043
- water power use for generation of electricity	7.5% of price per 1 kWh of actual average price of electric power at plant gate			
3. Water protection charge	-	0.90	-	0.120
D. ANNUAL CONCESSION CHARGES				
1. For water use	10% of water use charge or HRK 0.08/cu.m			
2. Water for market	2.5% of revenue from water sale			
3. For power generation	1% of actual average price of generated electric power at plant gate			

1 EUR = 7,5 HRK
Note: Weighted mean water prices for households are 2.56 and 5.82 HRK/cu.m and for industry 4.76 and 9.15 HRK/cu.m.

Analyzing the billing system for water consumption, prices and charges in Croatia and several other European countries (Ostojić and Lukšić 2001, OECD 1998, Gereš 2002, Margat and Vallee 1998) the following conclusions can be reached:

a) the tariff structure has considerable influence on the final water price and creates sectorial and geographic differences in water price;
b) water policy has a considerable influence on water price. Inclusion of various cost components into water bills is the way to receive payments for a larger number of charges;
c) the major types of tariff structures are:
    - price according to the size of the housing unit
    - tariff according to quantity of consumed water
    - double tariff, as a sum of prices according to the size of housing unit and volume of consumption
    - “block” tariff, which usually includes the price according to the size of the housing unit and the falling and/or rising “block” tariff;

d) there are two kinds of water prices for the industrial sector, depending on the source: direct abstraction (own intake) or from public network.
e) Price of water in the agricultural sector is dependent on the general policy of development of the rural sector, status of environment, erosion, etc. These water prices in Europe vary a great deal.

4. Re-use of water

Treated waste water may be indirectly re-used when discharged into the water course, where it is diluted and again used downstream. Direct use of this kind of water would mean supplying industry, agriculture, recreation facilities, etc., with treated effluent from waste water treatment plants. Such water may also be used to recharge the aquifers (Assano 1994).

Generally, re-use of treated waste water is not common in European countries. In some Mediterranean countries such water is used for irrigation. In other countries, investigations of the possibilities for use are in progress. Table 6 shows the possibilities of application of such water.

Table 6. Application of Recycled Water

Field of re-use	Application
Environment	Regulation of discharges in watercourses
	Swamps and wetlands
	Recreation zones (lakes, parks)
	Fishery and aquaculture
Irrigation	Forage crops
	Edible crops
	Meadows and forests
	Tree nurseries
	Protection from freezing
Ground water recharging	Recharging of aquifers
	Control of mixing of salt and fresh water
Urban areas	Fire protection
	Flush sanitation
	Street washing
Industry	Cooling
	Construction
	Water heaters
	Process water
Drinking water	Indirect use

Source: (Levine et al. 1997)

The quality of waste water and the required quality of effluent for specific purposes determine the required degree of waste water treatment (Crook 1991).

5. Conclusion

Management of water demand is the general concept that allows more rational use of water resources, which contains the initiatives to protect the aquatic environment. Economic issues in water management have become increasingly important and present in the recent years.

Water demand management is achieved by the pricing policy for consumed water, technological improvements, metering of delivered water, education and training of users, and raising of the users' concern for water protection. Other measures to increase water availability

include re-use of treated waste water for purposes that do not require the highest quality of water, and use of alternative water sources. Reduction of leakages from the water supply system increases the available quantities for use without increasing water abstraction from the environment.

Management of water demand – requirements may be considered a part of protection of water resources, as a general concept. The objective of water demand management is to reduce water consumption, through economic instruments and metering of consumption, accompanied with informing of the public about rational water use.

Water demand management is an important way to achieve sustainable water management.

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