Scheele, U. & S. Malz (2007): Water saving: Measures, concepts and technologies in the urban, industrial and in the agricultural sector. In: Lozán, J. L., H. Grassl, P. Hupfer, L. Menzel & C.-D. Schönwiese. Global Change: Enough water for all? Wissenschaftliche Auswertungen, Hamburg. 384 S. Online: www.klima-warnsignale.uni-hamburg.de

4.3 Water saving: Measures, concepts and technologies in the urban, industrial and in the agricultural sector

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SUMMARY: *Water stress and water scarcity are measures of medium and high unmet water needs. The conditions of water stress and water scarcity exist in many parts of the world. Water deficiencies occur at the regional scale and are a result of a combination of physical and social factors: climate and hydrological conditions, population growth and level of economic development. Several policy options for managing water stress and scarcity exist. In the past, water policy has typically focused on supply oriented strategies, now the demand side management approach gains more and more attention. These strategies consist of measures and instruments to influence or control the amount of water used. There is a large technical potential for reduction of water demand in the different sectors. To exploit these potentials, an economic approach is necessary: Water prices have to reflect the true cost of water use and send the right signals to the customers for a more efficient use of water.*

The pressure on the water resources world-wide increases: A growing world population, an increasing water demand of the industrial sector and especially of the agricultural sector leads to problems in the supply of drinking water in many regions of the world. Excessive withdrawals above the regeneration rates lead to the exhaustion of water resources, simultaneously the introduction of pollutants lead to a worsening of the ecological condition of water bodies.

All available regional water supply and water demand projections and other related water studies refer to the problem with all clarity: the number of regions and the part of world population suffering from water shortage and a decreasing water quality will rise dramatically in the future, if it is not possible to reverse the trend and to implement a new policy of an integrated resource management.

It seems obvious, that in the future the balance between water supply and a growing water demand will not be achieved by the traditional supply-oriented strategy of the expansion of the water production and delivering system. Water conservation concepts are therefore central to suggestions of a new resource management or more generally speaking to the necessity of a demand side management and an efficient resources policy.

Of course, nature and extent of the conservation potential differ considerably between the water consuming sectors, to put it all in a nutshell in all countries there is a great unused potential of water conservation and efficient use of water.

Demand management in the water sector

Most industrial nations pursue a supply oriented water strategy up to the 1980s: the reaction on recognisable or threatening water supply shortages was to develop new water resources and the construction of long-distance supply systems in order to solve regional water problems. However, these strategies were limited for different reasons and first concepts of a water demand management were developed. These demand oriented approaches followed the objective to reduce the amount of water withdrawn from groundwater and surface water reservoirs and in a wider sense to control the use of water.

Despite the fact, that the development of these strategies is of course dependent on the specific regional conditions, their background and their objectives show some similarities (OECD 2003):

- The rising costs of the water supply system favours incentives to water conservation measures.
- New legal obligations for example with respect to the realisation of technical standards will contribute to the reduction of resource consumption through the industrial sector and thus lower the negative environmental impact on the resource use.
- Water saving and environmental compatible behaviour can increase the image of industrial companies and strengthen their position on competitive global markets.
- The environmental awareness of the consumers clearly increased during the last decades, in most cases this is supported and accompanied by special campaigns of environmental organisations. Still more frequent is the fact, that this new environmental awareness is converted into environmentally sound consumption and investment patterns.

The demand oriented approaches shall contribute to the balance of water supply and water demand on a regional scale. Often it is decisively the political resistance of those regions acting as raw water exporting area in favour of the metropolitan and agglomeration areas with high water demand and scarce resources. The water rights system differs, but in most countries there is no legal basis for compensating the exporting regions neither for the negative economic and ecological results of an excessive use of the regional water resources nor for paying a price for the water withdrawal.

During the last decades a broad range of instruments

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of water demand management were developed. These can be categorised by various criteria (European Environment Agency 2001, p.11) like

- type of incentives:

- legal obligation (e.g. compulsory use of certain technologies, quota for water use);
- economic incentives (e.g. tariff systems, progressive pricing, subsidies for watersaving investments);
- information, motivation (e.g. information campaigns, user education, programmes to increase environmental awareness, concern for public image);

- kind of tools used:

- infrastructure improvement (network improvement, repair leaks, etc.);
- non-structural measures (information, education, pricing) which may, however, finally lead to infrastructure improvements being implemented normally through end-users as a consequence of the measures adopted;

- time horizon:

- emergency measures;
- medium- and long-term measures;

- location of the water supply system where measures are implemented:

- abstraction facilities;
- storage facilities;
- conveyance and distribution network;
- end-users' facilities;

- entity bound to carry out measures:

- agencies and public authorities (e.g. initiatives within water supply companies);
- end-users (households, industries, farmers);

- entity promoting demand management initiatives:

- international treaties and conventions;
- EU legislation and policies;
- national legislation;
- local and regional initiatives;

- sector in which measures are applied:

- urban use (households, small commerce, etc.);
- industry;
- agriculture.

Usually water demand measures are part of a more comprehensive resources policy, covering water supply as well as water demand management approaches. Examples of such options and measures are given in *Table 4.3-1*.

Water savings in the household sector

Within private households numerous, partly very innovative measures of water saving were tested and implemented over the years. The technological progress of the household appliances technology has contributed to a continuous reduction of the water consumption. Technical innovations are often driven by the motive of energy saving, the reduction of water consumption therefore represents a by-product of these efforts to a more efficient use of energy. On the other side, the declining specific consumption values were compensated at least in the past by the rising number of water consuming appliances in private households. So the overall water consumption remains at least stable.

Important potentials for water saving are seen in the area of the toilet flush or respectively in those use categories where no water with drinking water quality is necessary. Quite often very simple technical installations can result in large water savings. Gleick et. al. (2003) mentioned, that the water saving potential in the private household sector is considerable and can amount up to 70% of the present consumption in developed countries (EEA 1999, 18 pp.).

A technically more sophisticated solution is water recycling, which is often seen as complementary to a centralised grid water supply system. Decentralised recycling concepts are often completed by small scale water abstraction schemes or measures like rain water harvesting.

These new supply models have put their suitability under proof, but up to now, they do not represent in any case an economic viable solution. They can probably be economical in new residential areas or housing estates. A lot of these projects mentioned in the literature are more or less pilot schemes of the respective water supply enterprises. A good known technical solution is a dual water supply network for delivering different water qualities (drinking water, grey water), but the economy depends on the specific local conditions. So in practice a completely new network is only economically viable under very exceptional conditions.

In developing countries special »low cost« solutions are promoted as alternatives to the central water supply system, due to the fact, that grids are limited for economical and ecological reasons and are not always sustainable with respect to the social and institutional dimensions (BMBF/ Forschungszentrum Karlsruhe 2001).

An essential component of all resource management strategies is, besides technical approaches, the claim for the introduction of cost-recovering prices in order to provide incentives for an efficient use of water to consumers. The OECD Environment Strategy (OECD 2001) invites the member states to develop water charging systems in the context of their National Action Plans, that will cover all costs of the water supply system but also take into account the social aspects of water prices and include all the external costs caused by the withdrawal and the use of water (OECD 2003 a, b). The aim is to create water prices which reflect the social marginal costs of the water use and provide incentives for a thrifty use of scarce water resources. This presupposes that the structure of the water prices largely correspond to the cost structure of the water supply with a high proportion of fixed costs, independent of the water

produced and delivered by water utilities. From an economic point of view therefore a price structure with a connection charge, covering one part of the fixed costs of the suppliers, has a favourable effect on the long term financial performance of the water supplier. Besides the connection rate there is a huge variety in the type of the tariff system (i.e. flat rate tariffs, uniform volumetric tariff or block tariffs). The water charges are determined by different factors (among others the availability of water resources, treatment costs, social and political factors) and take into account the different types of consumers with their specific consumption patterns. Overall it is the aim to give the right signals to the consumers about the true value of water consumed.

In the meantime the demand for a full cost recovering water price system has been realised to a certain extent in most of the developed countries, but also with respect to the developing countries it is obvious, that the privatization of water supply has to be accompanied by a policy of price reform. Of course this does not seldom result in social problems, political resistance against privatisation and the rising number of failed privatisation projects. The European Water Framework Directive commits all member states to put a price system into action, covering the operating costs as well as all kinds of related external costs. In most European countries some kinds of environmental taxes on water abstraction and water consumption exists, which pass at least some of the external costs to the consumer, but with a view to an efficient water price system it seems to be a serious backlog even in European countries. This is also true, because in many countries water prices are still subsidised and therefore do not reflect the true costs of running the water and sanitation system.

Table 4.3-1: Water resource management in the context of total water supply/demand management (EEA 2001, 13).

Process	**Options**	**Examples of measures**
Resource management (infrastructure + supply)	Exploitation of additional water resource	• Increase supply yield • New boreholes or abstraction points
	Construction of increased storage or transport capacity	• Reservoirs • Aqueducts
	Management schemes	• Conjunctive use • Artificial recharge
	Alternative sources to freshwater	• Use of seawater for cooling systems
Production Management	Production technology	• Technology for improving water treatment such as desalination
	Recycling treated wastewater	• Recycling for a variety of uses • Reduction of production requirements
Distribution management	Capacity of mains distribution network	• Increase mains capacity
	Efficiency of mains distribution network	• Localisation and repair of leaks • Pressure reduction
Customer-side management	Water-saving equipment	• R & D of water-saving devices • Encouraging use of devices by individual users and collective users • Efficient irrigation material • Alternative industrial processes
	Meter installation	• Assessment of volumes used
	Leakage reduction	• For individual users • For collective users
	Tariffs	• Adjustment of consumption-related tariffs • Use of permits for sprinklers • Penalties for exceeding irrigation volume ceiling
	Reuse	• Rainwater for watering garden • Recycling of used water for other uses
	Education and information	• General advice and information on conservation • Tactical irrigation advice • Advice on leakage

In general, water prices increased during the last decades and reflected the growing costs for water extraction and treatment as well as the costs of expansion and rehabilitation of the water supply system. Whether rising water prices will have a diminishing effect on water consumption depends on the price elasticity of the demand. Price elasticity is a measure to describe the sensitivity of demand towards price changes. Elasticity is expressed as the percentage change in water consumption caused by a one percent increase of the water price. Most of the economic studies and research reports refer to low short term price elasticity since consumption is largely technically determined by the number of water - consuming appliances and consumption behaviour is fixed. In the long run however, households will react on water prices and take them into account when making investment decisions and for example install more efficient water - saving devices.

The difference between short and long term elasticity is also an explanation for the observation that new efficient water technologies need time to establish on the market, although the profitability of such an investment is obvious even in short term.

The potential for water savings in the industrial sector

During the last decades the industrial production in most countries shows a sharp decline in the water intensity (European Environmental Agency 2001, Wolff & Gleick 2002). Water intensity can be expressed by the number water volume (often m^3) necessary for the production of one unit of a product. The decoupling of economic growth and industrial water consumption is from a macro-economic point of view the result of the ongoing structural change in the economy towards a service and information society and the declining economic significance of those industrial sectors relying on an intensive use of renewable and non renewable resources.

This view has to be conditional if taking into account concepts of »virtual water trade«: Virtual water means the amount of water »embedded« in an industrial or agricultural product. About 15% of the world-wide water withdrawals are estimated to be used for the production of export goods, water is »virtually« exported. If for example water – intensive production capacities are shifted from a developed industrialised nation to a developing country, this will reduce the pressure on the local water resources in one country but on the other side sharpens the resource situation in the developing country (Hoekstra 2003).

The globalisation process and the tightening of the competition on markets will force enterprises to exhaust all cost saving potentials in order to secure their position on the markets. These measures include all possibilities to reduce the amount of energy and water as well.

Of course the technologies and the demand side concepts differ in detail within the industrial sectors, but the measures can be categorised in the following way:

- Substitution of water as a production factor
- Improvements in the control of the production processes and
- the creation of closed circuit in internal water management.

The water saving potential is determined by the respective technical features of the production process and the state of the art of technology. The application of closed water cycles can reduce the water consumption up to 90%; most reports and case studies refer to an overall saving potential in the industrial sector of about 50% (European Environment Agency 1999, Wolff & Gleick 2002).

The amortisation of investments in new technologies and water saving devices can be realised in very short time periods due to the decreasing water demand and water cost. Additional financial benefits arise form the fact, that also sewage treatment and energy costs will go down.

In most countries, the industry obtains only a certain portion of the drinking and process water from public water utilities and many companies rely on their own water rights and water sources. Therefore only limited information about total water costs and the development in industry is available. This is true even in those cases, where large scale enterprises are served by public utilities under a special tariff framework. There is no duty for the public utility to publish details of such contracts.

As a rule, for the industry the supply of water out of own water resources is expected to be less cost intensive, because no or only limited investments in a water net infrastructure are necessary. Furthermore companies can reduce costs due to a relaxation of quality standards or are able to refrain from safety precautions like the determination of water protection areas. Requirement for industrial self supply is the existence of own water rights. The special features of such water rights in terms of the amount of water or the duration of concessions depends on the institutional arrangements and differ from country to country.

In future the introduction of cost-covering prices and of new water right trading models but also higher water costs due to new environmental obligation or increasing energy prices will further put pressure on companies to use all potentials of water saving for an efficient water use.

Efficient water consumption in the agricultural sector

The agricultural sector is the biggest water consumer in most regions of the world. On average about 70% of the world-wide water withdrawal is for irrigation purposes. The amount of water withdrawn depends on the different regional climatic conditions, the kind of agricultural use

and irrigation method. Water for irrigation is in most cases withdrawn from surface water, but in many regions serious problems arise due to an excessive use of groundwater reservoirs and increased water pollution through agro-chemicals.

Insufficient irrigation methods have contributed to a salting of agricultural land in many regions and to an ongoing expansion of the irrigated areas. The state subsidies for agricultural production, especially for the use of chemicals, energy and water leads to an expansion of those insufficient irrigation methods by paying not the true price for water.

The size of the irrigated arable land has tripled since 1950, one third of the total agricultural production and half of the world food production relies on irrigated land.

Despite the obvious negative implications, in the future irrigation will play a central role in the agricultural sector to guarantee the food supply for a still growing world population. To be able to keep pace with the growing food demand, according to recent forecasts the irrigated area should increase up to 20% to 30% till the year 2025.

The increasing costs of this form of the agricultural production and particularly the related ecological burdens but also the growing claims of the other water consuming sectors (industrial and residential water demand), however set clear limits. More efficient irrigation methods are therefore mandatory.

Any reduction in the water demand for agricultural purposes will result in a remarkable improvement of the regional water balance. A reduction of the water demand by 25% in an agricultural sector in a region, where the proportion of this sector on total water withdrawal is about 80% means that the water abstraction of all other sectors could be doubled without exceeding the current water utilisation.

Similar to the industrial sector, there are numerous already proven strategies to increase the efficiency of agricultural water use (POSTEL 1999). A considerable water saving potential arises from the application of new irrigation technologies (micro-irrigation system, laser levelling); these techniques contribute to a more specific and evenly distributed use of water on the irrigated land. Compared to conventional methods with micro-systems water saving up to 90% seem attainable and economically realistic (WOLFF & GLEICK 2002). There is only limited information available concerning the world-wide distribution of such techniques, but reports and past experiences support the assumption that due to the high costs these irrigation technologies will only be used for the production of high valued crops and food.

Also economic instruments will come into action: cost recovering water prices and the introduction of water rights markets can be measures to enforce concepts of an efficient use of water in the agricultural sector. Recent experiences in many countries show that the demand for irrigation areas is relatively insensitive to changes in water prices. Climatic conditions, the development on global markets and especially the reaction of agricultural policy determines what kind of agricultural products are cultivated and are economically competitive. This also leads to the important conclusion that for a more efficient use of water not only technical measures are sufficient but all instruments and concepts have to be tied into a comprehensive policy strategy.

Conclusions

The world-wide water crisis will not be solved without systematic steps to influence the demand side of the water cycle. This short overview refers to the huge variety of available technologies and instruments for water saving and makes clear that there is a large reduction potential particularly in those sectors with high water consumption at present. However, the full use of this theoretical potential is frequently limited by economic, legal or institutional factors and constraints. The use of the full potential for water saving in the private household sector for example may be limited due to the specific institutional conditions: the owner of an apartment will have no incentives to invest in more water efficient devices if his own water consumption is not metered but billed over a flat rate scheme covering the total water use of the dwelling. This may also be the case, if the department is rented and the tenant is not authorised to make some necessary structural improvements to the building.

Economic instruments especially in the water sector gained more acceptance world-wide. The sharpening of the resource situation and the misallocation are immediate results of a pricing policy which does not confront the users with the true costs of their consuming decisions. While the cost recovery principle in the meantime is an accepted standard in water price policy in industrialised countries, up to now in developing countries the prevailing view is to see water as a free good. As shown in the last years, it is a difficult task to implement price strategies which cover the costs of a water supply system, consider environmental aspects of water withdrawals as well as send the right incentives to the consumer and takes into account the social implications.

While the necessity of water saving measures lies mainly in regions with severe water resource scarcity, the situation in some other countries without such obvious scarcity is quite different. In Germany for example the discussion is actually about »sense and nonsense of water saving«. With the exemption of some regions there are no quantita-tive water problems in the country;

quite the reverse the decline in water consumption as a result of technological progress and the demographic change will cause new problems like rising groundwater levels.

Under these circumstances the economic efficiency of any measure to support water savings seems questionable, because the (high) costs of such measures are not fully compensated by social benefits. A good example for such an economic assessment of water saving measures is the reduction of leakage rates in the water supply network system. Whereas some utilities try to minimise the leakage rate without taking into account the cost – benefit ratio, in the privatised UK water industries water utilities determine a so called »economic leakage level«: The reduction target depends on the specific cost structures and the resources availability in the supply area, even high leakage levels may therefore not be problematic at all. But of course the benefit and cost assessment shows some methodological limits, so that such a cost – benefit – analysis can be misleading. From an ecological point of view a shifting of financial resources to other severe environmental problem areas could have a beneficial effect on the long term sustainable development of the society♦