Efficient Use of Water Resources

7 policy areas of the blueprint – how are they addressed in this assessment; land use management (partially – i.e. CAP, but more a vulnerability issue than RE); economic incentives (√); targets (√); Governance (X); Knowledge base (√ - reference to UN report and EEA accounts); Innovation (√ - but only implicitly through examples); Global dimensions (√ - virtual water)

To come; Water-Energy textbox; Labelling and Certification; DG Leakage report; Green Infrastructure (more a vulnerability issue?); Ecosystem Accounting; PES – drinking water protection; Resource Efficiency targets; Allocation and trading; Conclusions

1.) Introduction

Water is critical for life and is integral to virtually all economic activities, including food and industrial production, and the generation of energy. The availability of clean water in sufficient quantity is not only a prerequisite for human health and well-being it is also essential for freshwater ecosystems and the many services that they provide.

Whilst historically most Europeans have been insulated from the social, economic and environmental impacts of severe water shortages, the balance between water demand and availability is reaching a critical level in parts of Europe. This water stress typically arises from over-abstraction together with periods of low rainfall or drought. Reduced river flows, lowered lake and groundwater levels and the drying up of wetlands are widely reported, alongside detrimental impacts on freshwater ecosystems, including fish and bird life. Lack of water has also had severe consequences for key economic sectors including agriculture, energy production and industry. At times, Europe's citizens have also been affected, being subject to rationing and reliant upon the shipping in of drinking water supplies.

In addition to the growing problem of water stress, the quality of some of Europe's freshwaters is also of concern. A range of pollutants, derived from various sources, can be found at levels which detrimentally impact aquatic ecosystems, degrade habitats and result in the loss of flora and fauna. Poor water quality is also a potential threat to public health through freshwater and marine recreation, the consumption of contaminated freshwater and seafood, where sanitation is inadequate and, where access to safe drinking water is lacking.

The pressures currently exerted upon Europe's water resources are likely to be exacerbated over coming years by climate change. Much of Europe will be increasingly subject to a reduction in water availability in summer months, whilst the frequency and intensity of drought is projected to increase in the south. In the absence of appropriately strong measures, climate change may also detrimentally impact water quality, as reflected, for example, by a projected increase in the occurrence of toxic algal blooms. Furthermore, both a growing global demand for food and an increase in the cultivation of energy (biofuel) crops may exacerbate the impacts of agriculture upon Europe's water resources.

Europe needs a sustainable approach to water resource management, focusing on conserving water and using it more efficiently. Integral to this is a more equitable approach to water abstraction that addresses not only the requirements of competing economic sectors but also the need for healthy freshwater ecosystems. Successful implementation of sustainable water resource management across Europe will both address the need to adapt to climate change and contribute to lower energy consumption because water and energy use are closely linked (reference to a textbox). Efforts are also needed to reduce the pollution of Europe's freshwaters and would yield improvements in aquatic ecosystems, reduce treatment costs and diminish risks to human health.

A more efficient use of water and of those constituents that lead to its pollution can play an important role in the delivery of a green economy across Europe. Historically, economic growth has imposed ever greater demands on natural ecosystems – including freshwater – and as is increasingly understood, this cannot continue indefinitely; the environment has natural limits in terms of how much it can provide and absorb. A green economy addresses this issue, being designed to generate increasing prosperity while maintaining the natural systems that sustain us (SOER Synthesis). To achieve this, requires a more efficient use of resources and the importance of this is recognised by a flagship initiative - 'a resource-efficient Europe' - under the Europe 2020 Strategy (EC, 2011a). In addition to the role of natural resources in underpinning the functioning of the European economy, both the initiative and its related roadmap (EC, 2011b) allude to the importance of sustainable water management and the provision of water of good quality.

By itself, resource efficiency will not guarantee steady or declining resource use, since it is possible to become more efficient but still put excessive demands on the environment, for example, through increasing production and consumption. For this reason, resource efficiency policy must be grounded in an awareness not just of the quantity of resources used but the impacts on the environment and its capacity to sustain us. It is important, therefore, that as well as a focus upon technologies to increase efficiency, understanding of the natural capital stocks that drive our economies is enhanced. With respect to freshwater, this requires knowledge, robust data and indicators that can show the link between water management and social and economic benefits and ecosystems services (UN Int Resource Panel). Furthermore, the role of water in maintaining biodiversity and providing a range of ecosystem services needs to be recognised, valued and paid for (UNEP, 2011). Such an approach is in close alignment with the Water Framework Directive's requirement for the recovery of environmental and resource costs of water services.

This assessment describes the opportunities for improved efficiency of water use across all sectors including those activities that give rise to the pollution of freshwater. New technologies and innovative practices are outlined and the potential for efficiency gains is explored. Water pricing as a means to incentivise sustainable use is highlighted, as is the clear need for better information to improve the management of water resources and diminish those environmental impacts arising. Targets

2.) Water Resource Efficiency – Sectoral Measures

Intro

2.1 Agriculture

2.1.1 Efficient use of water by agriculture

Agriculture is a significant user of water in Europe, accounting for around 24 % of total water use. This share varies markedly, however, and can reach up to 80 % in parts of southern Europe, where irrigation of crops accounts for virtually all agricultural water use. In many regions within southern Europe, crop irrigation has been practised for centuries and is the basis of economic and social activity. In arid and semi-arid areas of Europe, including much of southern France, Greece, Italy Portugal, Cyprus and Spain, irrigation allows for crop production where water would otherwise be a limiting factor. In more humid and temperate areas, irrigation provides a way of regulating the seasonal availability of water to match agricultural needs, thereby reducing the risks to crops during periods of low rainfall or drought.

While enhancing the yield and quality of crops, irrigation can and does lead to a range of negative environmental impacts, including water scarcity. The detrimental effects of excessive agricultural water use are exacerbated by its relatively high consumptive use. Although some irrigation water is 'returned' to groundwater via percolation, consumption through plant growth and evapotranspiration is typically significant and approximately 70 % of water abstracted does not return to a water body (Molle and Berkoff, 2007).

Traditionally, supply-orientated approaches have ensured a regular supply of water for agriculture through a combination of reservoirs, inter-basin transfers and increasing abstraction of both surface water and groundwater. Generally, however, such practices are not sustainable in the longer term and simply exacerbate the adverse impacts of agricultural water use upon freshwater ecosystems. Fortunately, a number of technological and management measures exist to improve the efficiency and sustainability of agricultural water use and are described below. It should be noted, however, that the efficiency gain associated with each approach is strongly dependent upon a range of factors including crop and soil type and climate, and full understanding of this is required before implementation (Bio Intelligence Service, 2011).

Improving irrigation efficiency

Irrigation efficiency can be improved by improving conveyance efficiency, field application efficiency or both. Conveyance efficiency refers to the percentage of abstracted water that is delivered to the field. There are large differences in conveyance efficiency depending on the type of irrigation network. In Greece, for example, average conveyance efficiencies are estimated at 70% for earthen channels, 85% for lined channels and 95% for pipes (Karamanos, 2005). The conversion from open channels to pressurised pipe networks can, therefore, be an important water saving measure. For example in the Cote d'Azur region in

France, such a conversion has helped save around 300 million m^3/year (Dworak *et al.*, 2007). Across the EU, potential water savings from the improvement of conveyance efficiency are estimated at 25% of water abstracted (WssTP, 2010).

Field application efficiency is the ratio between the water used by a crop and the total amount of water delivered to that crop, indicating how well an irrigation system performs in transporting water to the plant roots. A strong contrast is apparent when comparing furrows with sprinkler and drip systems, with the former having an efficiency of around 55 %, sprinklers 75 % and drip systems 90 % (Dworak *et al.*, 2007). More efficient irrigation systems are gradually being implemented within Europe. In Spain, between 2002 and 2008, the area irrigated by gravity (flooding) methods decreased from around 1.4 million to just above 1 million hectares. Over the same period, drip irrigation increased from 1.1 million hectares to 1.6 million hectares (MARM/BPIA, 2009).

Increased irrigation efficiency can, however, result in either no change or even an increase in water used, when the gains in efficiency simply drive an expansion of the irrigated area. For example, García (2002) reports that drip irrigation technologies that were subsidised in the Valencia region of Spain did not lead to reduced application rates, whilst Candela et al. (2008) report a tripling of irrigation area following efficiency improvements. Research in Crete has revealed that the technical efficiency of some farmers using drip irrigation systems is low and they are not fully exploiting the potential water resource savings (OECD, 2006). Any installation of improved irrigation systems need, therefore, to be accompanied with advice to farmers.

Modification of agricultural practices

Crops vary in their resistance to drought, water requirements and the time of year at which the requirement peaks. These factors, together with irrigation management and soil moisture conservation can all reduce crop water use. Crop tolerance to drought depends partly on the depth of root systems. Crops with deep root systems such as grapes, alfalfa and sorghum are able to draw upon moisture deeper in the soil horizons than those with shallow roots (e.g. maize and pea) and so cope better during periods of water stress. Crops also vary in their timing of peak water demand. Water demand for maize, for example, is concentrated in the summer months when water stress is at a maximum. In contrast, the cropping calendar of rape, winter wheat and winter barley is centred on the autumn and winter months when there is more water available. The timing of the cropping calendar can also be used as a technique to reduce irrigated water use. Early sowing, for example, can help capture winter rains so that the need for supplementary irrigation is reduced. Early sowing also helps avoid the extreme evapotranspiration rates typical of Mediterranean summers.

Aside from economic considerations, changing from high water demanding crops to low water demanding (and drought tolerant) crops is an obvious option for reducing irrigation water requirements. The success of such a change is, however, highly dependent on market prices. In addition to changing to less water demanding crop types, there is also potential for returning irrigated land back to traditional rain-fed practices, particularly in regions where water-stress is acute. While such a wholesale change in the approach to farming would clearly make a marked impact on water use, it raises a number of socio-economic issues and may not be economically feasible in some locations.

Deficit irrigation is a technique that aims to reduce the amount of water applied to below the 'theoretical irrigation need' on the basis that the substantial water savings realised outweighs any reduction in crop yield. The approach takes advantage of the fact that maximum production does not necessarily lead to maximum profitability. Deficit irrigation has been shown to have more success with tree crops and vines than field crops (Fereres and Soriano, 2006). For grapevines, a reduction in water use ranging from 16.5 % (rainy years) to 53 % (dry years) produced no significant impact on the grape yield or the quality of the must (Battilani, 2007). The water stress sensitivity of maize, however, means that it does not respond well to the practice (Bio Intelligence Service, 2012). A number of factors must be accounted for when considering deficit irrigation, including the crop type, its phenological phases, and the monitoring of soil water content.

Improving the timing of irrigation so that it closely follows crop water requirements can lead to significant water savings. The approach does require, however, that farmers are well trained and familiar with issues such as temporal changes in crop water demand and the estimation of soil moisture. The irrigation advisory service of Crete informs farmers by phone of when and how to apply water to crops, based on estimates of daily crop evaporation, which account for crop type, growth stage, soil type and rainfall. Water savings of 9% to 20% have been realised (Bio Intelligence Services, 2012), reducing costs to farmers.

Wastewater re-use

In areas where water is scarce, treated wastewater provides an alternative source of water for irrigating crops. Depending upon the level of treatment, it can be relatively nutrient rich, reducing the need for additional applications of inorganic fertiliser. The practice is growing within Europe and in Gran Canaria, Spain, for example, 20 % of water used across all sectors is supplied from treated wastewater, including the irrigation of 5 000 hectares of tomatoes and 2 500 hectares of banana plantations (Mediterranean EUWI Wastewater Reuse Working Group, 2007). Following a comparative analysis of desalination, importation and reclamation of wastewater on the Aegean islands, Gikas and Tchobanoglous (2009) conclude that the latter is characterized by the lowest cost and energy requirements. Reclamation of wastewater is recommended as part of a long term sustainable strategy for managing water resources across the islands and has a number of potential applications, including agricultural irrigation. Re-use of wastewater for agriculture does, however, mean that that volume of water is no longer directly discharged to a watercourse. In addition the practice raises soil contamination and public health concerns, particularly with respect to pathogens and hazardous substances.

Tackling illegal water use

While reliable quantitative information on the issue is scarce, it is clear that the illegal abstraction of water, particularly from groundwater and often for agricultural purposes, is widespread in certain areas of Europe. Illegal water use may involve drilling an unlicensed well or exceeding a consented abstractable volume from wells that are licensed. In addition, it can occur from surface waters using transportable pumping devices. Addressing illegal water use is crucial but represents a major political and technical challenge. Monitoring is required to detect illegal wells and authorities have to follow up detected cases with fines or penalties sufficiently severe to deter further illegal abstraction. Surveillance is also required to ensure continued compliance.

Crop productivity and water use in Spain - textbox

The concept of virtual (or embedded) water describes the water used in the production of a good or service, including agricultural produce. Expressed in terms of crop water use per ton of yield, knowledge of virtual water can help to achieve a more efficient allocation of water resources for agriculture and inform crop production and trade decisions. The coupling of virtual water with economic information describing the production value of a crop, however, can further strengthen decision making with respect to agricultural water management. Water economic productivity, expressed in terms of crop market price per cubic meter of water required (€/m^3) has been derived, for example, for the Mancha Occidental region, Spain (Aldaya et al. 2010). This study distinguished ‘low virtual-water’ ‘high economic’ value crops from the converse, in a semiarid region characterised by irrigated agriculture. The findings showed that high virtual-water low economic crops such as cereals are widespread in the region, in part due to the legacy of earlier CAP subsidies. An expansion of low water consumption and high economic value crops such as vines was identified as a potentially important measure in achieving a more efficient allocation of water resources (Aldaya et al. 2010). Pricing can play a role in this respect, as a tool to allocate water to those crops that generate the highest economic value at low water demand (Bio Intelligence, 2012).

2.1.2 Efficient use of fertilisers and pesticides

Despite improvements in some regions, pollution from agriculture remains a major cause of the poor water quality currently observed in parts of Europe. In particular, nutrients — nitrogen and phosphorus — from fertilisers, pesticides, sediment, pathogenic micro-organisms excreted by livestock and organic pollution from manure are regularly detected in freshwaters at levels sufficient to impact aquatic ecosystems (e.g. through eutrophication) and require treatment where water is abstracted for drinking (EEA, 2010).

Many of these problems can be alleviated, however, through implementation of a range of cost-effective on-farm measures which realise a more efficient use of both inorganic and organic fertilisers, and pesticides, yielding improvements in water quality. The on-going adoption of such measures in Europe is likely to continue to be driven, in part, by legislation. The Pesticides Directive, for example, requires the establishment of national action plans to set objectives to reduce hazards, risks and dependence on the chemical control for plant protection. Source control measures have been identified that will result in a reduced use of pesticides including the encouragement of low-input or pesticide-free cultivation, prohibition of aerial spraying under certain circumstances, and defining areas of significantly reduced or zero pesticide use in line with measures taken under other legislation, for example the Habitats Directive. In addition, the potential to reduce the amount of harmful active substances by their substitution with safer alternatives is also recognised. Substantial reductions in pesticide use have been shown to be possible with little or no impact upon profitability or productivity. This is achievable, for example, through modification of crop rotations and sowing dates, and through the selection of more pest-resistant crop varieties (Refs).

Driving forces other than legislation will also play a key role with respect to a more resource efficient agricultural sector. Phosphorus, for example, is an essential plant nutrient, applied to agricultural land worldwide within fertilisers derived from phosphate rock. Phosphate rock, however, is a non-renewable resource that is being steadily depleted, with some estimates suggesting a depletion of global commercial phosphates reserves within 100 years at current rates of extraction (Schroder et al. 2009). Other studies suggest that the global peak in rock phosphate reserves will occur around 2035 (Cordell et al. 2009) after which mining and processing will become increasingly uneconomical. Whilst the timing of such a peak and the lifetime of remaining reserves is subject to on-going debate, there is a general consensus that the quality of remaining reserves is in decline, phosphate layers are becoming more difficult to access and costs are increasing (Schroder et al., 2009); ultimately, cheap phosphate fertilisers will no longer be available. Unfortunately, phosphorus has no substitute in food production and the European Union is almost entirely dependent upon imports, with China, Morocco, the US, South Africa and Jordan controlling 85% of global phosphate reserves (Schroder et al., 2009). The efficient use of phosphorus and its recovery from waste streams is, therefore, paramount within Europe, and will also help to reduce detrimental impacts upon aquatic environments, particularly as phosphorus is the primary cause of freshwater eutrophication (Correll, 1998).

Various on-farm measures have been shown to improve the efficiency of use of phosphate fertilisers. In some cases these measures control 'at source', for example, through the reduction of phosphorus inputs in fertiliser onto agricultural land where phosphorus levels in soils have progressively built up over time to the extent that they are sufficient for plant growth. Romer (2009) suggests that 70-80% of European soils have average to high levels of phosphorus and that yields could be maintained for several years without phosphorus fertilisation. Such an approach could reduce phosphorus losses substantially and at no cost (DEFRA, 2003). In addition, reducing phosphorus in animal feeds has been shown to be of minimal cost (Jacobsen et al., 2004; Malmaeus and Karlsson, 2010). Other low-cost measures include the restriction of fertiliser applications in high-risk locations (e.g. near water bodies or on steeply sloping land) and at high-risk times, for example when soils are saturated, since under these conditions a significant proportion of fertiliser applied can be simply washed away to the nearest waterbody.

Drinking water protection zones and water industry treatment costs. – Devaux example – task 2? WWF Germany example, with Mattheiss, Heinz?

2.2 Industry

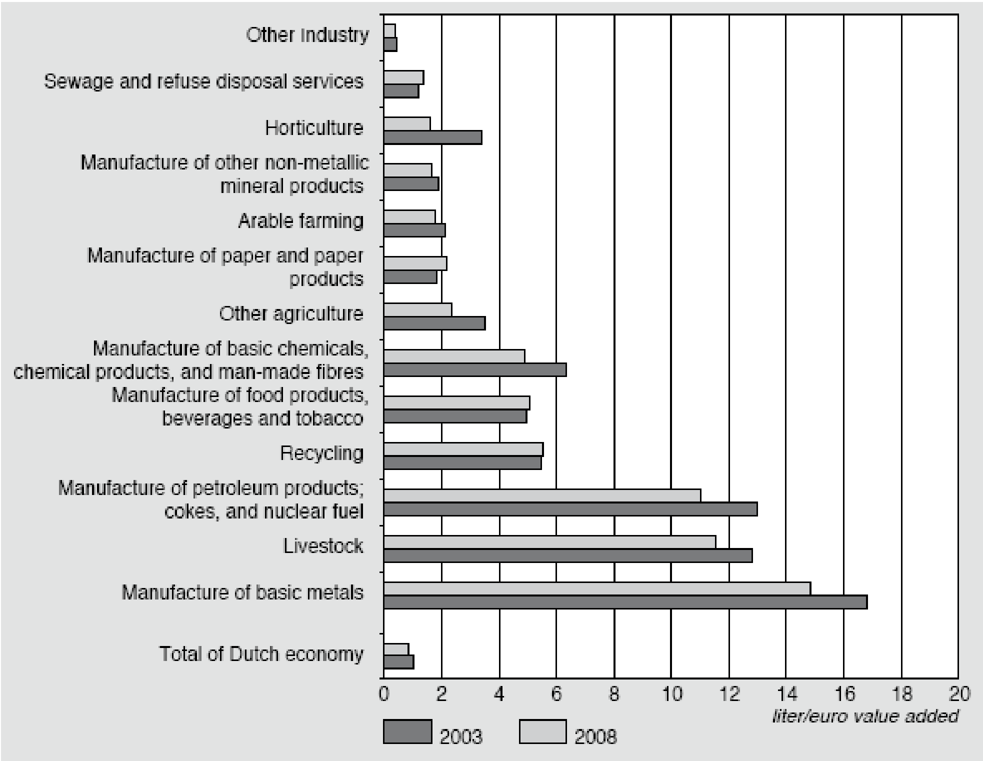
Reduction at source, recycle, re-use, on-site treatment, lower energy, less water supplied – need examples. – SOER examples – page 25

Chemicals should be produced and used more sustainably - textbox

Despite the comprehensive suite of legislation now implemented within Europe, the ubiquitous use of chemicals in society represents a major challenge with respect to the protection of aquatic ecosystems; emissions of hazardous substances to the environment, including fresh and marine waters, can occur at all stages of their life cycle. Whilst these emissions arise from various sources, the private and public consumption of consumer goods is a fundamental driver of the production and, therefore, of the release of hazardous substances to the environment. The promotion of more sustainable chemical consumption patterns for the future may be achieved most effectively through a mix of policy responses involving regulation, economic incentives and information-based instruments, including awareness-raising campaigns (EEA, 2010). Implementing a more sustainable approach to the consumption and production of chemicals would not only benefit Europe's environment but also reduce the detrimental effects arising in other parts of the world as a result of the growing proportion of goods imported to Europe. To help achieve a more sustainable production of chemicals, wider implementation of 'green chemistry' is required. This approach involves the development of new processes and technologies that maintain the quality of a product but reduce or eliminate the use and generation of hazardous substances. The adoption of sustainable, green chemistry techniques has been shown to generate financial benefits and hence provide competitive advantage. Currently, however, there is no comprehensive EU legislation on sustainable chemistry in place (EEA, 2010). Expand to include source controls?

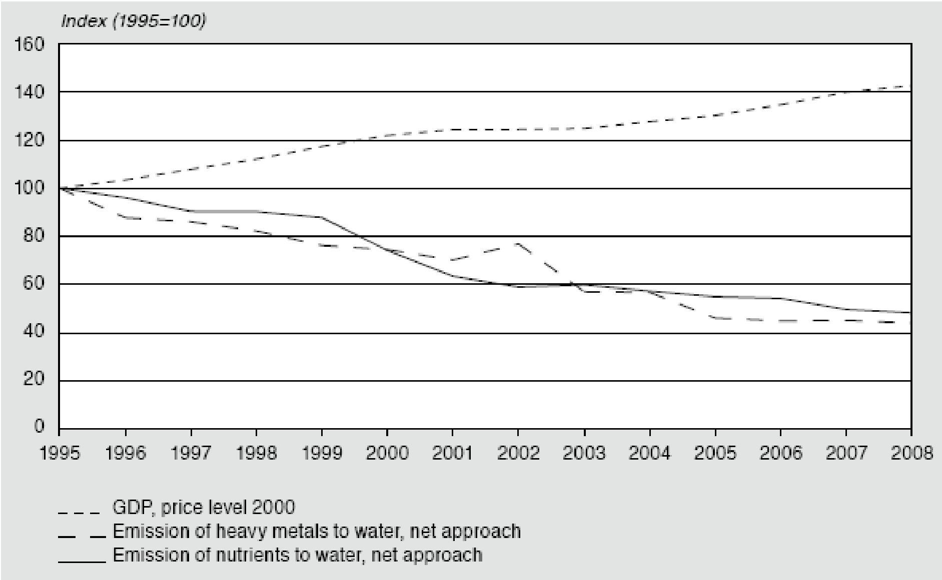
Industrial Water Use in the Netherlands – textbox example

The efficiency of industrial use of water from public supplies (as distinct from larger industrial plants which are typically self-supplied) has improved in recent years in the Netherlands. In 1990, on average, such industries used 1.64 litres of water for every euro of value added but by 2003 this figure had fallen to 1.04 litres per euro and by 2008 to 0.85 litres per euro. Significant variation is apparent between industrial sectors, with the manufacturing of basic metals, livestock breeding, and the manufacturing of petroleum products, cokes, and nuclear fuel all exhibiting a relatively high water use per euro value added. These three water intensive industries have all, however, reduced water use per euro value added by between 10% and 15% between 2003 and 2008. The recycling of waste (no change), manufacture of food products, beverages and tobacco (+3%), manufacture of paper and paper products (+22%) and sewage and refuse disposal services (+11%) have not improved their efficiency of water use over this period. (Statistics Netherlands)



Nutrient and Heavy Metal Emissions to surface water and sewer systems in the Netherlands

Between 1990 and 2008, GDP in the Netherlands grew by 43% whilst emissions of heavy metals and nutrients to surface waters and sewer systems fell by 56% and 52% respectively. Hence an absolute decoupling of these pollutant emissions from economic growth has occurred. Industrial emissions in particular have fallen markedly, including those arising from the manufacture of electrical and optical equipment, paper and petroleum (Ref). Such falls are likely to have been driven, at least in part, by abatement measures established under the Integrated Pollution Prevention and Control Directive (EEA, 2011). These general declines mask a rise in nutrient emissions from Dutch households, however, attributed to a rise in population and an increased use in dishwasher tablets which contain a relatively high concentration of phosphorus (Ref).



2.3 Resource Efficient Wastewater Treatment

Technological innovation is helping to achieve a more sustainable approach to wastewater treatment, shifting the conventional view of municipal sewage from a waste to be treated and disposed of, to a resource that can be processed for the recovery of energy, nutrients, and other constituents. Here two such examples of resource efficient wastewater treatment are described.

2.3.1 Recovery of phosphorus

The continued depletion of phosphate rock reserves is likely to promote a more efficient use of phosphate fertiliser upon agricultural land (see section 2.1.2). However, virtually all of the phosphorus that humans consume in food is excreted in urine and faeces, with an estimated 3 million tonnes produced globally each year (Cordell et al. 2009). Within Europe, human excretion is typically directed to an urban wastewater treatment plant. Depending on the level of treatment, effluent from such plants discharges some phosphorus to receiving waters, and can increase the risk of eutrophication. That component of phosphorus not discharged within effluent is retained within treated and nutrient rich sewage sludge (also known as biosolid), with the potential for its subsequent ‘recycled’ application to agricultural land. Such applications may not, however, always be feasible, for example, in the case of a lack of agricultural land sufficiently close to a large metropolis. They also raise public health concerns, particularly given the typical presence of a range of hazardous substances from industrial and household sources within the treated sludge. As a consequence, some European countries have banned the practice.

The recovery of phosphorus from sewage to make fertiliser represents a relatively new technological breakthrough and one which avoids the potential problems associated with applying contaminated sewage sludge to agricultural land. Phosphorus can be recovered from wastewater and sewage sludge as well as from the ash of incinerated sewage sludge, with recovery rates from the latter two reaching up to 90% (Cornel and Schaum, 2009). Experimental trials have proven the worth of a range of recovery techniques (Valsami-Jones,

2004) including technology developed within the SUSAN (sustainable and safe re-use of municipal sewage sludge for nutrient recovery) project (SUSAN, 2009).

Recently, the recovery of phosphorus on a commercial scale has been implemented at a Thames Water sewage treatment works in the UK (Refs). New technology developed by Ostara Nutrient Recovery Technologies, recovers both phosphorus and ammonia from the wastewater stream at the works, turning them into a slow release fertiliser that can be spread onto crops and gardens. Various win-win outcomes arise from the partnership and include; a reduction in maintenance costs associated with the damaging build-up of the mineral struvite (ammonium magnesium phosphate) in pipes and valves at the works, helping to ensure that regulatory limits with respect to the discharge of phosphorus to receiving waters are met efficiently; and the production of an estimated 150 tonnes of fertiliser a year.

In the Netherlands, a sewage sludge treatment company (SNB) delivers approximately 6 kt per year of P-rich sludge ash to a phosphate producer (Thermphos) for further purification. Thermos then sells pure P to, for example, food producers for additives, and pharmaceutical companies for medicines (Schipper and Korving, 2009).

2.3.2 Recovery of energy

As sewage sludge decomposes, it emits a methane rich ‘biogas’. This renewable energy source can be directly used in wastewater treatment, reducing or eliminating a plant’s dependency upon conventional electricity. Moreover, the gas can be used as a fuel for vehicles. Stockholm’s Vatten sewage treatment works, for example, is a net supplier of energy, producing 4.1 million m^3 of biogas annually which is used as a fuel for several of the city’s buses, taxis and private cars. Additionally, heat is extracted from the treated wastewater and used in Stockholm’s district heating systems. (Refs).

2.4 Public Water Supply

Approximately 21 % of water abstraction across Europe supplies public water systems, although significant variation exists between countries. Public water not only includes the supply to households but also to small businesses, hotels, offices, hospitals, schools and some industries. The key drivers influencing public water demand are population and household size, income, consumer behaviour and tourist activities. Technological developments, including water saving devices and the degree to which leakage in the public water supply system is addressed, also play an important role.

A number of measures exist that may potentially reduce the use of publicly supplied water. These can be broadly grouped into the broad categories of water saving devices; greywater re-use and rainwater harvesting; behavioural change through raising awareness; and leakage reduction in distribution and supply networks.

Water saving devices and products

Modern large electrical appliances such as washing machines and dishwashers together with numerous other household products including toilets, taps, showers and general plumbing have greatly improved their water efficiency over recent decades. Considerable scope exists, however, for a greater uptake and use of such modern appliances across much of Europe.

Toilet flushing accounts for about 25-30% of total domestic water use and as such, considerable overall savings (30 litres per property per day; Waterwise, 2010) can be achieved by the use of dual flush and low flush toilets. Cistern replacement devices (e.g. 'hippos') are a simple and cheap means of reducing flush volumes, typically by about 1 litre per flush. They are particularly used in older toilets with large cistern volumes. Water can also be conserved with a delayed action inlet valve, which prevents the cistern refilling during the flush. Without such a valve, the water released is greater than the cistern's capacity — by 17 % according to one study cited in a UK Environment Agency report (Environment Agency, 2007).

Many older urinal installations do not have controls and so flush continuously, wasting significant volumes of water in public and commercial buildings. A number of flush control devices are now available, however, and provide significant water savings. These are typically timer-based or else detect the presence of people using infra-red sensors.

Installation of water efficient showerheads can save about 25 litres per property per day (Waterwise, 2010). Water use by showers can be reduced considerably by aerating the water flow, which helps to simulate the feel of a power shower but without requiring high volumes of water. Such aeration can also be applied to water flowing through taps. Thermostatic mixing valves in both showers and taps maintain selected temperatures and have been shown to result in considerable savings of both water and energy. Taps with infra-red sensors provide water only when an object is detected beneath them, resulting in water savings of 70 % or more.

Reuse of greywater and rainwater harvesting

Greywater refers to all household wastewater other than that from toilets, i.e. wastewater from baths, showers, washbasins, the kitchen and washing machines. In the most simple re-use systems greywater is stored and subsequently used, untreated, for flushing toilets and watering gardens (other than edible plants) thereby reducing the use of potable water. Greywater from baths, showers and washbasins is generally preferred to that from kitchen sinks and dishwashers since it is less contaminated. The microbial quality of greywater raises public health concerns, particularly when it has been stored for some time. Immediate use of greywater is therefore preferred, although approaches also exist to minimise the contamination of stored water.

Rainwater flowing from a roof or other impermeable surface can be transferred via guttering or piping to a receiving container and subsequently used for activities such as gardening and car washing. The practice reduces, therefore, household use of treated public water supplies. Harvesting systems can range markedly in scale and complexity from a simple garden butt to community systems. In Berlin, for example, rainwater falling on 32,000m^2 of roofing associated with a large scale urban development – the Daimler Chrysler Potsdamer Platz - is collected in a 3,500 m^3 tank (UNEP, 2011).

Whilst harvesting and reuse yield water savings, evidence exists that for some systems, the energy cost in manufacture, installation and maintenance yields a greater greenhouse gas emission than that of mains water. However, scope exists to improve the design of such systems to reduce their carbon footprints, including with respect to storage tanks and pumps (EA, 2010).

Raising awareness

Awareness raising campaigns aimed at both domestic and business water consumers have an important role to play with respect to the conservation of water. Such campaigns encompass a number of different approaches, including websites, education programmes in schools, local authority and water company leaflets, advertising stands at live events and the use of general media outlets (i.e. television, radio and newspapers). Typically, the larger the geographical reach of the campaign, the simpler its content. Awareness-raising can address both behavioural aspects such time spent showering and, the installation of water efficient appliances and products.

Leakage reduction

Significant declines in leakage are apparent in Europe over the past 10–15 years, with a 30–50 % reduction in the Czech Republic, Denmark, England and Wales, Germany, Malta, the Netherlands and Spain. In Germany and Denmark, leakage rates are now less than 10% and close to what is technically and economically feasible (BDEW, 2010 and Statistics Denmark, 2006). In some other countries, however, water loss remains considerable, with leakage rates of around 20% in the Czech Republic, Malta, Spain and England and Wales (MoA and MoA, 2007; NSO, 2006; INE, 2010; EA, 2008). In Croatia and the city of Rome, loss rates are greater than 25 % (Crostat, 2009; ACEA, 2006).

Preventative maintenance and network renewal are key to minimising leakage. Modern and in some cases emerging technologies can detect leaks, significantly reducing the time taken to discover and locate a leakage. They include sensors that use the noise generated by a leak to locate it, ground radar that can identify disturbed ground or cavities around a pipe, and tracer gas and devices that use radio signals to detect the presence of flowing water.

Capture key points from the DG ENV leakage contract

Drinking water protected areas – improvement of water quality – here or under agriculture, include Framework Contract

2.5 Hydropower

Invest in existing plants, improved efficiency, lower environmental impact, lower cost

3.) Water pricing

Water Pricing is a key mechanism to achieve more sustainable use of water across all sectors. The Water Framework Directive recognises this, requiring the pricing of water services to reflect their resource and environmental costs, in accordance with the polluter pays principle. A water price is usually charged in the form of tariff, meaning that the provision of water including its abstraction, treatment and transport, is charged by the providing entity, whether public of private, or an abstraction tax or fee, payable to a public authority.

Historically, water prices in Europe have rarely reflected the true costs involved and in some cases, for example some industrial users, even decrease with increasing use. Where prices have failed to fully reflect costs, society at large has had to bear the costs of water scarcity or pollution. For example, the general public typically has to pay for the cost of treating drinking water contaminated by agriculture or industry. However, the calculation of such environmental costs in particular is not always straightforward and adding them to prices may be a difficult political decision. Overall, finding the 'right price' for water remains a challenge and requires a balance between; the need to incentivise efficient use; the recovery of costs involved such that infrastructure and utility services can be maintained (OECD) and adverse impacts on the environment accounted for; and equity concerns such that poorer groups or regions have sufficient water at a reasonable price. Subsidies, particularly those that are environmentally harmful, should not mask the incentive provided by pricing to use water more efficiently and reduce levels of pollution.

Water efficiency gains across all sectors can be realised by relatively new and innovative approaches to pricing. These include the setting of pricing levels to reflect water scarcity, or similarly, implementing seasonal variations in price. Increasing block tariffs can also be used, whereby the price increases stepwise with a increase in the volume of water use. Water market solutions may also have an important role in ensuring economically efficient and environmentally effective allocation of water (see later).

To optimise the incentive for efficient use of water, pricing must be tied to the volume of water consumed. In this respect, metering plays a key role and must be implemented across all sectors. In the UK, water metering is estimated to be able to achieve average water savings of 10-15% per household (Environment Agency, 20XX). The use of meters in buildings is growing steadily throughout Europe, particularly in single-family houses, although uptake in apartments is currently low due, in part, to technical challenges.

Agricultural water use across Europe has increased over recent decades, driven in part by the fact that farmers have seldom had to pay the 'true' cost of water (Greek-ETC, OECD refs). Historically, charges have rarely reflected levels of water scarcity or other environmental costs. In some locations they are still based on the surface area irrigated and hence provide no incentive for farmers to use less water. The Common Agricultural Policy (CAP) bears part of the responsibility, having in some cases provided subsidies to produce water-intensive crops using inefficient techniques. Reforms of the CAP have, however, now reduced the link between subsidies and production from agriculture and this decoupling has led to improvements in water use efficiency. Studies in the province of Cordoba, Spain, for example, have shown that following the decoupling of subsidies from production, cotton irrigation efficiency increased by approximately 40% (Lorite and Arriaza, 2008).

Irrigation water pricing is generally focused upon surface water and where infrastructure has been built to convey water from the source to fields (OECD, 2010). On-farm water resources, mainly groundwater, usually involve licences and other regulatory instruments, but the costs to enforce compliance are high, and hence illegal abstraction remains a challenge. More effort is needed to enforce regulatory measures and develop volumetric charging. A greater implementation of metering within agriculture is, however, noted for some European Member States (Commission's review of WS&D strategy).

A clear challenge exists to establish water pricing in agriculture that minimises impacts on farm income but provides an incentive to conserve water and recover a larger share of costs, including those related to environmental degradation. The process needs to reflect local and regional circumstances and incorporate broad stakeholder consultation to help establish prices that are socially and politically acceptable. Account also needs to be made for those situations in which an increasing price does not lead to reduced agricultural water use, for example, when alternative crops or irrigation practices are not available due to technical, social or economic constraints.

Further information to capture from the 'final' Agriculture Water Pricing - DG ENV consultancy contract?

Wastewater treatment costs also need to reflect environmental impacts including the build-up of contaminants in sewage sludge and their discharge in treated effluent to receiving waters. Appropriate pricing levels should encourage on-site industrial wastewater treatment, including the recycling and reuse of water and chemicals, and greater controls at source. The price of wastewater treatment should not simply be based on that for water supply, since the true costs of both are poorly correlated.

UK Water Services – Case Study?

In the United Kingdom, providers recover the costs of water services from customers within their areas of operation. Revenue in the companies arises from the provision of a range of services that make up the overall water service. These are measured and unmeasured water and sewerage charges, trade effluent charges, large user charges and other sources. The cost recovery mechanism is slightly different in each case but for each source of charge, prices are broadly cost-reflective. The process of recovery of costs guarantees that financial costs are recovered, whilst the five yearly periodic review process internalises environmental costs through the prices paid by customers. Price setting for the Water Industry is undertaken through the periodic review process and is the mechanism through which costs are recovered and necessary investments are financed.

Payments for Ecosystem Services – Textbox. Ecosystem or environmental services are the beneficial outcomes resulting from ecosystem functions and can be subdivided into 4 classes; provisioning, regulating, supporting and cultural (see Millennium Ecosystem Assessment 2003). Payments for such ecosystem services (PES) is a term for a wide variety of schemes in which the beneficiaries, or users, of ecosystem services provide payment to the stewards or providers of ecosystem services. Such services include the provision of food and water resources, flood control (regulating), water balance and climate regulation, recreation.

Issue of PES also discussed in the context of the next CAP to further green the agricultural sector. (European Commission, 2010, Commission communication on the CAP towards 2020.

PES can strengthen the integration between the natural environment and economy and society. Can deliver improved outcomes for water. Returns to investments in restoration of ecosystems. Le Quesne et al. 2010

4.) Targets

When, where and by how much should efficiency be improved (Targets To Protect Water Resources; also RE Workshop key question). Knowing environmental water requirements is key; concept of environmental flows – can suggest a broad approach?, i.e. CEH suggested threshold is Q95. This issue will also be included in the WS&D Vulnerability Assessment – so care not to repeat too much. Textbox on Environmental Flows

What is the efficiency target with respect to water quality? WFD led EQS and definition of good ecological and chemical status. Quantitative knowledge of emissions by source is needed in order to identify the sector and degree of efficiency needed. Alternative – allow for cap and trading of emissions – US approach.

5.) Allocation and Water Rights, Trading – textbox, use Australian example, but Spanish example too? - Trading – Australian example – Murray Darling – UN report.

Rights as a share of water available (i.e. once environmental needs accounted for – refer up to targets and importance of environmental flows) and not as a fixed volume because this cannot cope with rapid decreases in water availability.

OECD – As pressure builds up to reallocate water between different users and to meet environmental demands there is a need for water property rights to become more flexible, where these rights exist, and for supporting institutions to be more robust to ensure an economically efficiency and environmentally effective allocation of water. But it also emphasises the need to explore innovative water market solutions as allocative mechanisms – *see OFWAT.*

Different types of trade are possible – long and short-term leases, permanent transfers.

Those who value the water environment can also participate – e.g. Australia and U.S.

Water markets – theoretically guarantee economic efficiency – maximising the value of water across all sectors of the economy. Also incorporate the scarcity value of the resource, providing an incentive to save water.

Disadvantage – formal water markets can limit access of poor to the resource (there's always a political angle).

Water Banks

6.) **Improved Information for optimal water resource management**

Underpinning the implementation of a more sustainable, equitable and efficient use of water resources is the need to quantify water use and its environmental impacts. Three broad and complementary approaches can be identified which involve differing criteria, contexts and purposes. These methods are overviewed in brief below but have been subject to a recent and more detailed scrutiny by the water efficiency group under the UNEP International Resource Panel (Ref).

Water Accounting

Water accounts are developed to provide decision-makers with information describing the stocks and flows of water which can be linked to economic variables, including expenditures and benefits. The inclusion of water accounts into the United Nations Standard for Environmental-Economic Accounting (SEEA) led to the adoption of SEEA-Water (UNSD, 2007) as an interim standard framework subject to further revision. SEEA-Water encompasses physical supply and use tables which analyse the origin of the water abstracted by economic sectors, transfers within the economy, and returns to land and rivers. The framework enables physical and monetary information on water to be linked, hence enabling environmental and economic policy issues to be analysed together.

Possible textbox on EEA's water accounts at river basin scale across Europe

Following a decision of the United Nations Committee of Experts on Environmental-Economic Accounting in June 2011, water assets and quality issues will be developed in the second volume of SEEA-Water. Water will be measured in natural capital accounts, focusing on; the provision of water for people and key economic sectors such as agriculture and hydroelectricity service, security of access, and water use impacts on other ecosystem services and environmental infrastructure. The approach will enable water to be incorporated as one component of wider ecosystem accounts linking it to other aspects of natural infrastructure such as biomass production.

Possible textbox on EEA's ecosystem accounting

Water Footprint

The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce goods and services consumed. The approach captures the amount of water embedded within products such as food and clothes, highlighting the large water requirement of raw agricultural products. It also draws attention to the often substantial contribution to a footprint of water imported from wherever production takes place. For example, more than $10m^3$ of water are ‘embedded’ in the production of a pair of jeans (Chapagain et al. 2006) with most of this footprint relating to the irrigation of cotton, often grown in water-scarce regions; 84% of the EU’s cotton-related water footprint, for example, lies outside the region. The water footprint concept has value, therefore, with respect to the global dimension of water management, identifying opportunities for water scarce countries or regions to export low water footprint commodities and import water-rich products. The approach has limitations, however, primarily related to its failure to account for environmental harm in terms of levels of water scarcity at the point of extraction (Frontier Economics, 2008). The lack of information as to whether water is being used within sustainable abstraction limits thus offers no guidance for policy makers to ensure environmental objectives are being met.

Life Cycle Assessment

Life cycle assessment (LCA) is an ISO-standardized tool that evaluates the environmental performance of products and services along their lifecycle. The full lifecycle comprises various stages; extracting materials from the earth, processing, production and assembly, transportation, consumer use and ultimately disposal of the products or waste materials (UNEP, 2002). From the water perspective, LCA can encompass both the consumption of water resources and pollutant emissions to receiving waters. Example needed.

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