# Background Material

# Non Conventional Water Resources

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# Grey water & rainwater

- Greywater due to its cloudy appearance is placed between fresh, potable water ("white water") and sewage water / water containing fecal waste ("black water"). Greywater includes the leftover water from baths, showers, hand basins and washing machines only. In some cases, greywater may include water from kitchen sinks.
- Rainwater and stormwater are often considered as higher quality grey water.

# Non Conventional Water Resources Management (NCWRM)

NCWRM is integral component of many practices & methodologies addressed in various presentations of the current module, mainly DWWT.

- Rainwater harvesting and reuse
- Grey water collection, (treatment) and reuse
- Treated (black or mixed black/grey) wastewater reuse
- Desalination of marine and brackish water
- Submarine freshwater abstraction
- Replacement of several freshwater uses by marine or brackish water:
  - Domestic/touristic (flashing of toilets, swimming pools etc.)
  - Industrial (cooling, cleaning etc.)
  - Agriculture (selected cultivations and practices)

In some cases NCWRM includes also groundwater abstraction & use

# Rain Water Harvesting

It may include:

- Runoff and stormwater harvesting, eventually in combination with reduction of flooding. It requires relatively large scale storage reservoirs (dams etc.), surface or underground. It can be also used to recharge groundwater aquifers (*see presentation under Floods*)
- Collection of rainwater from roofs and surfaces that can be drained under control (*see also presentation under DWWT*)

# Rainwater harvesting as a component of water management in cities of the future

To address local domestic & municipal needs, eventually combined with local cluster decentralised water management

- Oriented to various storage types (large or small, private or public)
- Linked to green buildings / “future house” / green roof construction etc.

# Examples of various storage types for rainwater harvesting in the Cyclades

**RWH system in special school for 10 students & teachers (6 m$^3$), Naxos**

**Underground tank in school (40 m$^3$), Naxos**

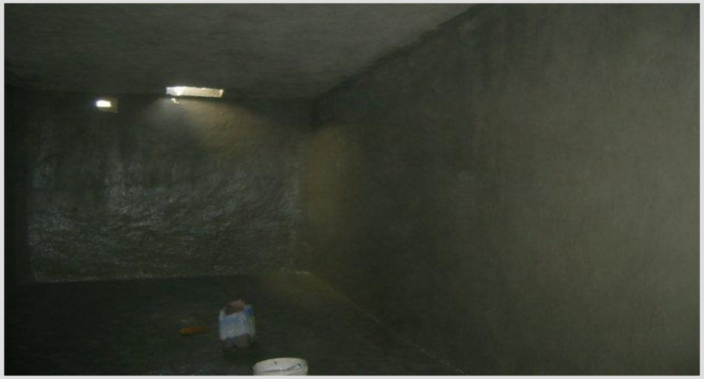
- Rainwater Harvesting Systems installed in selected public buildings/properties (schools, town halls etc.) for education/demonstration.
- The harvested rainwater is utilised for several non-potable uses (watering, toilet flushing etc.) contributing to water supply consumption reduction and water saving.
- Installations are harmonised with the architectural identity of the islands and the landscape.

**Amphora-type water barrels in kindergarten, Andros**

# Examples of various storage types for rainwater harvesting in the Cyclades

**Municipal reservoir for 270 residents (407m³), Sikinos**

**Municipal reservoir (350 m³) for 500 residents, Koufonisi**



**Stormwater retention (200m³) for 100 residents, Syros**

# Rainwater harvesting is frequently linked to grey water reuse in “green” buildings

## Future Water House

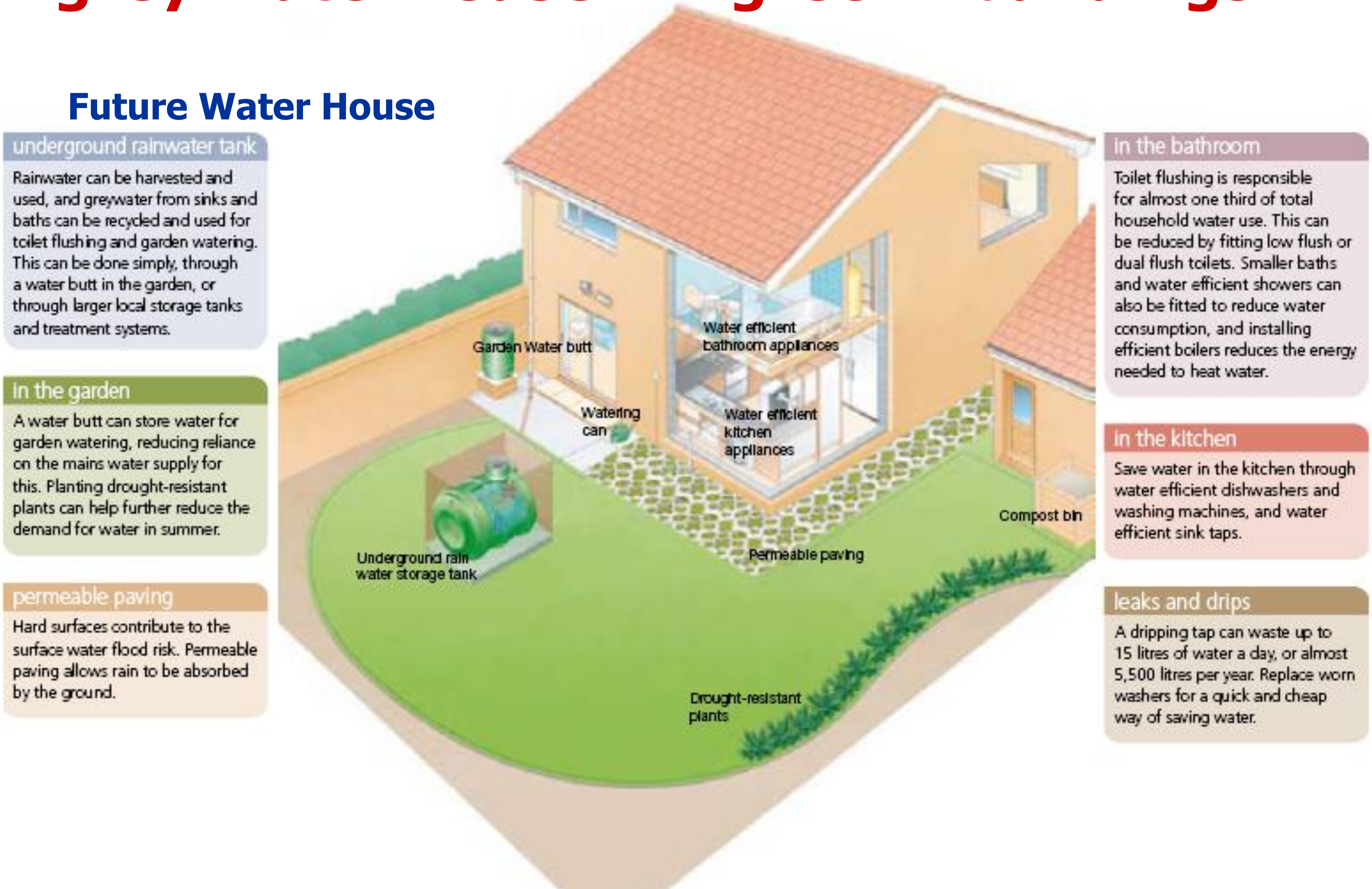


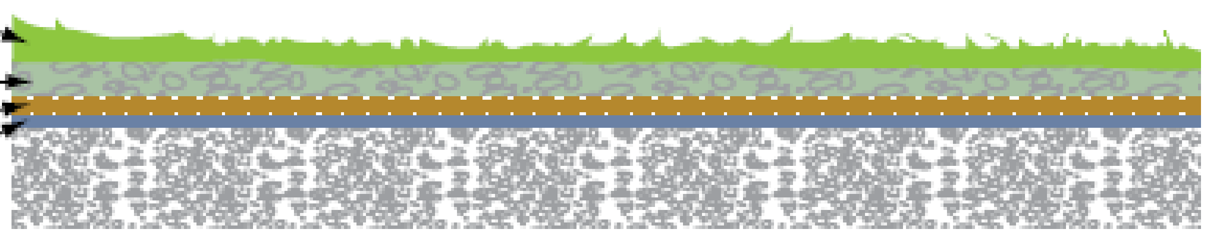

Image courtesy of B&Q and Waterwise.

# Rainwater harvesting linked to "green" buildings

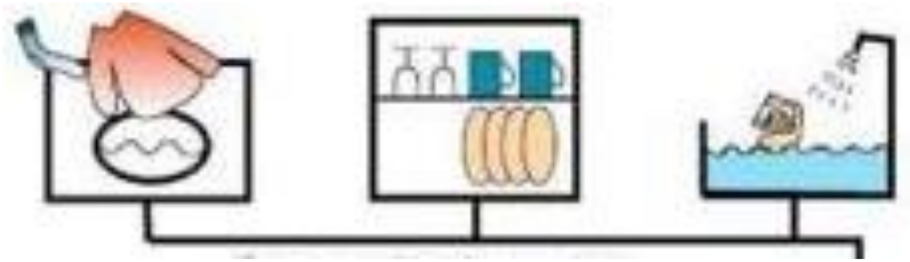
| Future Water House | Standard new built house (150 l/p/d) | | House meeting Code for Sustainable Homes level 5 (80 l/p/d) | | |
|---|---|---|---|---|---|
| Appliance/fitting | Specification | Contribution to daily use | Specification | Water reuse | Contribution to daily use |
| WC | 6 litre single flush | 28.8 | 4/2.6 litre dual flush (6.33+ 8.36) | 14.69 | 14.69 |
| Washbasin taps | 4 l/min | 14.11 | 6 l/min | | 15.87 |
| Shower | 10 l/min | 30 | 7.75 l/min | | 23.25 |
| Bath | 180 litre | 28.8 | 120 litre | | 19.2 |
| Sink taps | 8 l/min | 28.22 | 7 l/min | | 18.52 |
| Washing machine | 49 litre | 16.66 | 40 litre | 13.6 | 13.6 |
| Dishwasher | 13 litre | 3.9 | 10 litre | | 3 |
| Water re-use system | _ | 0 | -100m² roof, 0.6m annual rainfall, 0.6 efficient, 3 persons.<br><br>Water butts could also meet a significant proportion of garden watering demand | collected = 32.88 WC+washing machine use =28.29<br><br>Max benefit = 28.29 | –28.29 |
| TOTAL | | 150.49 | | | 79.84 |
| | Source: BRE | | Source: Code for Sustainable Homes | | |

# Green roofs

**Green roof, Warsaw University.** Image © jaime.silva. Source: http://www.eea.europa.eu/articles/cities-of-the-future-2013-how-will-european-cities-adapt-to-new-climate-conditions



# Grey Water Collection & Use



Grey water

- In most cases at the moment it is appropriate for Decentralised WWT systems because of the possibilities of separate drainage and collection systems
- The tendency is to be expanded also to bigger cities for watering of gardens, washing terraces, cars etc.

# Grey water recycling systems

Several water recycling systems exist which can be used to:

- Recycle the water without purification
- Recycle the water after purification and/or decontamination

# Grey water recycling without purification

- When collected through a separate plumbing system from blackwater, domestic grey water can be used untreated, directly indoors for flushing toilets, washing cars etc., or in the garden, or stored for very short time (less than 24 hours) to avoid development of bacteria.
- Some greywater, if free of sodium containing detergents, dyes and other non-degradable chemicals such as non-natural soaps, may be applied directly from the sink to the garden or irrigation, receiving further treatment from soil life and plant roots.
- Such a system could provide an estimated 30% reduction in water use for the average household.

# Grey water recycling with purification

For **indoor use**, the danger of biological contamination may be avoided by simple purification systems, such as:

- a cleaning tank, to eliminate floating and sinking items
- an intelligent control mechanism that flushes the collected water if it has been stored long enough to develop bacteria

For **general use**, the quality of grey water may be enhanced to become potable (or near-potable), by using processes of various degrees of sophistication, such as:

- mechanical systems (sand filtration, lava filter systems and systems based on UV radiation)
- biological systems (plant systems as treatment ponds, constructed wetlands, living walls) and Bio reactors or compact systems as activated sludge systems, biorotors, aerobic and anaerobic biofilters, submerged aerated filters, biorolls.

# Treated wastewater reuse

- Both grey water or black water and their mixtures can be reused when treated.

- Direct processes, such as distillation (evaporation) or mechanical processes such as membrane filtration, (typically ultrafiltration and reverse osmosis, which are capable of treating high volumes of grey water) can create potable, or near-potable water.

- In order to purify the potable water adequately, several of these systems are usually combined to work as a whole. Combination of the systems is done in two to three stages, using a primary and a secondary purification. Sometimes a tertiary purification is also added.

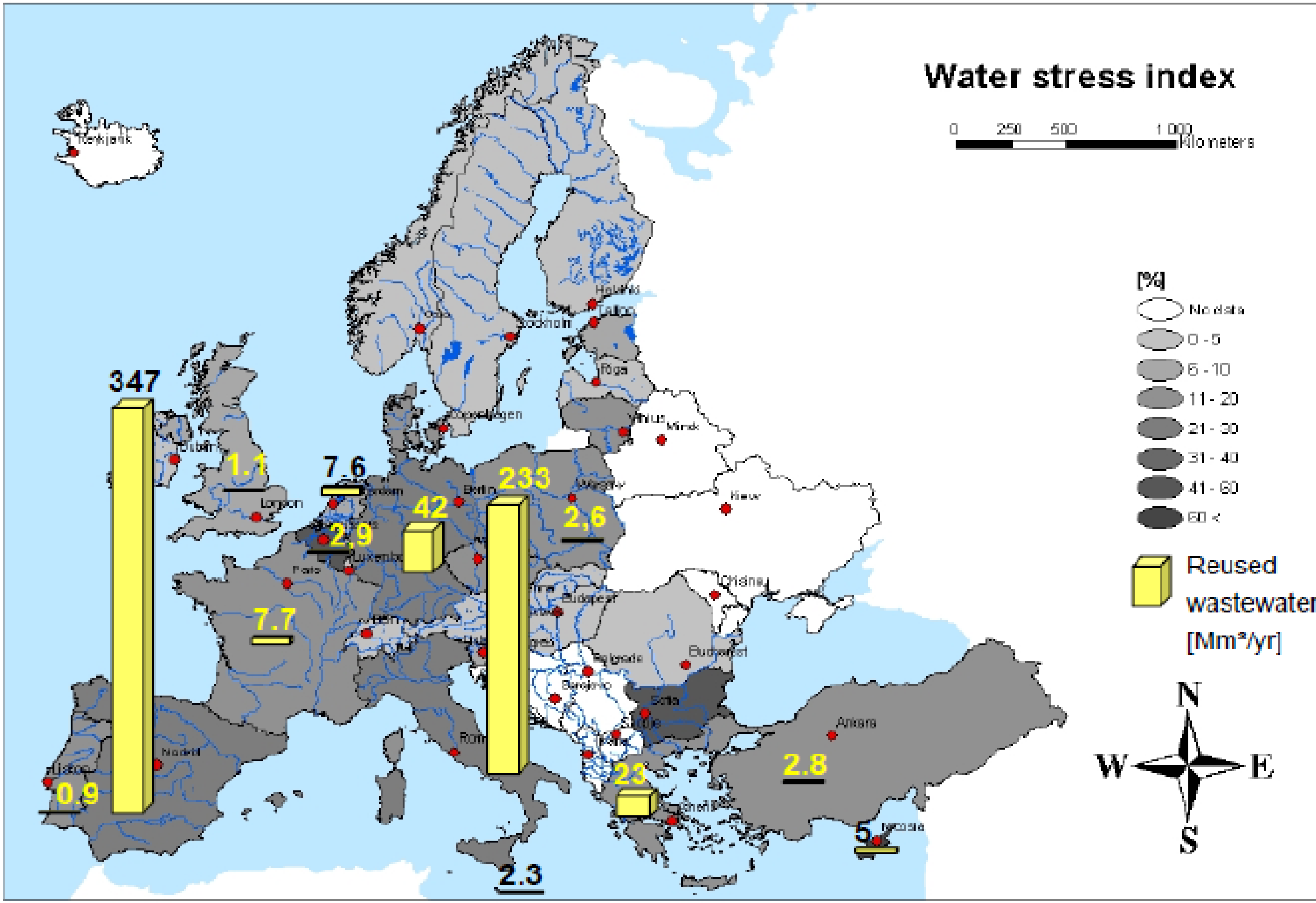
# Reclaimed water uses

- Both Decentralised and Centralised purified grey / black water using high standards of treatment could provide reclaimed water for irrigation, industrial cooling purposes, groundwater recharge, replenishment to avoid saltwater intrusion, fire protection, recreation ponds and other uses.
- Irrigation may include “urban” (watering of gardens, parks etc.), non-food “agricultural” crops (fibre, flowers, seed crops, commercial nurseries) and special categories of food crops (orchards, fodder)

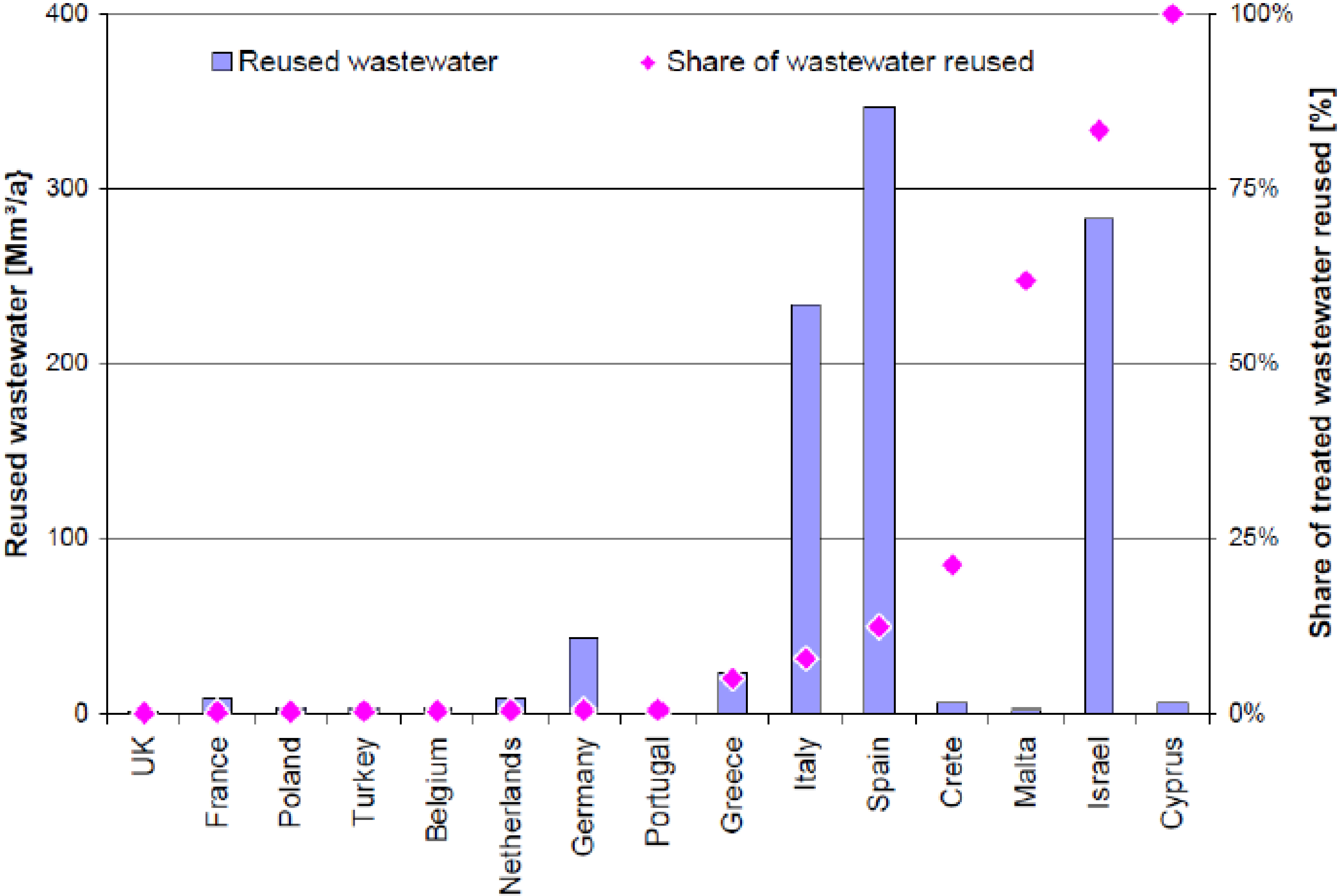
# Major constraints to reuse reclaimed water

- Potable
  - Unknown long-term health effects from micropollutants
  - Higher probability for risks from:
    - Microbes (viruses)
    - Trace Chemicals
    - Nitrogen species
- Irrigation
  - Salt toxicity
  - Specific ion toxicity (Boron etc.)
- Industrial use
  - Scaling problems when used for cooling

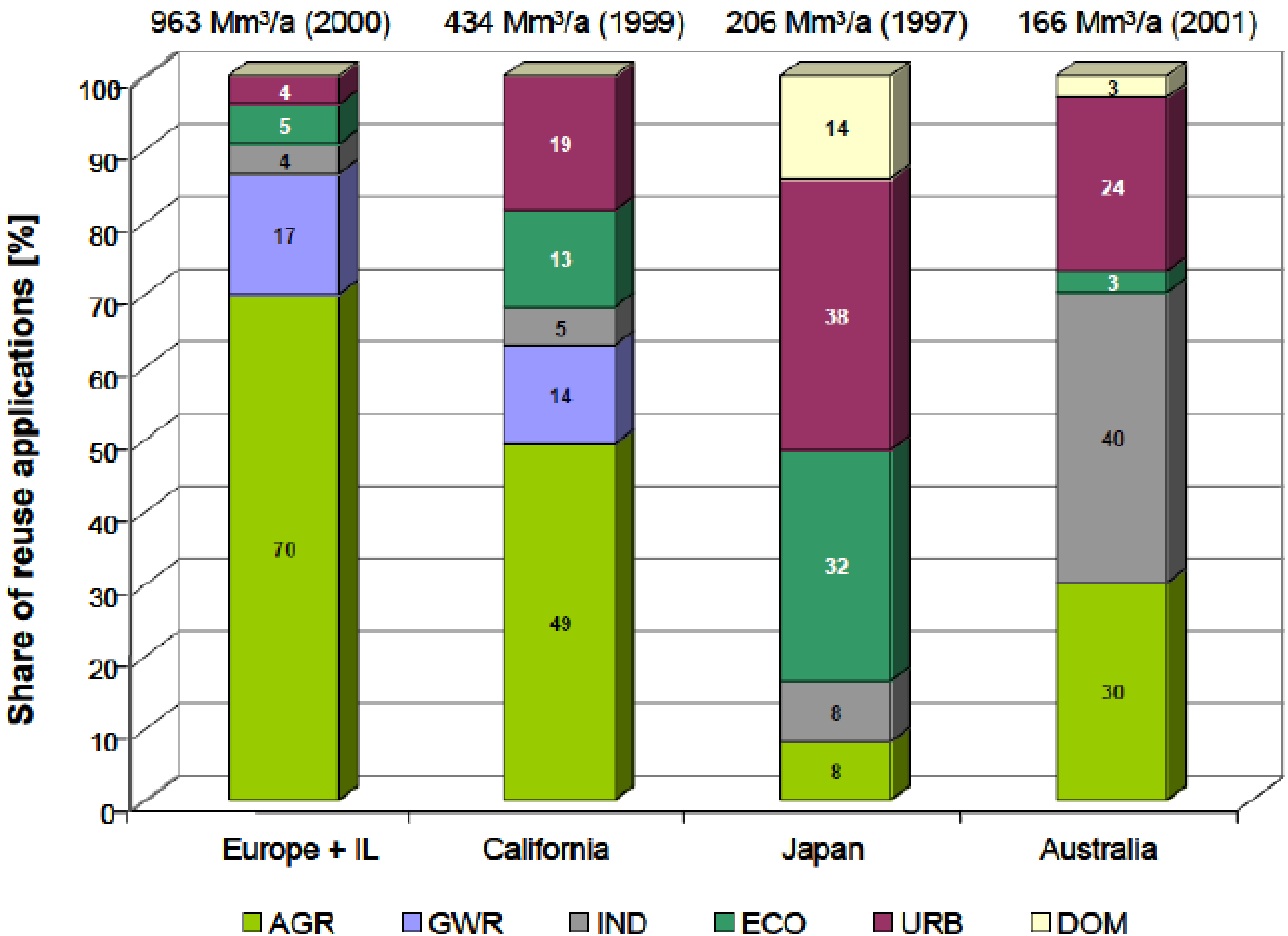
# Water stress and reuse



# Wastewater reuse



# Different reuse applications



# Reuse purposes

| | Unrestricted | Restricted agricultural irrigation | Landscape irrigation | Groundwater recharge | Industrial reuse | Parks and roads | Toilet flushing | USE OF UNTREATED EFFLUENT |
|---|---|---|---|---|---|---|---|---|
| Algeria | | x | | | | | | X |
| Egypt | | x | x | X | | | | x |
| Israel | x | x | x | x | x | | | |
| Jordan | | X | | | | | | |
| Lebanon | | | | | | | | x |
| Libya | | x | | | | | | |
| Morocco | | x | | | | | | x |
| Palestine | | x | | x | | | x | x |
| Syria | | x | | | | | | x |
| Tunisia | | x | x | x | | | | |

**(adapted from Bahri, 2008)**

# Wastewater treatment processes for reuse of reclaimed water

- Traditional (see CWWT & DWWT)
  - Activated sludge – secondary with nutrient removal
  - Filtration & disinfection
- Innovative water treatment options
  - New activated sludge configurations (ANAMOX, SHARON, NEREDA)
  - Direct membrane filtration (DMF) and other membrane technologies
  - Advanced oxidation
- Use of natural systems (wetlands, ponds etc.)

# Desalination

- Thermal Processes – distillation (need thermal & electrical energy)
  - Multiple Stage Flash (MSF)
  - Multiple Effect Distillation (MED)
  - Vapour Compression
  - Freezing desalination
  - Solar desalination

- Membrane Processes (need electrical energy only)
  - Reverse Osmosis (RO)
  - Electrodialysis reversal (EDR)
  - Nanofiltration (NF)
  - Membrane Distillation (MD)
  - Ultrafiltration (UF)

Both are energy intensive, accounting up to over 40% of the operating <u>cost</u> and each has a set of <u>environmental</u> issues

# Desalination: thermal processes

**Distillation** is a phase separation method where saline water is heated to produce water vapor, which is then condensed to produce freshwater. All processes generally operate on the principle of reducing the vapor pressure of water within the unit to permit boiling to occur at lower temperatures, without the use of additional heat. The major energy requirement in the distillation process is for the vaporization heat.

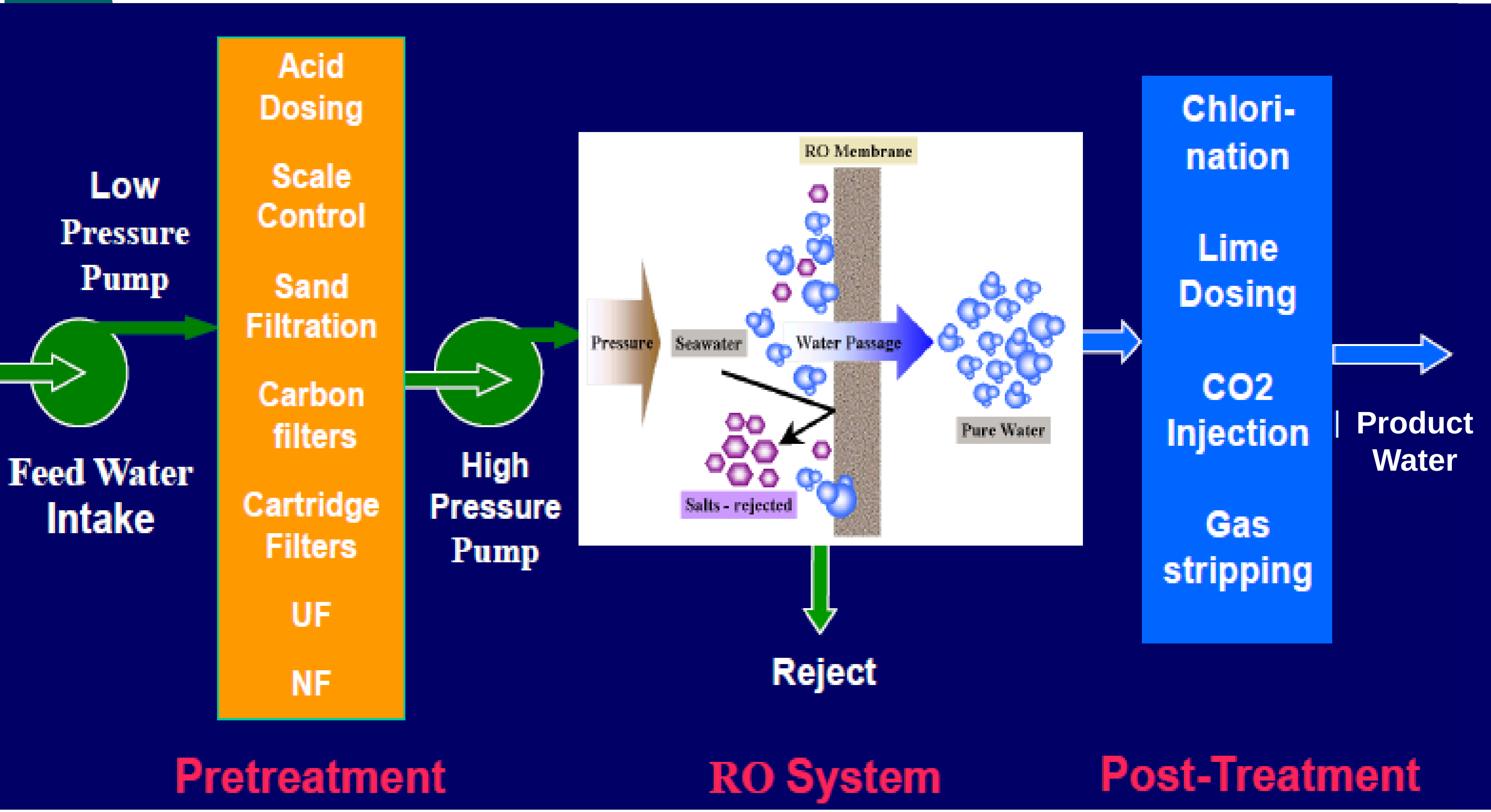
- **Multiple Stage Flash (MSF)**

  The incoming seawater is heated and subsequently enters various stages of flash-boiling. The vapor pressure in each of these stages is controlled to cause instantaneous and violent boiling/evaporation. The water vapor is condensed and collected at each stage.

- **Multiple Effect Distillation (MED)**

  The water vapor stream is condensed on one side of a tube wall while saline water is evaporated on the other side. The energy used for evaporation is the heat of condensation of the steam. Usually there is a series of condensation-evaporation processes (“effects”) taking place.

# Desalination: membrane processes




Videos: http://www.youtube.com/watch?v=_3Id7G1IFM8

http://www.youtube.com/watch?v=ETBxvN8wcpM

# Linking desalination with renewable energy

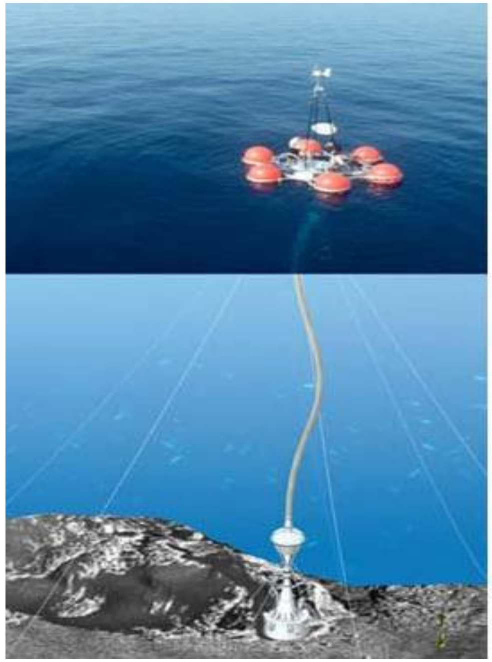
- Thermal Energy
  (combined with distillation)
  - Geothermal desalination
  - Solar / Seawater greenhouse

- Electrical Energy
  (usually combined with RO, MED, VC)
  - Photovoltaic (PV)
  - Wind (on-shore & off-shore)
  - Geothermal

## Linking Desalination with Renewable Energy

- Renewable Energy systems are the technologies of the future: there is great potential throughout the Mediterranean
- Presently it cannot be used for large scale applications due to technological and economic constraints
- There is limited scope to decrease the energy consumption in commercial desalination processes to make them powered by solar energy
- Presently $CO_2$ contribution from desalination plants is about 0.5% of total $CO_2$ load to atmosphere. This and the current trend in fossil fuel cost increase with parallel developments in solar collectors may make solar desalination a feasible option in the next ten years
- More R&D is needed to improve desalination systems coupled with renewable technologies, to reduce the cost of desalinated water and to make the processes suitable, particularly for remote location applications

# Submarine freshwater abstraction



- Submarine springs are located on the sea floor. The detection, analysis and potential benefit from submarine freshwater springs depends on their specific physical and chemical characteristics and their impact on the marine environment.
- Sources are measured over several months to model their behaviour and define technical and economic parameters for future production.
- Water can be produced without polluting the sea, by using clean technologies that make use of natural energies, such as buoyancy, hydraulic head and gravity. Hydrogeological balances can also be protected. In most cases, pumping is not required.
- Depending on quality, this water can be used for drinking, agriculture and industry.

# Conclusions

- The development of NCWR is an absolute necessity for the Mediterranean region due the current scarcity and the upcoming climate change.

- However, NCWR are not a panacea. They entail a series of secondary problems and side effects that need to be properly addressed (e.g. brine disposal from desalination plants etc).

- NCWR become efficient only in combination to water use efficiency and water demand management.