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# WAYS FOR RESOURCE EFFICIENCY
# Water saving in residential buildings
# Use of grey water

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## Abstract

According to current projections, world population will continue to grow, and climate change shows: a) a continuous need to face floods, and b) a decrease of freshwater availability and an increase of drought in some geographic areas for the future. With the target to face these challenges it is of use, among other possibilities, to continue to improve the resource efficiency.

In this paper ways concerning improvements relating to developments of innovative systems applications addressed market uptake, that use alternative resources [like: use of grey water] to save traditional resources (like: drinking water), are described.

## Introduction

This paper, in addition to this "Introduction" and to the final "Conclusion", consists of three chapters; the heading: **a**) for the chapter 1 is "Consumptions", **b)** for the chapter 2 is "Framework of ways for resource efficiency", **c)** for the chapter 3 is "Development of innovative systems applications".

In the chapters 1 and 2, as support to the description of the chapter 3, it is respectively reported: a) a description of main kinds of resources consumptions, b) a framework concerning kinds of ways (*ideas*) for research development that could contribute to the improvement of the efficient use of the resources.

In the chapter 3 ways concerning improvements relating to developments of innovative systems applications, that use alternative resources [for example (*e.g.*): use of grey water] to save traditional resources (e.g.: drinking water) and that are taken into account in the framework just mentioned, are described.

The conclusion underlines main interesting aspects that lead applications of innovative systems to a sustainable market uptake.

## 1.0 Consumptions

As support to what reported in the chapter 3 of this paper, in this chapter 1 main kinds of consumptions are described.

### 1.1 *Resources consumptions and wastes in residential buildings*

In residential buildings typologies of consumptions for exigencies of domestic life, among other consumption goods, are:

a) drinking water: to drink, for food preparation, and for washings, toilet flushing, etc.

b) foodstuffs (that can be of: solid and liquid nature) for nutritional needs

c) energy [like: electric energy and energy from combustion of gases composed of hydrocarbons (e.g.: $CH_4$)] to (among other things) heat the water used, e.g., to feed: hot water taps and radiators.

After these uses:

$a_1$) water (dragging along: dirt, faeces, urines, etc.) is discharged

$b_1$) part of the foodstuffs used in kitchen, in particular way the organic solid substances that are rejected (like: skins, rotten fruit and left-overs), are disposed of as urban solid wastes

$c_1$) the energy converted into heat (like, e.g.: the energy used to obtain hot water to use to feed showers) is disposed of as thermic energy; like, e.g.: **1)** the energy contained as heat in the discharged hot water coming from showers, and **2)** the energy released by radiators and wasted (*dispersed*) in the external environment, around the residential buildings, and this in particular in the winter season.

## 1.2 *Water consumptions in sectors of use*

As integration on what described above, details on water consumptions (in urban, industrial, energetic and agricultural sectors) are reported below.

### 1.2.1 *Urban sector*

Typologies of building structures of the urban sector, where water (in particular drinking water) is used, are: a) residences in single homes located in urban or in rural areas, b) residences in single condominium (apartment block), c) residences in more than one condominium, d) barracks (for soldiers), e) hospitals, f) offices, g) hotels, h) schools, i) public urinals, j) service areas in motorways, k) restaurants, l) beach resorts, m) sports complexes; and also: n) shopping centres, o) fairs, p) cinemas, q) discotheques, pubs, r) tourist centres (camping, etc.), s) cruise ships. Furthermore in the urban sector, there is also consumption of water for: t) irrigation of: gardens, parks, football fields, u) fountain water supplies, v) car washing, w) fire extinguishing sprinkler systems.

Typologies of water consumptions in building structures of the urban sector [in particular for residential buildings (in cities)] concern: a) drinking, b) food preparation, c) body washing (in bath-tub and/or by use of showers), d) washings, e.g., of: hands, face, teeth and washings to make beard (by use of bathroom washbasin), e) washings: by use of bidet, f) washings in kitchen of dishes, cutlery, etc., g) washing of clothes (linens, curtains, dresses, etc.), h) car washing, i) other washings (floors, furniture, glasses of windows and mirrors, etc.), j) toilet flushing, k) irrigation of gardens (flowers, plants, grasses, etc.); and also, in cities: l) irrigation of fields for sports (football, golf, etc.), m) irrigation of parks (grasses, plants, flowers, fountain water supplies, etc.).

### 1.2.2 *Industrial and energetic sectors*

Establishments, where technologies and plants of the industrial and energetic sectors are installed and where water is used for needs of the same sectors, concern e.g.: **a)** production of energy, sugar, paper, pasta, milk products, and **b)** canning industry and textile factories.

In these establishments, water uses concern:

a) consumptions of water for needs of operations relating to, e.g.: process circuits, auxiliary circuits (cooling) and washings
b) consumptions of drinking water to use, e.g., for services (concerning personnel of: offices, production lines, warehouses, etc.) relating to the same establishments; where, e.g.: toilet flushing, washbasins and showers are installed.

### 1.2.3 *Agricultural sector*

Water consumed in the agricultural sector is used for irrigation of agricultural fields and for other uses, like: aquaculture and cattle breeding.

Water used for irrigation can concern fields dedicated at production of: fruit (e.g.: kiwis, peaches, apples and grapes), sweet corn, grain sorghum, sugar beet, wine, vegetables (e.g.: tomatoes, lettuces and peppers), etc.

Other uses of water concern: aquaculture (for breeding, e.g., of: fish, molluscs and crustaceans) and cattle breeding (e.g., drinking water for: bovines, pigs, sheep and poultry); in particular about breeding, water is also used for different kinds of washings relating to, e.g., cleaning of: cowsheds and rooms for tanks (like: milk tanks).

# 2.0 Framework of ways for resource efficiency

In this chapter 2 as support (similarly to the chapter 1) to what reported in the chapter 3 a framework, relating to ways (*ideas*) that could be explored and that address innovative research aimed to contribute to the improvement of the efficient use of the resources and in particular to contribute to the water management optimization, is described. The framework reports in particular a synthetic overview concerning possible activities (research*)* and so opportunities of actions (*job*) that could be developed (*realized)* to contribute to resources saving (e.g.: drinking water saving).

The ways reported below, concerning in particular research addressed improvement of current management of resources, are related to: traditional technologies improvement, alternative resources use, innovative systems development, and sensitization to realize the relative improvements.

### 2.1 *Sensitization*

It is interesting to acquire sensitization (e.g.: by dissemination): **a)** to acquire awareness at level of persons, management, politics, administrations, etc. for a rational use of the resources, and also **b)** to stimulate grant (*concession*) of funds, incentives, and to allow possibility of purchasing at reduced taxes (e.g. without VAT) of technologies concerning activities relating to resources efficiency and in particular concerning the realization of innovative and sustainable technological development.
As integration on what just mentioned, sensitization can concern:

- safeguard of environment [e.g.: pollution limitation (e.g. contamination limitation from emergent pollutants)]
- waste reduction (e.g.: to avoid excessive consumptions)
- care to keep the technologies of existing plants in efficient state [in efficient conditions (e.g.: reduction of water loss from piping)]
- implementation of new sustainable technologies [e.g., installation of: a) components at reduced consumption, b) systems at reduced emission: of $CO_2$ and of emerging pollutants].

### 2.2 *Improvement of traditional technologies*

Improvements of traditional (*current*) technologies relating to water treatment can concern:

- improvement of yield (about this topic, involved parameters can concern, e.g.: kinetics, reaction mechanisms and control)
- reduction of $CO_2$ emissions
- reduction of contamination from emerging pollutants
- reduction of malfunctionings (e.g., concerning: maintenances, failures and breakdowns)
- reduction of costs (of: realization, operation).

### 2.3 *Use of alternative resources*

Use of alternative resources to reduce traditional consumptions of resources can concern, for instance:

- reuse of water [e.g.: use of grey water (e.g.: water coming from showers) into residential buildings]
- interchangeability of water (discharged and available) from a sector (like: urban, industrial and energetic sector) to one of the other available sectors (like: urban, industrial, energetic and agricultural sector) and vice-versa
- use and management of rainwater [e.g.: use of rainwater into residential buildings, and management of situations concerning abundant rains and relative actions for environmental impact mitigation (by the way, one of these situations is the flood)]
- use of other new kinds of available waters near the area of interest
- obtainment of energy and fertilizer by treatment of organic solid wastes and treatment of discharges of waters coming from residential buildings.

### 2.4 *Development of innovative systems*

As integration on what mentioned above, research can address feasibility and applicability tests relating to experimental developments of innovative treatment systems for a market uptake concerning topics like (see just above): use of alternative resources (e.g.: alternative waters) to save traditional resources (e.g.: drinking water). This kind of research is deepened in the following chapter 3.

## 3.0 Development of innovative systems applications

In this chapter 3 possibilities of optimization concerning developments of innovative systems for efficient use of resources are described; in particular concept, applications

and ways (*ideas*), concerning improvements of current innovative applications of these systems relating to use of alternative resources to save traditional resources in the urban sector for a sustainable market uptake, are described.
Traditional resources, that can be saved, are: water, energy and fertilizer; systems applications concerning use of grey water to save drinking water in residential buildings are particularly deepened.

## 3.1 *Concept*

### 3.1.1 *Objective*

Objective of innovative systems development consists in contributing to realization of applications aimed at efficient use of resources by use of available alternative resources to obtain traditional resources saving.

### 3.1.2 *Available alternative resources*

Available alternative resources can be: resources already used (e.g.: water), rainwater and other new kinds of available resources (not already used) near the area of interest.

### 3.1.3 *Treatment of alternative resources*

Use of alternative resources (e.g.: water) can be realized by (see hereinafter: applications):

- use of resources contained in alternative resources (like, e.g.: nitrogen, energy)
- removal of undesired substances contained in alternative resources (like, e.g.: bacteria, emerging pollutants).

Undesired substances (pollutants) can be of microbiological-physical-nuclear-chemical nature. Examples of undesired substances can be:

- bacteria
- emerging pollutants.

Kinds of bacteria contained in grey water can be, e.g.: faecal coliforms and streptococci; about concentrations of these and other pollutants [e.g.: solids and COD (i.e.: Chemical Oxygen Demand)] in grey water (and rainwater), see reference 1 (Innovative …: Tab. 1-6, pages 359-361).
Emerging pollutants (*contaminants)* are:
1) Nonlyphenols, octylphenol, and alkylphenol ethoxylate (APEs) compounds, 2) Polynuclear aromatic hydrocarbons, 3) Polybrominated biphenyl ethers, 4) Pesticide, 5) Pharmaceuticals and personal care products, 6) Steroids and Hormones, 7) Other; for more details about these pollutants, see reference 2 (EPA ….: Table 3, pages 13-14).

Pollutants represent a barrier (*bottle-neck*) that hinders the market uptake concerning the reuse of the resources; negative effects of undesired substances (pollutants) must be removed (by treatment). Process operations, that can be adopted to treat pollutants contained in the water and so to make water available for other uses, are of microbiological-physical-chemical nature; typical examples of operations are:
a) filtration, b) biodegradation, c) advanced oxidation processes, d) disinfection, e) activated carbon treatments, f) ion exchange, g) desalination (*electrodialysis*), h) electrolysis, i) denitrification, j) phosphorus removal, k) coagulation or softening;
for more details about these treatments, see reference 2 (EPA …: Table1, pages 8-12 ).

## 3.2 *Applications*

There are applications of innovative systems, that have been developed in the world in the last times, that treat alternative resources.
Aspects, characteristics and considerations, concerning some of these current applications which targets are addressed resources saving (like: energy, fertilizer and water saving), are described below; in particular, applications concerning drinking water saving by use of grey water in residential buildings of urban sector are deepened.

### 3.2.1 *Drinking water saving by use of grey water*

Main objective (*target*) of these applications consists in the use of grey water as alternative to the drinking water use just to save part of the traditional consumption of the

drinking water, in particular way, in residential buildings; grey water is used to substitute drinking water for uses for which water with quality lower than that one of the drinking water can be used; typologies of these uses can be: toilet flushing and garden irrigation.
The process of these applications [see: Figure 1 and relative reference 3 (Il progetto …: Figure 2, page 41); and for more details see reference 4 (Experimental …)] consists of: a) gathering pipe to collect grey water coming, e.g., from showers, bathtubs and washbasins of bathrooms, b) treatment of the water in a way that it can be used in a safety way, c) distribution pipe to send water to the points of consumption, like e.g.: toilet flushing.
With the applications, that send treated grey water to toilet flushing, the consumption of the drinking water can be 23% less than that one of the traditional system [see again: reference 3 (Il progetto …: Figure 4, page 46)].
Main treatment process operations and relative technological components, adopted by these applications [see: reference 5 (Swamp …)], concern:

a) filtration [e.g., for suspended solids removal, by means of: sand filter, microfiltration, ultrafiltration (that can also remove bacteria)]
b) biodegradation [e.g., for BOD (i.e.: Biological Oxygen Demand) removal, by means of: $b_1$) reactors like: Membrane BioReactors (MBRs), Sequencing Batch Reactors (SBRs) and Rotating Biological contactors (RBCs), and $b_2$) constructed wetlands whose reactors can be at, e.g., horizontal flow and vertical flow]
c) advanced oxidation processes [AOP (e.g., for BOD removal, by means of: electron ray beam)]
e) disinfection [e.g., to remove effect of bacteria, by means of: sodium hypochlorite, ozone, UV (ultraviolet light)];

other components, that can be utilized, are: tanks, pumps and piping.
One bears in mind, by the way, that these applications recover also the water that normally is discharged (wasted) when one is waiting for the hot waters coming from taps like, e.g., those ones that are involved in the reuse.

These kinds of applications can also contribute to heat (energy) saving; this because the hot grey water coming from showers can release heat inside the buildings where the same relative applications are installed, while it flows in piping, stays in tanks of storage and stays in cisterns of toilet flushing.

Rainwater coming from roof can also be collected and treated to save drinking water; treated rainwater can be used for: toilet flushing, garden irrigation, car washing, washing machines, etc. Treatment of rainwater is easier than treatment of grey water; this because rainwater is less polluted than grey water; in fact rainwater presents, e.g.: less turbidity, less bacteria, less conductivity, less surfactants, less suspended solids [for relative data see: reference 1 (Innovative …: Tab. 1-4, pages 359-360)]. The two systems (concerning grey water and rainwater uses) can be used in an integrated way.

### 3.2.2 *Obtainment of energy from faeces*

Main objective of these applications is to obtain energy (or compost) from organic substances coming, e.g., from urban sector, like: **a)** faeces coming from toilets, and **b)** wastes of organic solids (for details on nature of these substances, see above:
"chapter 1 > resources consumptions and …").
In these applications the organic substances, coming e.g. from residential buildings, are gathered in a bio-reactor; where after a biodegradation treatment operation (e.g.: anaerobic biodegradation of faeces and organic solids) there is a build-up of gas (biogas).
So one obtains a biogas that can be used, by a following treatment, to produce energy; in particular, it is possible to obtain: **a)** heat by combustion of the biogas, or/and **b)** electric energy by: combustion of the biogas followed by a treatment system that converts the obtained combustion heat into electricity.

### 3.2.3 *Recovery of energy from hot waters*

There is possibility to recover heat contained in discharged hot waters (like, e.g.: waters coming from showers) to use, e.g.: **a)** to heat cold waters, or in winter season **b)** to heat by radiators the relative buildings; see also what described above about the heat in: “use of grey water < applications” and “chapter 1 > resources consumptions …”.

### 3.2.4 *Obtainment of fertilizer from urines*

Objective of these applications is to value nitrogen (*$N_2$*) contained into urines. In these applications, urines are gathered and then treated in a way to use the $N_2$ contained in themselves as fertilizer.
In the urines, there is about the 70% of the total $N_2$ expelled by men. Fertilizer, obtained from urines of a person, can fertilize about 200-400 $m^2$ of land.

### 3.2.5 *Emerging pollutant removal*

Interesting activities concern removal of emerging pollutants contained in waters with the aim to make treated waters:
a) adequate to be released in basin of drainage, or
b) available for other uses.
About the second topic b) one can say that, it is very interesting the realization of treatments concerning, when possible, streams containing single pollutant (or pollutants of similar nature); and this (always when possible) where or near where it has been produced, before that it is discharged into another stream with other different pollutants. This in general taking into account the following consideration: if there is a single stream that contains a single pollutant (e.g.: bacterium, or emerging pollutant), whose negative effect must be removed by specific treatment, one can say that this stream could be (normally) treated in an easier and more economical way than another stream containing more than one pollutant in more volume and lower concentration. As integration, see above: “concept > treatment …” and “framework > sensitization”.

### 3.2.6 *Scale*

Scales of applications depend on scales of situations taken into consideration for their relative realizations. For instance the scale of the implementation of a grey water use application can depend on the number of the persons involved in the use of the relative realization; for this example in particular, relating to grey water use applications, it is possible to have situations concerning:
- small scale applications for small number of persons (e.g. up to 10 persons)
- medium scale for medium number of persons (e.g.: up to 500 persons)
- large scale for large number of persons (e.g.: up to 1000-2000, and more).

As illustration concerning different scales for grey water use applications, see: Figure 4.

### 3.2.7 *Favourable and unfavourable aspects*

Realizations of resources efficiency by applications like those ones described just above, compared versus supposed realizations of same resources efficiency by traditional municipal waste water treatment systems, have the: **a)** advantage that they can save resources by means of easier treatments [lower pollutants number or higher concentration of resources (energy, nitrogen) in lower volume], this because they have to treat only a single specific stream containing a single specific pollutant [or useful resource (nitrogen, energy)], **b)** disadvantage of more costs for their same realizations.

Hereinafter one compares, as other example, an innovative system concerning a grey water use application to install in a residential building versus a traditional management system to install in a similar building. It is assumed (as described just above in the grey water use applications) that the total consumption of drinking water of the innovative system is about 23% less than that one of the traditional system for which the drinking water consumption is 100% of the total consumption.
Differences are reported about the characteristics of the two systems, that take into account also as assumption: a) the drinking water supply treatment system that is upstream of the residential building, and b) the municipal wastewater treatment system that is downstream of the same residential building (see Figure 2).
**A**) About the treatment system (concerning the innovative application) that makes water drinkable, one can say that: it must supply a lower drinking water volume [-23% (i.e.: it

must supply only the 77% of the total consumption that the traditional system needs)]. So it needs lower dimensions, and so lower costs for its realization.
**B**) In the building with use of grey water, one needs: **a**) the installation of technologies for the realization of the application, and **b**) the management of the grey water treatment for (among other things) a safe use of the treated water, in a way that the treated water does not create risks against persons for its use (so one needs safeguard care for persons health prevention, to avoid e.g.: effects of pathogenic bacteria and formation of those odours that are not agreeable); in particular from the economical point of view, one needs of: **a)** additional realization costs for components installation concerning the application, **b)** additional costs for operation (e.g.: for pump electricity) and maintenance (e.g. for: repairing, cleaning, components substitution); so one needs higher costs.
In addition, one can say that the innovative system can contribute, by means of additional technologies, to the recovery of the heat contained in the discharged hot waters (for this see above: “recovery of energy from hot waters < applications”).

One notes that in case of use of rainwater, one has: a potential consumption of detergent (used for washings) smaller than that one consumed with the traditional system; this for the smaller hardness of the rainwater.
**C**) About the municipal wastewater treatment system (concerning the innovative application), one can say that it has to treat a lower volume of water [-23% (i.e.: it must treat only the 77% of water volume instead of the 100%)]; this water, by the way, is drained from the residential building. So it needs: lower dimensions, and so lower costs.

One can also say, that one has also lower eutrophication; this is possible: a) because one has also a lower outlet (*drainage)* volume that goes to the basin of drainage, and b) taking into account also the consideration that: the concentrations ($C_i$) of the not desired substances contained in the outlet stream of the municipal wastewater system relating to the innovative application which stream goes to the drainage basin (river, lake, sea) are the same of the concentrations ($C_i$) of the same not desired substances contained in the outlet stream relating to the traditional wastewater system.

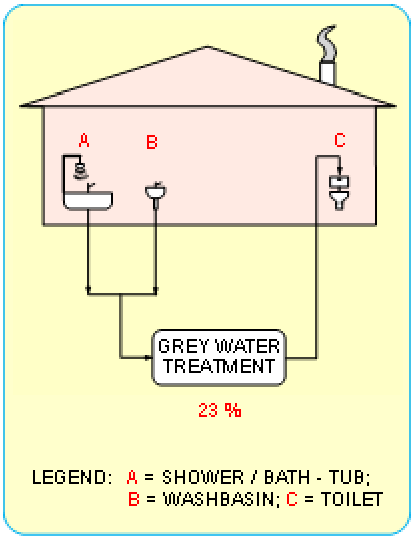


**Figure 1** Use of grey water.

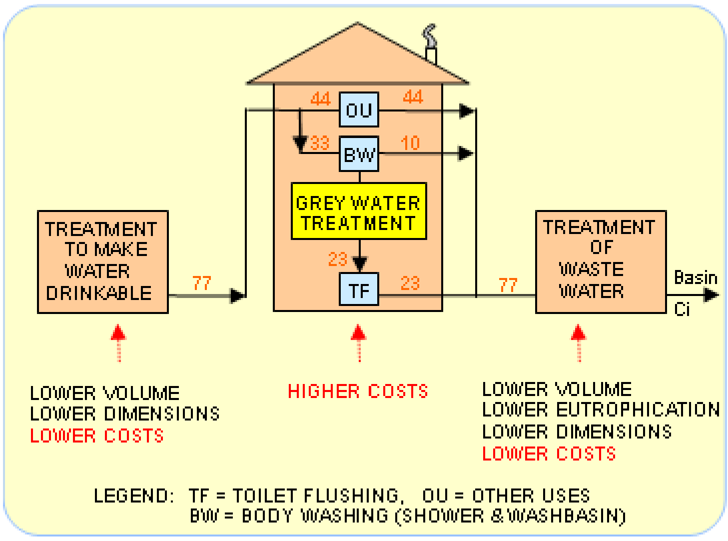


**Figure 2** Reuse: favourable and unfavourable aspects.

### 3.3 *Improvements*

Aspects and topics concerning possible ways (*ideas*) that could be explored to improve current innovative applications, like those ones described above whose targets are addressed research for resources saving [like, saving of: water (*e.g. drinking water*), energy and fertilizer] with respect of health safeguard and for market uptake, are described hereinafter.

Acquisition of awareness concerning rational use of resources (for integration, see above: “framework … > sensitization”) can also contribute to the creation of other opportunities for the improvement of the sustainability of the innovative applications.

### 3.3.1 *Aspects*

Ideas (*ways, suggestions*) to improve current innovative applications can concern optimization of aspects relating to the sustainability of the applications and in particular relating to, e.g.:

- technologies
- persons health and environment safeguard (*rule*)
- costs.

These aspects and relative characteristics can be improved by experimental activities [job (*actions of research*)] concerning developments of topics like those described below.

### 3.3.2 *Integrated use of alternative resources*

Additional criterion, to take into account to define design concerning installation (*realization)* of new applications, can be based in stimulating the carrying out *o*f a preliminary study to identify available alternative resources and to evaluate*,* in an integrated way, their possible use.
Available alternative resources can be: resources (e.g.: waters*)* already used, rainwater and other new kinds of available resources (not already used) near the area of interest (different of those ones normally used); for details on these kinds of waters see above: chapter 1 (consumptions) and chapter 2 (framework … > use of alternative resources).
Waters already used can be reused: **a)** in the same sector from which they come, **b)** through interchange among sectors (e.g.: from energetic sector to urban or to industrial sector, and vice-versa from urban or industrial sector to energetic sector or …; and so on from urban sector to ….). Furthermore waters coming from industrial, energetic and urban sectors can be sent to agricultural sector. As illustration concerning these integrated reuses among sectors, see Figure 3.

### 3.3.3 *Optimization of current technologies*

About this topic see what described above about the applications, in particular see e.g.: “use of grey water” and “favourable and unfavourable aspects”. Criterion concerning improvements of these applications could be related to the optimization of the technologies concerning the relative treatment process operations (like, e.g.: filtration, biodegradation, disinfection) which, by the way, are addressed resources saving with respect of health safeguard.

### 3.3.4 *Development of different scales*

Different scales can entail different kinds of designs. For this, it is interesting to optimize (*improve*) current technologies of applications concerning specific realizations (relating to, e.g., grey water use) of different scales; these scales depend on the different situations (e.g., numbers of involved persons) that are taken into consideration. For this topic: a) see above: “applications > scale”, and as illustration b) see: “Figure 4”.

### 3.3.5 *Rule improvement*

Concerning the sustainability of applications for market uptake it is important the role of the rules (regulations, legislations) that define: criteria and requirements for systems applications realizations, and in particular allowable limits of not desired substances (e.g.: bacteria and emerging pollutants); for details on bacteria and emerging pollutants, see above: “concept > treatment …”. One bears in mind that treatments must guaranty (*safeguard*) that values of concentrations of not desired (*dangerous)* substances do not exceed values that could damage health (that could be a risk against safeguard) of persons (and of plants, in case of irrigation).
Current allowable limits specified in rules of innovative applications are not identical among different nations; so, it is interesting to reduce the differences among the values of the limits specified in the rules of the different nations. For this, it is interesting to stimulate

the development of activities addressed the improving of current criteria and requirements specified in the rules; and this with the purpose to contribute to the achievement of the uniformity of the rules among different nations.

### 3.3.6 *Costs optimization*

From the point of view of the financial sustainability of the applications for a market uptake, earnings (*gains*) concerning benefits must overtake costs that must be sustained for the realization and during the life of the relative applications. This means that: if realization costs are high, they must be reduced in a way that: earnings coming from resources saving are higher than the same realization costs; i.e. (id est), costs must be reduced in a way that the years ($y_l$) of the application life are greater than the years ($y_e$) for which costs and earnings are equal; as illustration concerning this topic, see figure 5.
For this reason, it is interesting to stimulate developments of activities addressed costs minimization (optimization) of current applications (concerning, e.g.: use of grey water).

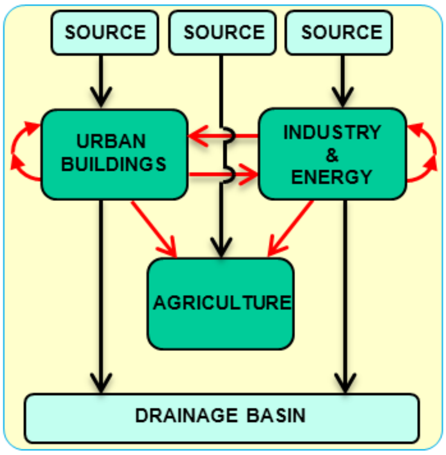


**Figure 3** Sectors: integrated water reuse.

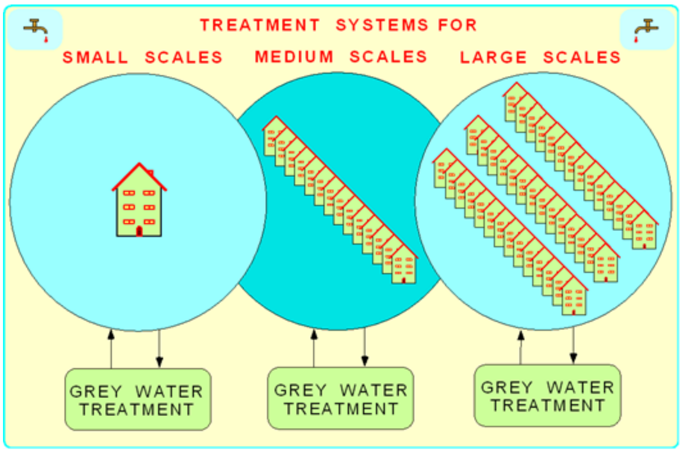


**Figure 4** Different scales of reuse.

### 3.3.7 *Integrated systems at large scale*

As integration on what described above and as a great challenge to face, it could be interesting to realize a new big research centre at large scale (composed of residential buildings that can accommodate, e.g., 1000 – 2000 persons) to install in urban sector. This realization has the characteristic that takes into account:

not the only implementation of a only single specific application [with a relative specific treatment and target (objective) to realize aimed at the improvement of the efficient use of the relative specific resource (target that could be like one of those ones described above, as for example: reduction of drinking water consumption)],

but the implementation of more than one specific application, each-one with a relative specific target to realize, in an unique integrated realization (project). Examples of specific single applications, each one with a relative specific target to realize and that (some of these) could be implemented in an unique integrated project, could be of the kind of those ones described above in the applications of this chapter 3, which (by the way) can save resources by: **a**) emerging pollutant removal, **b**) use of: grey water, rainwater, faeces, urines, hot water; and this, of course, with the target to save in an integrated and specific way the traditional consumption of more than one resource, like: water, energy and fertilizer.

With this kind of research centre it could be possible (*by the realization of an unique integrated project with more than one target)* to contribute to improvements of current applications by optimization in synergetic way of kinds of aspects concerning topics like those ones described just above (in this sub-chapter of the improvements), and in particular to contribute to: **a**) improvements through tests of different typologies of current innovative process treatment technologies (concerning, e.g.: filtration, biodegradation, disinfection), **b**) achievement of use of saved resources inside the same centre [like, e.g.:

use of obtained energy (heat and/or electricity) and fertilizer], and of course **c**) improvements of rules and reduction of costs.

All this with the aim to contribute to the development and realization of an optimized and integrated innovative sustainable (in terms of: technologies, rules, costs) system (application); system that is: **a**) addressed efficient management of resources [concerning, e.g., saving of: water (e.g.: drinking water saving), energy and fertilizer], and: **b**) sustainable for a market uptake concerning the realization of new models (systems) relating to the urban sector (*city*) of the future. As exemplified scheme of this idea (*suggestion*), see the illustration of Figure 6: resources saving in urban sector.

## 4.0 CONCLUSION

The ways described above [both with single target and with more (integrated) targets], relating to use of alternative resources to save traditional resources [like: water (e.g.: drinking water), energy and fertilizer], can contribute to:

a) removal of bottlenecks that hinder the sustainability of the innovative applications, and so
b) realization (with respect of health safeguard) of innovative production industrial chains suitable for a sustainable market uptake of new models of applications, concerning the optimization of the resources management relating to, e.g., the urban sector (city) of the future.

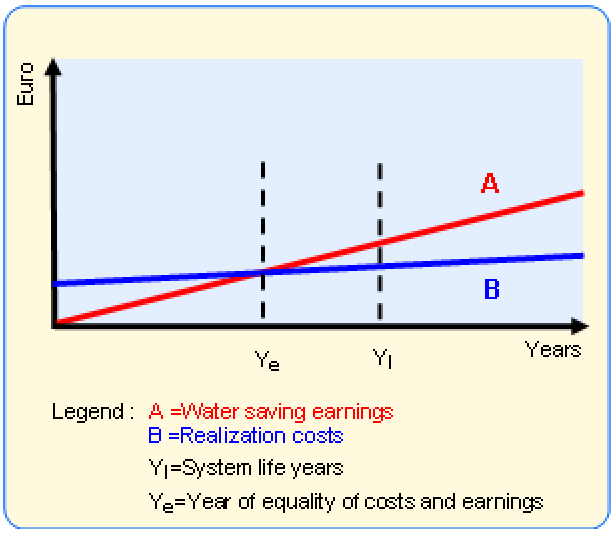


**Figure 5** Cost optimization.

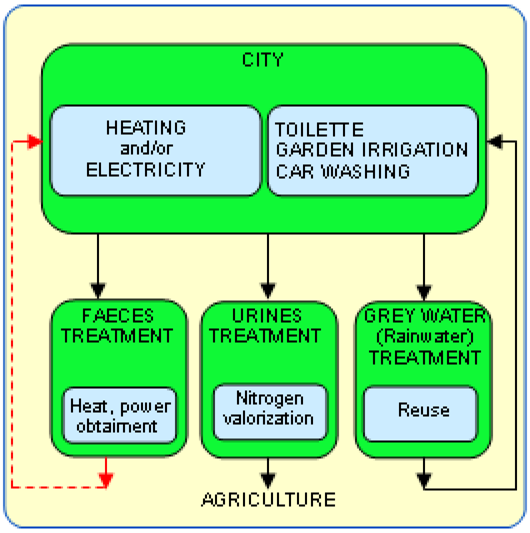


**Figure 6** Resource saving in urban sector.

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