DESIGN REQUIREMENTS FOR WATER SUPPLY AND SEWAGE SYSTEMS IN THE ENERGY SAVINGS CERTIFICATES IN THE CONSTRUCTION INDUSTRY

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Summary:
The paper presents problems related to the design and installation of systems for greywater use in indoor installations in buildings in Poland. These problems are related to the lack of references in the current legislation, appropriate technical terminology in Poland, and appropriate design guidelines and regulations for the dual installations.
The study was based on the most popular in the world certification systems according to which investors obtain green certificates of buildings. In these rules, in addition to a whole range of requirements are also requirements for indoor installation, including dual installations. The second issue is putrescibility time for grey wastewater. For this purpose, samples were taken and measurements of their putrescibility time were made depending on the chemical composition.
Dual Installation enables a significant saving of drinking water. Unfortunately, in Poland there is no clear regulations governing the design and construction of this type of installation. Often the cost of the installation exceeds the economic benefit of saving water.

Keywords: dual installation, grey wastewater, ecological certification in buildings

Introduction

The idea of a dual system is closely linked to the concept of “green construction” that began in the 70s of the last century. Just then there was the first severe energy crisis. At that time, attention was drawn to the growing problem of environmental pollution. Those unfavorable processes have forced people to change their perception of available energy sources and to notice the fact of irreversible environmental degradation. Then there were first attempts to reduce the negative effects of human impact on the environment.

One form of such activities is an establishment of associations developing guidelines for obtainment of green certification (ecological) for buildings.

Specific to designs and buildings with this certificate is a significant decline of energy consumption within their whole life cycle. Recently, also in Poland that investment processes, using procedures to reduce energy consumption of buildings, started to be employed. The authors present in this paper the selected legal, technical and terminological aspects, related to the design and implementation of dual systems in our country.

Brief overview of ecological certification systems for construction works

The most popular ecological certification systems in the world are currently the following:

BREEAM (*Building Research Establishment's Environmental Assessment Method*) – Great Britain [2] [6][8][17],

LEED (*Leadership In Energy and Environmental Design*) – USA [7][13][17],

CASBEE (*Comprehensive Assessment System for Built Environment Efficiency*) – Japan [6] [16],

DGNB (*Deutsche Gesellschaft fur Nachhaltiges Bauen*) – German Sustainable Building Council –Germany [5].

The German DGNB certificate is the youngest of the reviewed certificates. It was developed by the German Sustainable Building Council, and it seems to be the most transparent system of multi-criteria evaluation of buildings. It is worth mentioning that this is the only certification system which strongly emphasizes the need for facilities for disabled. The DGNB certification could be used virtually in every building, because of its unique criteria. These criteria can be applied either to office buildings, residential, schools or kindergartens. This gives us almost unlimited possibility of use, which in a short time could translate into a large growth of popularity and applicability of this young certification system [5].

There has been no environmental certification system developed yet that would be dedicated only for Polish conditions, and because of that we use certificates, which are based on the most popular worldwide LEED and BREEAM [2] [17] systems.

Currently the LEED system gives an opportunity to certificate almost every investment, both newly built and existing objects undergoing renovation. Various types of buildings can be certified: industrial, office, schools, hotels or multi-family residential buildings. Exceptions are only detached houses, which could be certified only in the USA [7][13].

For the European version of the BREEAM system certification is possible only for office, industrial and commercial buildings. Any other type of building has to be certified basing on the criteria prepared individually by BRE[1]. Because of the specificity of developing ecological certification criteria, the requirements included there are related to the conditions characteristic of a relevant country. Consequently these criteria differ considerably [8][13] [17]. Of the entire group of differences resulting from the application of the type of certification we can mention two, which will have a direct impact on the design of internal water supply and sewage systems (dual systems), namely:

✓ building regulations:
  – according to the BREEAM regulations – European standards apply with the possibility of adapting to local regulations,
  – according to the LEED regulations – American regulations required, without the possibility of adapting to local regulations,

✓ system
  – according to the BREEAM regulations – European standards apply,
  – according to the LEED regulations – ASHRAE[2] standards apply.

[1] BRE - *Building Research Establishment's* –British organization dedicated to sustainable construction.

[2] A set of standards prepared by ASHRAE (*American Society of Heating, Refrigerating and Air-Conditioning Engineers*). This specific set of standards includes regulations and guidelines for various branches used in building

One of the elements to be certified is the water supply system for a building, and more specifically the size of demand for drinking water and the possibility of limiting this value by replacing a certain amount of water used for purposes other than drinking and for hygienic purposes with greywater supplied by a dual system. Below is presented the method of calculating water requirements for the purposes of certification of an object according to the BREEAM [2] and LEED [7] criteria.

Water saving in the BREEAM certification

A design or a building to obtain the green BREEAM certificate has to get a required number of points from various environmental categories, including water saving.

The number of points is awarded depending on the evaluation of e.g. innovation level, but mainly of the savings made, in this particular case the drinking water consumption savings during the annual operation of the building. The value of the savings is expressed as a percentage, and it correspondents to the indicated number of points (Table no. 1). The percentage of drinking water conserved is evaluated in the relation to baseline values of usage provided by the BREEAM.

In calculations of either forecasted water usage or of its demand the following draw-off points and sanitary utensils in the internal systems in the assessed building should be included:

- toilets,
- urinals,
- shower baths,
- sinks,
- baths,
- dishwashers,
- washing machines.

Tab. 1. The points awarded depending on the volume of drinking water savings [2].

The volume of drinking water saved [%]	**BREEAM certification points**
12,5	1
25	2
40	3
50	4
55	5
65	above expectations

Since demand for water is closely linked to a commercial use of a building, and equally the percentage indicator of water saving decides about the number of points awarded in the certification, in the BREEAM specification is given a formula of how to calculate the savings ratio for various ways of using the surface in one building.
For this reason the below relationship should be used:

objects – from lighting, to mechanical devices' performance, to the methodology of energy calculation. In the case of requirements for the systems in buildings energy efficiency calculations are carried out using the Quest program.

$$I = 100 * \left[1 - \frac{(T_{1Act} * T_{1Occ}) + \cdots + (T_{nAct} * T_{nOcc})}{(T_{1Base} * T_{1Occ}) + \cdots + (T_{nBase} * T_{nOcc})}\right]$$

where:

T_{nAct} – actual water consumption for every type of utilization, [dm^3/ (number of persons x number of days)],
T_{nBase} – referential water usage for the corresponding type of utilization, [dm^3/ (number of persons x number of days)],
T_{nOcc} – load factor for the relevant surface type, [-].

Based on the I – the savings' percentage indicator calculated a proportionate number of points in the BREEAM certification is being awarded. Buildings are being assessed according to the baseline standards. If the assessed building deviates from the generally accepted standards, it has to be assessed individually through a comparison with guidelines developed by the BRE Global[3].

The table no. 2 shows both the baseline values of water consumption for a given sanitary utensil and the number of points, dependable on the size of reducing drinking water consumption in relation to the baseline values shown in the BREEAM system.

Tab. 2. Baseline values, points awarded for the size of reducing water consumption [2].

Utensil	**Baseline value**	**Points**					**Unit**
		1	**2**	**3**	**4**	**5**	
Toilet	6	5	4,5	4	3,75	3	dm^3
Sink	12	9	7,5	4,5	3,75	3	dm^3/min
Shower bath	14	10	8	6	4	3,5	dm^3/min
Bath	200	180	160	140	120	100	dm^3
Urinals (2 items and above)	7,5	6	3	1,5	0,75	0	dm^3/(items x h)
Urinals (only 1 item)	10	8	4	2	1	0	dm^3/(item x h)
Greywater/rainwater	0%	0%	0%	25%	50%	75%	% coverage of demand for toilets and urinals by grey and rain water
Draw-off point in kitchenette	12	10	7,5	5	5	5	dm^3/min

[3] BRE Global (*Building Research Establishment's Global)* – these are guidelines created individually for the analyzed building. The guidelines are created by the BRE organization which deals with the sustainable green construction [17].

Kitchen draw-off point in restaurant	10,3	9	8,3	7,3	6,3	6	dm^3/min
Household dishwashers	17	13	13	12	11	10	dm^3/cycle
Household washing machines	90	60	50	40	35	30	dm^3/usage
Garbage disposal units	17	17	0	0	0	0	dm^3/min
Commercial dishwashers	8	7	6	5	4	3	dm^3/drawer
Industrial washing machines	14	12	10	7,5	5	4,5	dm^3/kg

Water saving in the LEED certification

The in line with the American guidelines certification assumes the water demand for a given draw-off point according to the data included in the table no. 3 for uninhabited buildings or in the table no. 4 – for residential housings.

Tab. 3. How many times sanitary utensils in uninhabited buildings were used [7].

Type of appliance	Working time [s]	Usage /day			
		FTE	Temporary	Retail customers	Students
Toilets (Women)	n/a	3	0,5	0,2	3
Toilets (men - if there are urinals)	n/a	1	0,1	0,1	1
Urinals (women)	n/a	0	0	0	0
Urinals (men)	n/a	2	0,4	0,1	2
Sinks in toilets	30	3	0,5	0,2	3
Shower bath	300	0,1	0	0	0
Kitchen sinks	15	1	0	0	0
FTE – *Full Time Equivalent* – an indicator of usage of a utensil in the whole work cycle of a building, for example an assumption of usage for 3 times for 24 hrs is a 100 % utilization of the work cycle, which means FTE = 100%					

Tab. 4. How many times sanitary utensils in residential housings were used [7].

Type of appliance	Working time [s]	Frequency of use [1/24 hrs]
Toilet (Women))	n/a	5
Toilets (men)	n/a	5
Sinks in toilets	60	5
Shower bath	480	1
Kitchen sinks	60	4

In order to determine the size of water demand according to the LEED system, the total volume of water used should be calculated. The calculation should be made by knowing the normative outflow for both the given draw-off point and a utensil. For example, the volume of 1,6 US gallons is presumed for one usage of a lavatory bowl according to the American guidelines, and when flashing the bowl with a smaller amount of water– then 1,1 US gallons[4].

The American guidelines allow the reduction of the drinking water demand by covering water volume necessary for flashing of lavatory bowls with the use of the local water sources, e.g. rivers or lakes.

The following could be also used for this purpose: condensate of an air conditioner, rainwater and greywater.

Legal aspects of applying ecological certificates in Poland

The proposed and recommended solutions in the introduced ecological certificates for the construction industry usually do not comply with the technical specifications for buildings and their components in the country (for example, can be not economically justified) or are not in these requirements taken into consideration.

Sanitation services, evaluating the design documentation, are placed in a difficult situation, because there is no any legal basis in Poland for certain technical ecological solutions, such as systems reusing grey wastewater.

These aspects are the reason that the investor, who wants to build a building that meets very high environmental requirements; low consumption of energy, water and other utilities, may not obtain the building permit in the traditional way.

Fortunately for investors who want to build a building in our country in accordance with the LEED or BREEAM certifications the design documentation of such a facility can be treated in accordance with the Building Materials Act, Article 10, paragraphs 1 and 2 of that Act [14] as individual design documentation. Such a classification of design documentation is associated with an innovative concept of technical solution in that design, for example, water supply and sewage systems allowing reusing some of the processed water in the designed building.

[4] One gallon = 3,785 dm^3.

An additional problem of using dual systems is the lack of single-valued terminology for such technical solutions. In the case of wastewater terminology, the following definitions of the sewage systems standards are the base [9]:

grey water – does not include faeces and urine,

blackwater –includes faeces and urine.

Unfortunately, the definitions do not cover all terms necessary in dual systems. An example of this would be here colloquial use of the alternate wording for grey wastewater - greywater. This term is often used in marketing materials for producers of dual systems appliances and also in everyday language.

Some justification of this status can be a faithful translation of the term in English: *greywater* - *grey water*.

It should be noted, however, that the term "*sewage*" has a synonym in English: wastewater, which in a free translation is "water *worn*". Of course, in the field of water supply and sewage systems such a translation is not applied, the term *wastewater* translates into domestic sewage or municipal waste (not to be confused with rainwater).

An additional problem is terminological distinction between grey water incoming from sanitary utensils, such as sinks, and grey water purified and reused in a separate system, distributed, for example, to flushing cisterns. The latter wastewater type has a totally different qualitative composition (this is connected with the use of various treatment processes).

For the purposes of both technology description and technical solutions used in dual systems, adopting separate terms for these two types of greywater can be considered, namely:

Grey wastewater – wastewater incoming to the storage reservoir before its treatment,

Grey water – grey wastewater after purification and disinfection processes, ready to be reused in a construction work.

In national regulations, relating to building systems, there is no clear reference to dual systems. General requirements for water supply and sewage systems, however, can be interpreted.

An important reference to the possibility and the purposefulness of the dual systems usage is the PN-EN 12056-1:2002 standard [9], in which a sewage system discharging by separate circuits grey wastewater and blackwater (the so-called IV system) has been classified.

Among the national standards the PN-EN 1717:2003 standard [10]should be mentioned, the standard that is on the protection of water supply systems transporting drinking water against the risk of secondary pollution through a backflow. The dual systems consist of at least two duct systems, which transport grey wastewater (greywater) and drinking water. It should be noted that any joints of these systems may be achieved only through an air break (protection of the A group).

At this point, we should also mention the Regulation of the Minister of Infrastructure on the conditions to be met by buildings and their location [11]. This document includes the transcript (§126, section 3) about the possibility of use of rainwater in buildings for domestic purposes (watering the green around the house, washing, flushing lavatory bowls, etc.). There is no transcript, however, about the possibility of reusing grey wastewater for these purposes.

In this respect, the national legal status will be changed in the near future. At the present time (2012 – 2013), there are ongoing works on the amendment to the mentioned regulation, which is the basic legal act in the case of buildings under construction. In terms of substance, changes are being prepared by the Modern Buildings Association[5] delegated by the Ministry of Infrastructure. From many modifications made, there is also a transcript introduced about the possibility of using dual systems in buildings, in which grey wastewater is to be reused. An introduction of the amendment to the regulation is planned at the end of this year.

Technical problems when using dual systems

Our country, when it comes to designing, executing and exploitation of dual systems reusing grey wastewater, does not have any of the following: technical guidelines, recommendations, technical literature and practical experience. Hence the designers out of necessity are looking for the designing data in the foreign regulations and guidelines. Most often used for this purpose are the British standards for the design and requirements for the systems transporting grey wastewater [3] [4]. However, taking the recommendation and guidelines developed for other countries without adjustments might be a problem not only when designing but also during the assembled dual system's operation. It is necessary to remember that the standards and technical guidelines of other countries have been developed taking into account many specific criteria, such as tradition of using water, cultural habits of the inhabitants, weather conditions, etc.

Because of the special nature of dual system operation a very important issue is grey wastewater stability, namely its putrescibility time. This parameter is influenced by many factors, such as composition of grey wastewater (e.g. type of used tensides), temperature, etc. The data from the studies conducted in other countries may be unreliable in the relation to the real composition of grey wastewater in our country.

In order to estimate the stability of grey wastewater depending on the source of its formation, there has been conducted time measurement of putrescibility [12]. For this purpose, samples of grey wastewater from a single-family house have been examined. This wastewater has arisen as a result of using the following: baths, shower baths, sinks and washing machines. The tests were conducted in two stages. In the first stage the putrescibility time of wastewater samples coming only from one sanitary utensil was being analyzed. In the second stage there was analysis carried out of mixture of wastewater coming from the above mentioned utensils. The wastewater combinations chosen for the tests are typical for wastewater from daily use of the mentioned utensils both in a household and in public buildings.

Table no.5 presents putrescibility time of the analyzed samples and of their mixtures of specified proportions.

[5] Modern Buildings Association (www.snb.org.pl) - An Internet website of interdisciplinary collaborative platform of experts for improvement of regulations and implementations of laws in construction for the effective use of developments in the field of energy-saving and innovative solutions, and for ensuring respect for sustainable development.

Tab. 5. Putrescibility times for grey wastewater of different composition [12].

Wastewater source	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**
	putrescibility [24 hrs]			
Bath/Shower	5	2	4	3
Sink	3	2	4	2
Washing machine	1 – for one test			
Mixture 2:3 Bath/Shower + Washing machine	1 – for one test			
Mixture 5:1 Bath/Shower + Sink	1 – for one test			
Mixture 2:2:1 Washing machine + Bath/Shower + Sink	1 – for one test			

The wastewater putrescibility time was found to be closely dependent on the content of biodegradable substances. The reason of different sustainability of analyzed wastewater samples coming from one utensil was the use of different chemicals. Designations of those indicators are very essential in determining the time of the possible detention of grey wastewater in a storage tank, which is part of a dual system.

Summary

This paper presents some of the problems encountered in the design of dual systems, which are becoming more and more attractive because of significant potential to reduce drinking water consumption for buildings of different types of ecological certifications.

Technical solutions to save water and other media supplied to the designed building are so expensive that often have no economic justification compared with the projected savings.

Often such solutions are implemented "by brute force", without any rational justification, and investor and the designer go only by the ability to obtain a very prestigious certificate for themselves.

An example here might be the method of calculating the balance of water demand and the participation of some grey wastewater in this balance for an office building located in one of the largest Polish cities according to the LEED standard. The designer had assumed that about 80% of the employees of the building will commute to work by bicycles (the designer has in this way additional LEED points for the decline in the number of parking spaces in the basement of the building), and on the arrival they will take a shower. In this way, in the balance has been obtained a sufficient amount of gray wastewater, which then could be reused for flushing lavatory bowls.

During the summer season (approx. 4-5 months) such a forecast is possible to be performed. The problem, however, will occur in the winter season, because traveling by two-wheel vehicles in our climate zone will be quite difficult.

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