Financial viability of the gray water reuse in single-family homes

A. O. Granja 1, P. M. Sanches 1, R. C. Cavalcanti 2 and F.J.C.Magalhães Filho 3

1 Dom Bosco Catholic University (E-mail: ecv@ucdb.br), 2 Teacher of the course of Civil Engineering Dom Bosco Catholic University, Avenue Tamandaré 6000, Campo Grande, MS, Brasil (E-mail: ecv @ucdb.br) and 3 Teacher of the course of Sanitary and Environmental engineering (E-mail: fernandojcmf@hotmail.com).

ABSTRACT
This study aimed to determine the financial viability of the gray water reuse in single-family homes, for it has proposed three different scenarios: The first one a residence with the traditional system of water use compared to the one with the gray water reuse system. The second scenario comparing two households with the same reuse system, one of them with the increase of another set of motor pumps. And the third a residence with the implementation of the reuse system for its execution compared to another with post occupation installation, all scenarios presented financial viability, and the payback time of the investment, 104 months, 110 months and 145 months, respectively.

KEYWORDS
Water reused; grey water; payback time

INTRODUCTION
Gray water is referred to any residual water from domestic processes such as: use of washbasins, bathtubs, washing machine and tanks that do not have fecal contributions and effluents from the sanitary bowl.

The main purposes of focused sanitation resources are the increase in water availability by the economy in the uptake of water and the protection of drinking water by not release sewage, it being treated or not, using in a rational and safe manner the nutrients in excreta, demonstrated in table 1. In a way that is accessible to people who have lower purchasing power and pay attention to the techniques of site limitations (Winblad e Simpson- Hérbert, 2004).

The reuse of gray water is a sanitation alternative focused on resources to fulfill its purposes and reducing the number of people without access to adequate sanitation (Werner et al., 2009). This is also an alternative to lower costs with consumption, as well as water collection and treatment, besides the decrease in waste release in water sources that are subject to future uptake.

Water reuse is the reuse of water, which, after suffering appropriate treatment, is intended to various activities, for the purpose of preservation of existing water resources and ensuring sustainability (Fernandes et al., 2006).

The involvement of these practices with the hydro-sanitary installations construction system is still incipient, with few standards and methodologies services, and the system cost-effective compositions, causing the designer having no technical support to create an attractive system to the customer.

OBJECTIVE
Study the financial viability of the gray water reuse in single-family homes, showing the necessary

constructive changes, as well as assessing the cost incurred for the implementation and operation of the system and the payback time.

METODOLOGY

Presentation of scenarios

For comparative presentations were proposed three scenarios: Scenario 1, a residence with conventional system compared to a residence with the focused system in resources with a motor pump set; Scenario 2, the same residence with the focused system in resources with a motor-pump set compared with the addition of another motor-pump set, due to the need to maintain these pumps; Scenario 3, a residence with the implementation of system focused in resources from the beginning of the construction compared to the implementation of the reuse system after the completion of a conventional residence. The residence model used for the preparation of projects is an average standard, chosen because they are the most characteristic houses of the area and the gray water reuse system investment does not become something of great cost to the user. All projects of building facilities of the residence with the conventional system and the residence with system focused in resources are presented below.

Steps of the treatment in the system

After evaluation of possible treatments that could enter in the gray water reuse system for the water to reach the required quality at the point of use we choose (sanitary bowl and external tap), the following treatments were chosen: Septic tank, built wetlands, Chlorination with formulas and concepts of dimensioning.

Projects

For this paper, hydraulic and electrical designs were developed for both types of system, the conventional system commonly performed, which consists the entry of drinking water in the residence and its use in all the same points without the need to be drinking water, and system focused in resources is utilized gray water generated inside the residence for receiving treatment and be used at points without requiring drinking water. Showing the floorplan exemplifying the type of residence and grounds for the statement, isometrics details and sewage details that show the changes that differentiate the two systems in relation to the water cycle inside the houses and electrical design exemplifying the motor-pump set. The development project was accomplished with the assistance of Auto Cad software with the help of the relevant standards.

The following hydro sanitary and electrical projects were developed for both types of systems.

Sanitary system project

The sanitary system design were developed based on the NBR 5626, containing necessary details so in case of implementation, this happens in the best possible way. The materials appearing in the projects are described in the budget with their proper quantification.

Major changes that happened to adaptation of a conventional system to a system focused in resources: the need for two water tanks, one for feeding points of drinking water and another one for supply the points of reuse water; in the separate tubing that use reused water, they are: sanitary bowl and external tap; separate tubing to capture the effluents that are transported to the treatment system; implementation of built wetlands, septic tank and tank chlorinator.

Electrical project

The electrical project designed mainly to demonstrate the difference in the energy framework, added a circuit to the operation of the motor pump set responsible for water discharge to the upper reservoir. Where used flexible and rigid PVC conduits that connect to the motor-pump set through the ground, where they yarns and gauge cables were designed according to the required for the set, representing phase, neutral and ground, connected in a circuit breaker at the distribution board, according to NBR 5410.

The main difference in the electrical design of the two systems is the added motor-pump set in system focused in resources. As motor pump set adding some changes were made, such as wiring, piping and differential circuit breaker for all.

The payback calculation method

A simple payback system was used to demonstrate the system's payback time. It also took into consideration to determine the cost of the data for the initial investment and periodic additional costs as follows.

Initially the additional costs over the years and the tariff structure of water have been established, below in Table 1:

Table 1 – Adicional costs

Adicional Costs	Unitary Price	Maintenance Interval	In a Year
Monthly consumption of the pump energy	R$2,34	Monthly	R$ 28,08
Maintence of Wetlands	R$50,00	Once a year	R$50,00
Maintence of chlorinator	R$6,50	Monthly	R$78,00
Water analysis	R$40,00	Every 6 months	R$80,00
Maintence of Motor pump set	R$50,00	Every 6 months	R$100,00
Cleaning of septic tank	R$120,00	Every 2 years	R$60,00

The water used in the residence was taken into account that the initial consumption of the users would be 18m^3 and with the use of recycled water at the point of sanitary bowl, garden faucet, car wash and floor, reduce consumption of drinking water in about 38%, which is calculated according to (Priante 2012). Having as new final consumption about 11,16m^3.

To determine the values that are included in the financial return calculations for the home specified in the projects, it was considered the end of its execution at the end of September, thus starting its consumption of water and energy in October.

Table 2 - Tariff structure for collecting water

Consumer Range Tariff Structure	Consumer Range	2015 Rate Water (R$/m³)	2015 Rate Sewage (R$/m³)	2016 Rate Water (R$/m³)	2016 Rate Sewage (R$/m³)
Residencial	0 a 10 m³	3,69	2,59	3,91	2,75
	11 a 15 m³	4,71	3,30	4,99	3,50
	16 a 20 m3	4,80	3,36	5,09	3,56
	21 a 25 m³	5,29	3,70	5,61	3,92
	26 a 30 m³	6,52	4,57	6,91	4,84
	31 a 50 m³	7,82	5,48	8,29	5,81
	Acima de 50 m³	8,60	6,02	9,12	6,38

Above in (Table 2) are the prevailing rates in Campo Grande in 2015. For the following years were added a rate of 6%, of the value of each rate. This value was calculated in accordance with an overall average annual rate adjustment of Águas Guariroba, with the smallest forecast adjustment. Noting that there may be major increases in the water rates, as this is highly dependent on the amount of electricity tariff, as it requires a large set of pumping in the water collection held by the licensee, which could further increase the value of water tariff leaving the system implementation with a shorter return

Budget

For budgetary statements of the two types of systems, the materials used in these were collected, and the cost of labor for the execution. For these surveys were used features such as TCPO book, the unit price list provided by PINI, where was obtained the price of each material and subsequently prepared in spreadsheet calculations and assembly tables.

RESULTS AND DISCUSSIONS

Comparative systems

Scenario 1

Comparing the electrical installations costs, it is showing: In the system focused in resources 51% of spending to 49% of expenses in the conventional system; in the sanitary facilities we have: In the system focused on resources 61% of spending to 39% of expenses in the conventional system and the total cost of the work in both systems we have: In the system focused on resources 51% of spending to 49 % of expenses in the conventional system.

Scenario 2

Below is shown in (Table 3) the total cost difference of a reuse system using a motor pump set and another with two motor pump sets.

Table 3: Difference of the total cost of a residence with focused system resources with a motor-pump set with two motor pump.

System focused on resources with 1 pump	System focused on resources with 2 pumps	Difference between alternatives
R$ 127.605,24	R$ 128.326,50	R$ 721,26

Scenario 3

Table 4 show the difference between the total cost of a house built with the system focused in resources and a residence built in the conventional system after being implemented the reuse system.

Table 4: Total cost difference of a residence with implementation of the reuse system from the beginning of the work and a conventional residence later with the implementation of the reuse system

System focused on resources deployed from the start of work	System focused on resources deployed on conventional system	Difference between alternatives
R$ 127.605,24	R$ 131.757,10	R$ 4.151,86

Financial feedback

Scenário 1, after defined: The cost of initial investment, additional costs and the return would be given in the water bills of users, it could be observed that the value of the initial investment plus additional costs of maintence are tied with the discounted value of the water bill in 104 months. This reuse system deployment scenario before the execution of the work appears to be the most favorable for investment seeking a short-term return.

Scenário 2, In case of using two pump sets inside the residence it can be seen in the same year of the previous scenario, the system being paid in 110 months.

Scenario 3, with the reuse of system deployment in a residence already built with it, was with a return time a bit longer, being paid in October 2027 and then allowing the investment framework to be positive. It could change significantly during this time, since the scenario assembled to amendment of the water rate was lowest adjustment possible, which would be unlikely to occur.

We evaluated only the reuse of water and leaving out the capture of rainwater. What would generate another positive point to opt for these systems, since the city of Campo Grande - MS there is a "green tax" that would generate a 4% discount on the collection of property tax. Allowing faster return on investment of a system focused in resources.

It should be made clear that the adjustment in the water tariff rate was extremely optimistic, noting the moment that is found and unfavorable diagnoses proposed for a future not too far away. This rate was adopted for a simple demonstration that the construction of a residence is feasible with this type of system despite the busy area for its implementation, it can be designed to have a harmony with home architecture.

CONCLUSIONS

The changes in the conventional system for gray water reuse system, occurred in the electrical and plumbing projects of a residence, necessary for the implementation and proper function of the system are of low complexity. The differences in initial costs and payback time for each scenario are:

Scenario 1 shows a difference in the initial cost of the conventional system installations for the system focused on funds of R$ 6,265.53. This amount being added additional maintenance costs and having a return value equalized in 104 months. This scenario proved to be the most favorable, thus being the most financially viable with shorter payback times and lower initial investment.

Scenario 2, the difference of the conventional system to another using two motor pump sets, showed a difference of R$ 6,896.79. Its value plus additional maintenance costs to calculate the financial return, showing that in 110 months, the costs equal to the revenue. In this scenario it can be observed that there is no significant difference in initial costs, leaving the investment increase of only 6 months at its period and therefore proven viability.

Scenario 3, designed to demonstrate the difference in the cost of a residence built in the conventional system and later adapted to a gray water reuse system, reached a value of R$ 10,417.39, and this value is the difference between a system focused in resources deployed from the beginning of the work and the other implemented over a conventional system already running. This achieved a value of 145 months to equalize with the revenue. Demonstrating considerable payback period, being the worst case scenario and this not feasible residence.

Analyzing the investment costs in the three scenarios with their return times, it is concluded that all scenarios have financial viability but can highlight scenario 1 as the most viable, due to lower initial investment and shorter payback time.

REFERENCES

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 5410: **Instalações elétricas de baixa tensão**. Rio de Janeiro, 2008.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. NBR 5626: **Instalação predial de água fria**. Rio de Janeiro, 1998.

Fernandes, V. M. C.; Fiori, S.; Pizzo, H., 2006. **Avaliação qualitativa e quantitativa do reúso de águas cinzas em edificações**. Ambiente Construído, Porto Alegre, v. 6, n. 1.

Priante, N. **Distribuição do consumo de água em uma residência**, 52º Congresso Brasileiro de Química, Recife 2012.

Werner, C.; Panesar, A.; Rud, S.B.; Olt, C.U., 2009. **Ecological sanitation: principles, technologies, and project examples for sustainable wastewater and excreta management**. *Desalination*. **248**, 392-401.

Winblad U & Simpson-Hébert M, 2004. **Ecological Sanitation - revised and enlarged edition**. Stockholm Environment Institute - SEI, Stockholm.