Work Package: 5

Deliverable 5.1.4: Environmental and social benefits

Beneficiary: AUTH

INTERREG V-A COOPERATION PROGRAMME:

GREECE – BULGARIA 2014-2020

The Project is co-funded by the European Regional Development Fund and by national funds of the countries participating in the Interreg V-A "Greece - Bulgaria 2014-2020" Cooperation Programme.

About this document:

This document presents an account of the main environmental and social benefits, including educational ones, which result from the application of the GREEN PUMP project. Moreover, its relevance with the Sustainable Development Goals of the UN is underlined.

Deliverable Version: v. 2.0

Date:

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Table of Contents

1. Introduction

The GREEN PUMP project has been conceived (rather ambitiously) to address two of the three basic and interconnected pillars for the survival and wellbeing of humans on Earth, namely water and energy (the third one being food).

There is no doubt that water supply, sewer and electricity networks constitute the vital infrastructure of modern societies. Actually, their quality can serve as a non-typical index of regional and country prosperity. In EU countries most settlements with population larger than 2000 enjoy uninterrupted water and electricity supply. Unfortunately, this is not the case for large areas of the World.

Construction, maintenance and operation of the aforementioned infrastructure is not easy and poses an important managerial problem. Urbanization and increasing complexity of our society push towards centralizing management of water and energy resources. Centralized systems have many advantages, such as economy of scale. Their development, though, has led quite often to neglect of small local resources, which could cover on site needs, at smaller environmental and even financial, cost. A prominent example is the deterioration of private rain-water collection systems in the Greek islands.

One of the main aims of the GREEN PUMP Project is to demonstrate that local water and energy sources can be used in urban areas, as a supplement to the main centralized facilities, with net environmental benefit, accompanied, in most cases, by financial profit.

2. Environmental benefits

The environmental benefits are related to the energy and chemicals used for the treatment of raw water, in order to produce potable water, suitable for any domestic use. It is also related to the energy needed: a) to pump and transport ground or surface water to the water treatment facilities and b) to transport water from the water treatment facility to the tanks and finally to the consumers. On the other hand, the energy needed to pump groundwater for local use depends on the depth of the local aquifer and is generally smaller. In the case of the Aristotle University campus it is much smaller, since the respective aquifer is shallow. Actually, we have opted to use the shallow aquifer only, for the following reasons: a) To keep the pumping energy consumption (and the respective environmental footprint) low and b) To keep the drilling cost low.

Regarding the use of local water resources, the GREEN PUMP project has demonstrated that shallow groundwater can be efficiently used for toilet flushing in the Building of the Division of Hydraulics and Environmental Engineering of the Aristotle University of Thessaloniki. Water pumped from the shallow well is temporarily stored at two interconnected water tanks, which have been installed at the roof of the building. The capacity of each tank is 400 l. We have opted to install two tanks instead of a larger one with larger capacity, in order to avoid concentrating loads on a small area of the roof. They are partly protected from direct sun radiation, as shown in Figure 1.

The pipe network, which connects the tanks to the toilets, allows for their alternate use with the main water supply network, in case of emergency. This dual system is more dependable and increases safety of water supply, at least for hygienic purposes.

The quantity of water saved, cannot be measured directly. Nevertheless, it can be calculated from the anticipated use under normal (non-covid-19) conditions, in the following way:

Members of the scientific and administrative personnel, occupying offices at the building of the Division of Hydraulics and Environmental Engineering: 25

Number of graduate and Ph.D. students, working regularly at the building of the Division of Hydraulics and Environmental Engineering: 15

Average number of students and other visitors to the Division of Hydraulics and Environmental Engineering: 35

Then the water consumption for toilet flushing is calculated as:

40 x 0.075 + 35 x 0.030 = 4,05 m^3/day (for 200 days per year).

For the remaining days we assume a much smaller consumption, namely 1 m^3/day.

Then, the annual water savings are estimated at almost 1000 m^3 (for toilet use only).

Water will be also available to cover irrigation needs for the small plots around the building of the Division of Hydraulics and Environmental Engineering. An additional positive aspect of this, is the fact that irrigation water is mainly needed during the months of summer, when the hygienic water demand is very low. Moreover, it is easy to regularly check its quality at the Environmental Laboratory of the Division.

Figure 1. The two tanks at the roof of the Building of the building of the Division of Hydraulics and Environmental Engineering (Source: Archive of the GREEN PUMP project)

The successful demonstration of the use of groundwater from a local aquifer may have the following net social benefit: To serve as a lever for the much-needed change of the respective legal frame, which is further discussed in the Deliverable 4.1.5. Moreover, our project has demonstrated that use of dual water supply networks (one for potable water and one for water of inferior quality) can be applied in practice, by available skilled personnel. One of the installed connections appears in the photo of Figure 1. Promotion of the installation of dual networks could alleviate the water scarcity problem in islands and coastal areas, in particular if they depend financially on summer (dry season) tourism. Again, a change of the respective legal framework is necessary, and probably overdue, in Greece. Other countries, which have adopted dual water supply networks, can serve as guiding examples. For instance, relevant information can be found at: https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=304910 .

Figure 2. Connections of the dual network (Source: Archive of the GREEN PUMP project)

Besides the aforementioned “indirect” energy savings, the GREEN PUMP project contributes directly towards an environmentally-friendly energy sector, as its second basic idea of the GREEN PUMP project is to promote and demonstrate the use of geothermal energy. The latter is one of the soft and renewable energy sources, which have two basic advantages over conventional energy sources (coal, oil and natural gas): a) They are inexhaustible (provided that they are used at sustainable rates) and b) Their environmental impact is definitely lower (if properly used). Moreover, they are more evenly distributed on Earth, with respect to natural gas and oil. For this reason, their penetration to the energy market in order to cover local needs, promotes peace, security of energy supply and regional development.

Promotion of geothermal energy (and other renewables) is very important and timely for Greece, for two reasons: a) Its energy balance is deficient and has to rely on imports and b) It has entered, rather abruptly, a decarbonization process, which foresees closing down the electricity (and heat) producing units that are fueled by lignite, namely by domestically produced coal. If it is not substituted by other

domestic energy sources, it will render the country even more dependent on energy imports and more vulnerable to energy price hikes .

The GREEN PUMP project included also water quality measurements at water samples, collected either from shallow wells, used for basement protection, or from rain-runoff, which directly feeds shallow aquifers. Results from some sites are rather alarming, mainly regarding microbiological load. They are included in Deliverable 5.1.2. The respective conclusions will be communicated to the authorities, which are responsible for the protection of public health.

It should be mentioned, though, that the quality of water pumped from the well that has been constructed in the framework of the GREEN PUMP project, seems acceptable for secondary uses.

3. The connection of the GREEN PUMP project with the UN Sustainable Development Goals

It follows from the above, that the GREEN PUMP project is directly connected to the Sustainable Development Goals of the UN, which are graphically summarized in Figure 3. This connection is explained in the following paragraphs.

Figure 3. The 17 Sustainable Development Goals (Source: https://unstats.un.org/sdgs/)

In 2015, all United Nations member States decided to adopt a set of goals. These goals have been characterized as a call to action, all around the world, in order to bring poverty to an end, help protect the planet and make sure that everyone can enjoy peace and prosperity by the year 2030. The name of these goals is Sustainable Development Goals (SDGs) and they are 17.

One characteristic of the SDGs is that they are integrated, meaning that it is recognized in them that outcomes in one area will likely affect outcomes in other ones, as well. Thus, a balance is needed among social, economic and environmental planning and action taking. The SDGs are claimed to have been designed in such a way so as to bring an end to a number of worldwide problems, like: poverty, hunger, AIDS and discrimination against women and girls.

The GREEN PUMP project is in alignment with a number of different SGDs. These SDGs are the following:

a) **Goal 7:** “Ensure access to affordable, reliable, sustainable and modern energy for all”. This goal aims, among other things, to bring access to affordable, reliable and sustainable energy. Our project makes use of a renewable energy source, namely geothermal energy. This form of renewable energy

can be found all around the world, both in more and less developed countries. Thus, in many areas, where energy must be supplied in some form externally, and more often than not as fossil fuel, the success of our program can provide an example, as well as offer general guidelines and technical know-how, for a similar implementation in countries all around the world where available geothermal energy resources are not being used.

b) **Goal 8:** "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all". Sustained and inclusive economic growth is a prerequisite for sustainable development, which can contribute to improved livelihoods for people around the world. Economic growth can lead to new and better employment opportunities and provide greater economic security for all. Moreover, rapid growth, especially among the least developed and other developing countries, can help them reduce the wage gap relative to developed countries, thereby diminishing glaring inequalities between the rich and poor.

The GREEN PUMP project at the Aristotle University campus included well construction (drilling, testing pump placement etc.), installation of heat pumps complete with their appurtenances, installation of water tanks and construction of a local pipe network, connecting all the above to each other, to the existing heat distribution system and to existing water supply and sewage systems. What is more, there was the need for certain pieces of equipment. Thus, a number of people were provided with extra work and income. There was a direct benefit for those who worked in the digging, drilling, use of special machinery, transportation and installation of equipment. There was, as well, an indirect benefit for those designing, producing and distributing the necessary equipment for the project. If electric energy produced by fossil fuel were used, as it is the usual case in the vast majority of areas around the world, and if water from the local Water Supply Company of each place was used, as it is also common in quite many areas, all the needed infrastructure would be in place already. Thus, no extra income would have been provided to the aforementioned people that did.

If the design of our project could turn into a common practice in several areas, a large number of jobs could be created, as there would be higher demand for this specific equipment to be produced, transported, installed and maintained. Thus, a transition away from fossil fuels, in such a way, could be beneficiary for both the environment and employment.

c) **Goal 9:** "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". Sustainable Development Goal 9 addresses three important aspects of sustainable development: infrastructure, industrialization and innovation. Infrastructure provides the basic physical facilities essential to business and society; industrialization drives economic growth and job creation, thereby reducing income inequality; and innovation expands the technological capabilities of industrial sectors and leads to the development of new skills. It is worth mentioning that infrastructure systems are characterized as resilient, if they can absorb disturbance and still retain their basic function and structural capacity.

A system that makes use of locally sourced renewable energy and water sourced locally, as well, such as the one used in our project, could be thought of as much more resilient than a system that makes use of electric energy produced by fossil fuels, most likely at a distant area, and water brought by a distant source, as well. What is more, in many cases the fossil fuels are transferred to the energy producing plant from other countries. The first system has much less room for disturbances to occur

and affect it, while the second one relies on a great number of, usually large-scale, sub-systems to function continuously in an acceptable way.

d) **Goal 10:** "Reduce inequality within and among countries". This goal calls for reducing inequalities in income as well as those based on sex, age, disability, race, class, ethnicity, religion and opportunity – both within and among countries. As it is the case now, the majority of the countries around the world are dependent upon certain ones in order to cover their energy demand. Consequently, any step of a country towards becoming more self-reliant in its energy production is in alignment with SDG 10.

e) **Goal 11:** "Make cities and human settlements inclusive, safe, resilient and sustainable". Today, more than half the world's population lives in cities. By 2030, it is projected that 6 in 10 people will be urban dwellers. Despite numerous planning challenges, cities offer more efficient economies of scale on many levels, including the provision of goods, services and transportation.

By making use of geothermal energy, as well as locally available groundwater, our project contributes into making our communities and cities where it is being implemented more resilient and sustainable.

f) **Goal 12:** "Ensure sustainable consumption and production patterns". Sustainable growth and development require minimizing the natural resources and toxic materials used, and the waste and pollutants generated, throughout the entire production and consumption process. Sustainable Development Goal 12 encourages more sustainable consumption and production patterns through various measures, including specific policies and international agreements on the management of materials that are toxic to the environment.

What commonly takes place in our communities, as many other ones around the world, is that a Water Supply Company provides the community with high quality water. Usually, in order for this to be feasible, large amounts of water are being transferred from distant areas and then processed until the quality of water reaches certain high standards. This process often leads to an overuse of natural resources and mostly underground aquifer and it includes the use of chemicals, as well. However, the water provided to the communities is not used exclusively for drinking, cooking, showering etc. It is used in flashing the toilets, the irrigation of parks and other secondary uses. The amounts used in these secondary uses are actually substantial, as well. At the same time, especially in urban areas, there can be aquifers that not only contain water of high enough quality for secondary uses that stays unused, but also their head level is so high that the water in them actually can have detrimental effects to several buildings.

The obvious problem of the aforementioned situation is that inefficient use of water resources and chemicals, as well, takes place, leading to environmental problems, increased costs and non-optimal use of resources in general. Our project, by making use of water in urban areas for secondary uses, helps change the current practice to a more sustainable one. Moreover, it contributes to the reduction of the unnecessary use of chemicals.

g) **Goal 13:** “Take urgent action to combat climate change and its impacts”. Climate change presents the single biggest threat to humanity as a whole, and its widespread, unprecedented effects disproportionately burden the poorest and the most vulnerable. Goal 13 calls for urgent action not only to combat climate change and its impacts, but also to build resilience in responding to climate-related hazards and natural disasters.

Since in order to combat climate change a common goal is to reduce carbon dioxide emissions, any steps taken towards the reduction of fossil fuel use can be considered as steps in the right direction. As it has been stated multiple times already, our project makes use of renewable energy to cover energy needs that otherwise would be covered by energy produced mainly through burning fossil fuels. Thus, the GREEN PUMP project contributes to the desired direction.

Summarizing, the GREEN PUMP project is related, more or less, to 7 of the 17 SDG goals and contributes to their achievement.

4. Educational value of the GREEN PUMP Project

Proper education, in particular of younger people, is a prerequisite for the preservation of our environment and for social welfare. The GREEN PUMP project contributes directly to this goal, through familiarizing university (and high school) students with environmentally sustainable practices, as explained in the following paragraphs.

Figure 4. Students attending the construction of the geothermal well
(Source: Archive of the GREEN PUMP project)

One basic idea of the GREEN PUMP project is to promote and demonstrate (if successful) the use of the same water quantity, first for heating purposes and then to cover water demand for secondary uses (e.g. irrigation, toilet flushing). In this way, the crucial notion of reuse is promoted, namely one of the 6Rs for global sustainability: Rethink, Refuse, Reduce, Reuse, Recycle, Repair. It is worth mentioning that reuse is an ancient practice that gave solutions and saved materials, energy and sources for millennia. This practice had been “forgotten” in the industrialized world, overtaken by the “consumerism” spirit. This spirit has been fueled by a misinterpretation of the limits of modern

technology, which may facilitate the use of precious sources and render them more accessible, but it cannot make them inexhaustible. In this aspect, the GREEN PUMP project contributes to the formation of an environmentally sustainable attitude towards the resources of our planet.

Moreover, the principle of fitting available resources to the specific needs is promoted by the geothermal application as well.

A useful educational byproduct of the GREEN PUMP project, is that the construction of the pilot installation at the Aristotle University of Thessaloniki, allowed for the production of additional educational material for three courses, taught in the Civil Engineering Department, namely Groundwater Hydraulics and Hydrology (compulsory), "Groundwater flows" (elective) and Geothermal energy" (elective).

It is also worth mentioning that the construction of the pilot installation attracted the interest of many students, as shown in the photo of Figure 4. Future students will have the opportunity to see the main components of a typical geothermal installation, namely the heat pumps, the heat exchanger and the expansion tank.

One more educational asset of our project is that it offers the opportunity for an interdisciplinary approach. It is obvious that geologists, civil engineers, mechanical engineers, electrical engineers and economists may be directly involved in the development of geothermal projects. The GREEN PUMP project has highlighted the supportive role that can be played by historians and archaeologists: Historical and archeological data, e.g. on traditional wells inside the urban fabric or on the course of sections of streams that have disappeared due to unplanned expansion of cities, can offer valuable information on the existence of shallow aquifers. We have collected data of this kind for the Aristotle University campus. The Hortatzides stream, which has been reduced to a closed conduit, runs less than hundred meters away from the building of the Division of Hydraulics and Environmental Engineering. Such indirect information might be very useful, in many cases, because geophysical research may offer very restricted information in densely built areas. In our case the available space is restricted by the building of the Division of Hydraulics and Environmental Engineering, Building E of the Faculty of Engineering, the University kindergarten building and the facilities of the Faculty of Education. For this reason, the measuring devices could not be developed at sufficient length and the respective cross-sections could not reach depths larger than 6 meters (see deliverable 4.1.2 for more details).

5. Conclusions

The GREEN PUMP project indicates clearly that various environmental and social benefits can result from the development of local water and energy resources, which are usually neglected in urban environments, which are served by complex water, sewer and energy networks.

Existence and proper function of the aforementioned networks is necessary and is not questioned by our work. We underline, though, that supplementary use of local resources may result in environmental and social benefits, which can be substantial, if a large number of small-scale projects is implemented. The concept of the GREEN PUMP project can serve as a model.

Finally, our project has an educational dimension, since proper education and training are essential for supporting environment-friendly policies.

The contents of the report are the sole responsibility of AUTH and can in no way be taken to reflect the views of the European Union, the participating countries, the Managing Authority and the Joint Secretariat.