

Work Package 5: Monitoring and evaluation of pilot outputs

Deliverable 5.7.2 (former 5.3.2): Evaluation of the environmental and social benefits (partner contribution)

Beneficiary: IHU (former TEICM)

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About this document:

The present Deliverable reports the environmental and social benefits that would come as a result of an efficient broad application of studies similar to the ones described in GREEN PUMP project.

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Deliverable Contributors:

1. Emmanouil Kirtas
2. Georgios Panagopoulos
3. Panagiotis Anastasiadis
4. Emmanouilidis Marios
5. Koutrovelis Panagiotis

Has been reviewed and approved by: Emmanouil Kirtas

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1. Scope of Deliverable 5.7.2 (former 5.3.2) – IHU (former TEICM) contribution

The present Deliverable reports the environmental and social benefits that would come as a result of an efficient broad application of studies similar to the ones described in GREEN PUMP project.

The environmental benefits could be summarized as follows:

- Reduce the oil consumption by satisfying heating requirements with shallow geothermal energy, having a direct positive effect to global oil reserves.
- Replace oil as a raw material for heating with renewable energy sources such as shallow geothermal energy.
- Reduce CO₂ emissions linked to oil usage for heating purposes.
- Reduce chemical treatment of the water by replacing water source for secondary uses.
- Reduce chemical residues in the soil by using untreated water for some applications such as irrigation.

The social benefits could be summarized as follows:

- Teach the public of the multiple advantages of renewable energy sources.
- Educate citizens to select environmental friendly approaches to satisfy their everyday needs.
- Raising public awareness with respect to the excessive usage of potable water to needs that do not require water treated with chemicals such as irrigation and toilet flushing.

Of course, application of the specific studies included in TEICM participation in the GREEN PUMP project would also have similar direct positive effects, yet in smaller scale compared to a broader application of the GREEN PUMP project findings.

2. Environmental benefits

2.1 Environmental benefits arising from shallow geothermal energy as an alternate energy source for heating

Any action aiming to replace the use of oil and other fossil fuels as a raw material to cover energy demand, is in principle environmental friendly. When the alternate energy providing solution comes from renewable sources, the beneficial effects are multiplied since they can, in theory, exponentially exceed the global energy demand (Ellabban et al., 2014). According to the US Environmental Protection Agency (1993), Geothermal ground Source Heat Pump systems (GSHP) are one of the most energy efficient, environmentally clean, and cost-effective space conditioning systems available. The renewable energy sources have the ability to provide over 3000 times the current global energy needs.

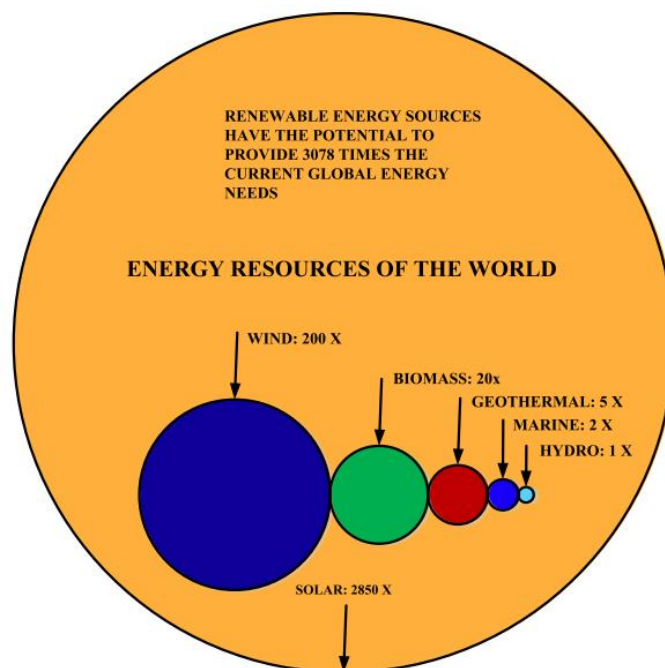


Figure 1. Energy resources of the world and their ability to cover current global energy demands (after Ellabban et al., 2014)

Geothermal energy is included in renewable energy sources deriving from natural mechanisms. Indeed our planet stores enormous quantities of heat energy, mainly because it was formed with a core of molten metal which is slowly transferring heat to its outside crust (Johnston et al., 2011). Moreover, additional sources of heat are linked to the decay of

naturally occurring radioactive materials beneath the Earth's surface and to the sun's energy absorbed by our planet that is acting as a large solar collector.

Shallow geothermal energy (SGE) is related to heat extraction from the ground at normal temperatures (not directly related to deep geothermal energy), using devices widely known as heat pumps or more correctly as Ground Source Heat Pumps (GSHP). This energy could be used both for heating and cooling purposes. An example of heat pump utilization in an open loop form is presented in Figure 2 (Bonte, 2013).

Some of the numerous reasons proving the necessity of replacing fossil fuels for heating purposes are described in the next sections.

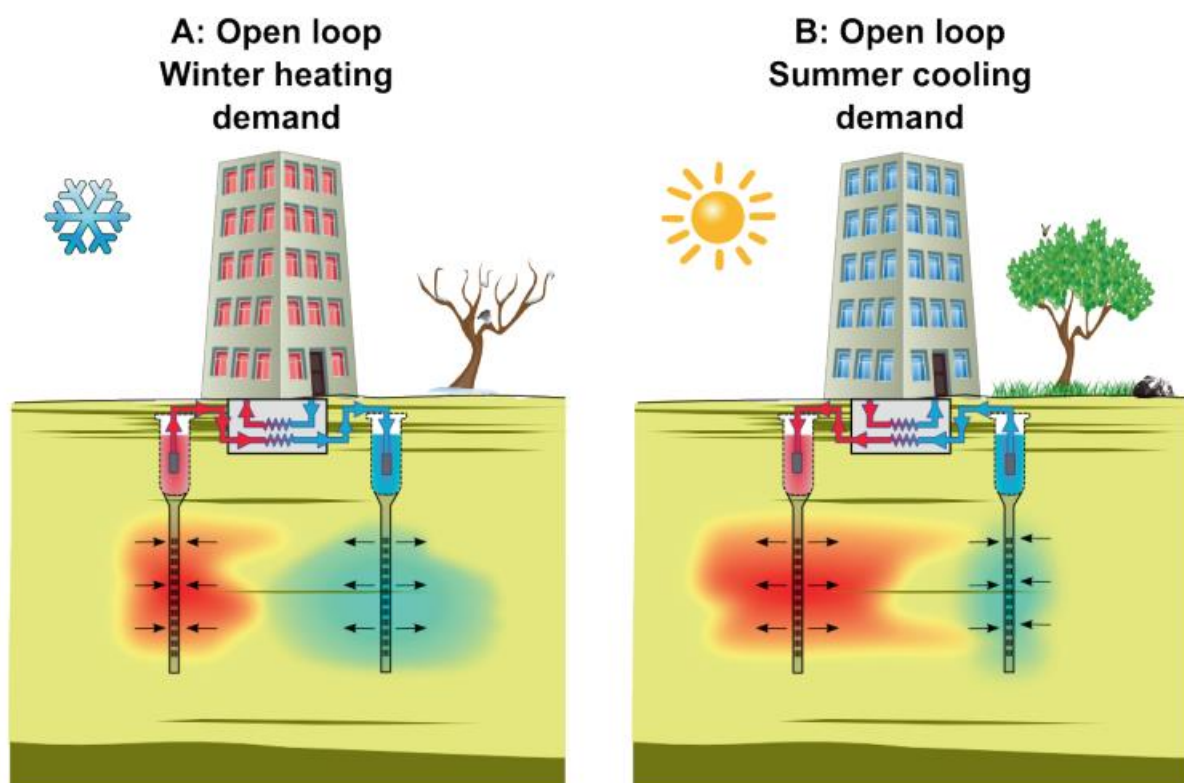


Figure 2. Different types of Shallow Geothermal Energy (after Bonte, 2013)

Reduction of oil and fossil fuels usage as an energy source

Mining procedure to exploit fossil fuels are directly linked to environmental degradation (<https://www.ucsusa.org>). Surface mining for example, often employs highly invasive

techniques, removing the overlaying soil to access the coal below (including area strip mining and mountaintop removal), devastating thus local environments. All trees and other surface vegetation are stripped from earth surface, whereas large volumes of earth are blasted away.

In the short term:

- A large amount of land is disturbed by the drilling activities, creation of access road system, processing facilities, etc.
- Large volumes of excess rock and soil are dumped into adjacent valleys and streams, altering their ecosystems.
- Noise and dust from drilling activities and explosions may lead to abandoning whole neighboring communities as well as harm local wildlife populations.

In the long term:

- Burn of fossil fuels emit carbon dioxide and other harmful air pollutants resulting in severe health problems (often fatal) of the neighboring communities.
- Extraction processes can also generation air and water pollution with similar consequences for local communities.
- Ground subsidence and/or frequent floodings often come as a long term consequence of mining activities (ground cavities, alteration of natural flow ways of underground or surface water, stripping of surface vegetation etc), forcing local population to abandon their communities.
- Coal removal sites are left with poor soil, not suitable to host any vegetation for decades.

Adoption of renewable energy sources such as shallow geothermal energy

Adoption of renewable energy sources is the optimal future direction since they are clean and inexhaustible energy resources (Ellaban et al., 2014). The share of renewable energy sources is therefore expected to increase significantly during the next decades, as indicatively described in the 2040 scenario of Figure 3 (Panwar et al., 2011), estimated to reach a percentage of 30-80% by 2100 (Fridleifsson, 2001).

Moreover, unlike solar and wind energy, geothermal energy is always available, 365 days a year, providing an ideal energy source to cover need that are constant on a 24/7 basis.

	2001	2010	2020	2030	2040
Total consumption (million tons oil equivalent)	10,038	10,549	11,425	12,352	13,310
Biomass	1080	1313	1791	2483	3271
Large hydro	22.7	266	309	341	358
Geothermal	43.2	86	186	333	493
Small hydro	9.5	19	49	106	189
Wind	4.7	44	266	542	688
Solar thermal	4.1	15	66	244	480
Photovoltaic	0.1	2	24	221	784
Solar thermal electricity	0.1	0.4	3	16	68
Marine (tidal/wave/ocean)	0.05	0.1	0.4	3	20
Total RES	1,365.5	1,745.5	2,964.4	4,289	6,351
Renewable energy source contribution (%)	13.6	16.6	23.6	34.7	47.7

Figure 3. Global renewable energy scenario by 2040 (after Panwar et al., 2011)

Reduction of oil and fossil fuels consumption as related to global reserves

It is widely known that oil as well as other fossil energy sources have been vastly used during the last century. Unfortunately, improvement of life standards and industrialization of developing countries result in a continuous increase of fossil fuel consumption (Panwar et al., 2011), as an easier and straightforward way to cover increasing energy demands compared to alternate energy sources. Since a large percentage of the global energy demand is even today covered by conventional energy sources, taking into consideration the limited fossil fuels resources, their exploitation is often a matter of national interest, dispute between countries etc. Therefore, since oil and gas are expected to continue to be important sources of energy (Nakicenovic et al., 1998), since the renewable energy sources are still not commercially competitive in many cases, it is wise not to exhaust global reserves of fossil fuels to avoid irreparable damage to the natural environment and prevent at the same time energy crises amongst countries with clear social implications.

Reduction of CO₂ emissions linked to oil and fossil fuel usage for heating purposes

During 1990-2050 the primary energy consumption is expected to increase by 50% (environmentally conscious scenario) or by 275% (highest growth rate scenario). If the latter takes place, then it will lead to a doubling of current carbon emissions (Nakicenovic et al., 1998). Adoption of renewable energy sources offer the possibility to reduce greenhouse gas emission and global warming through substituting conventional energy sources and especially oil related (Panwar et al., 2011).

Even compared to other electricity based heating systems, shallow geothermal energy contributes significantly to the reduction of CO₂ emissions. After all, one of the advantages of geothermal heat pumps (GHP) is that they use up to 50% less electricity than conventional heating or cooling systems (US DOE, 1998), whereas more recent studies re-estimate that consumption percentage to rates lower than 25-30% of the energy consumed by even the most efficient conventional alternatives (Hanova and Dowlatabadi, 2007). Because of the GHP system efficiency, according to the EPA (US Environmental Protection Agency), geothermal heat pumps can reduce energy consumption - and corresponding emissions - up to 44% compared to air-source heat pumps and up to 72% compared to electric resistance heating with standard air-conditioning equipment.

According to data supplied by the U.S. Department of Energy (DOE) Office of Geothermal Technologies (<http://www.energyhomes.org>), nearly 40% of all U.S. emissions of carbon dioxide are the result of heating, cooling, and hot water systems in residential and commercial buildings. This is roughly equivalent to the amount of carbon dioxide contributed by automobiles and public transportation [reference 2- National Renewable Energy Lab, D., Office of Geothermal Technologies, Environmental and Energy Benefits of Geothermal Heat Pumps. 1998].

Because geothermal pump heating systems do not burn fossil fuels for heat production, they generate far fewer greenhouse gas emissions than a conventional furnace. They also provide higher air quality because there are no emissions of carbon monoxide. In general, a 3-ton residential geothermal heat pump system produces an average of about one pound less carbon dioxide per hour compared to a conventional system. Over an average 20-year lifespan, installation of 100000 units of residential geothermal systems can reduce greenhouse gas emissions by almost 1.1 million metric tons of carbon equivalents [3]. That would be the equivalent of removing 58700 cars from our highways or planting more than 120000 acres of trees.

Comparing Global Warming Emissions of Energy Sources

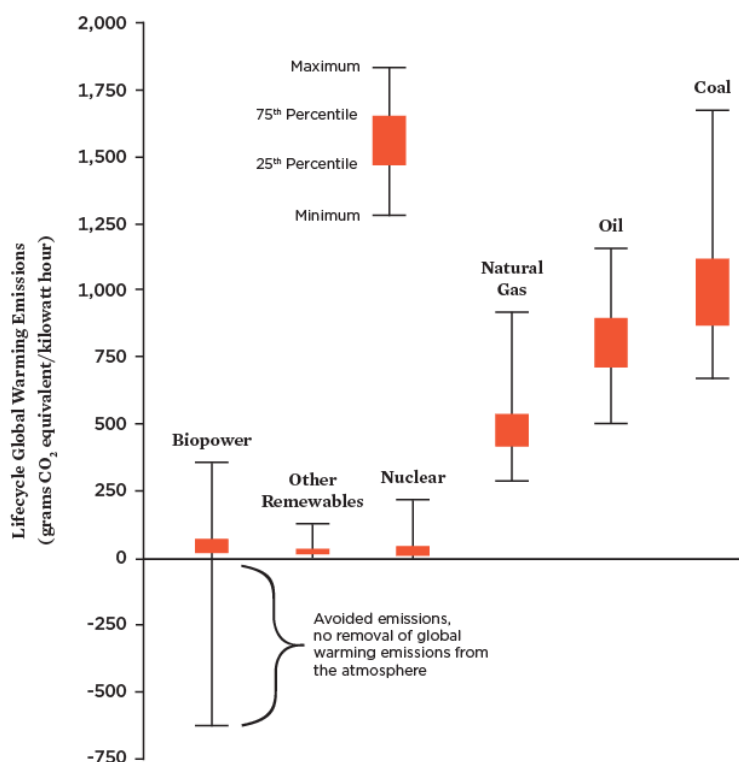


Figure 4. Comparing energy sources in terms of their global warming pollution (source: <https://www.ucsusa.org>, Adapted from information from the Intergovernmental Panel on Climate Change)

2.2 Environmental benefits arising from using pumped water for secondary uses

A water conservation system that exploits the excessive underground water pumped to protect constructions from flooding could reduce efficiently the consumed network water quantities. The environmental benefits of such an application are described below.

Reduce chemical treatment of the water by replacing water source for secondary uses

The water undergoes chemical treatment in order to be used as potable. A five stage combination of biological, chemical, and physical treatment procedure is usually adopted, depending on the source of the water. Those stages include the collection of the water, screening and straining, chemical addition, coagulation and flocculation, sedimentation and

clarification, and finally filtration and disinfection before entering the water distribution system (<http://www.cosatx.us>). Chlorination, which is the most common disinfection process used worldwide, is only part of the last stages of water treatment for disinfection purposes. The most commonly used chemicals for water treatment process are algicide, chlorine, chlorine dioxide, muriatic acid and soda ash or sodium bicarbonate. In addition to the above chemicals, there are numerous other water treatment chemicals used. Coagulants, flocculants, clarifiers and filter cleaners also form an important part of water treatment methods (<https://www.worldofchemicals.com>).

Considering the above, it is quite easy to understand that utilization of treated water should be limited only to cases where high quality water is required (e.g. potable water, cooking, bathing and washing etc). If other everyday needs, such as toilet flushing and irrigation, can be covered by untreated water, it would have a clearly positive environmental impact.

3. Social benefits

The social benefits of adopting an environmental friendly policy with respect to energy sources and water consumption are linked to the project application after considering the multiplying effect of supportive actions and initiatives triggered from the GREEN PUMP project. A brief presentation of social benefits in different aspects is given in the next few paragraphs.

Teach the public of the multiple advantages of renewable energy sources.

Although the public in general is familiar with a general trend towards renewable energy sources, the specific advantages of selecting such environmental friendly options are not clear to most people. Selection of renewable energy sources to satisfy the needs of large public buildings, such as schools, Universities, public services etc, apart from the direct environmental effects provides also an example to the public, especially when accompanied with properly formed informative material. Learning of the numerous advantages of renewable energy sources is the first step towards educating people in favor of broadening their use.

Raising public awareness with respect to the excessive usage of potable water to needs that do not require water treated with chemicals such as irrigation and toilet flushing.

Utilization of water for multiple everyday needs is taken for granted in the developed countries. People in western societies tend to forget, or ignore, that unlimited water supply

is not the case for –perhaps- the majority of the Earth’s population. Therefore, water is wasted in several ways and in several instances every day worldwide.

Moreover, the ease of water supply through installed networks in the residential areas, through a simple action of opening the tap, does not provoke any second thoughts on the required chemical treatment of this water even in cases that could be satisfactorily served using water of lower standards than potable.

A two fold informative initiative is therefore required, that raises the public awareness of the specific chemical treatment of the network water and the negative effects to the environment and demonstrates at the same time all those everyday activities that would be equally well covered with water lacking such treatment, such as toilet flushing and irrigation.

Educate citizens to select environmental friendly approaches to satisfy their everyday needs.

Apart from selecting environmental friendly approaches as the deciding parties i.e. government institutions, public or private sector companies etc, it is crucial to also educate the citizens to act in favor of such policies:

- By informing the public of the environmental friendly establishments that have been adopted. In the case of the IHU-former TEICM studies, this could be achieved by proper signs informing of the heating system type in each building and of the secondary water system and presenting in brief the environmental benefits of such actions.
- By trying to encourage and simultaneously educate the citizens to prefer such policies. In the case of the IHU-former TEICM studies, this could be achieved e.g. by offering the choice to use a toilet with flushing system based on the main water network or on the secondary water system that utilizes excessive pumped water, and by informing the public at the same time of the “environmental footprint” (consequence) of both actions (in qualitative terms or in the large scale).

Improve life standards of unprivileged social groups

Since the world population is expected to double by the end of the 21st century, an important issue to improve the life standards of social groups with high poverty level is to make clean, renewable energy available to them (Fridleifsson, 2001). There is a strong positive correlation between energy use per capita in a country and life expectancy, one that makes the use of renewable energy resources a necessity.

Facilitation of energy access for rural areas

Renewable energy sources, such as geothermal energy, are a viable solution of providing access to energy resources in rural areas and sparsely populated areas, upgrading life standards of local communities.

Diversification of energy sources in small scale

Shallow geothermal energy exploitation does not require large scale establishments and expensive investments but can be a viable alternate energy source even in small scale, for single houses. It is therefore an ideal energy source to satisfy diversification of single people or social groups from centralized energy providing networks and enhance their sense of self-management.

Prevent social discrimination related to side-effects of using fossil fuels

Exploitation of energy sources related to fossil fuels (coal, petroleum, and natural gas) is commonly linked to land degradation and social discrimination of broader areas where access to raw materials or their processing takes place (<https://www.ucsusa.org>). Extraction processes, fuel burning, fuel transportation, waste products management etc, can generate air and water pollution, with obvious health consequences for local communities. Moreover, even modern mining methods tend to be accident prone resulting in increased accident rate for people working in the energy industry section. Those consequences are usually far removed from our daily lives and only affect a minority or marginalized subset of the population. In many countries, Greece included, specific communities or broader areas are widely known for the direct impact of the fossil fuel industry on the health and safety of their members. Reduction of fossil fuels usage in favor of renewable energy sources can mitigate the above social discrimination.

4. Possible disadvantages of geothermal energy use

In order to obtain the whole picture of geothermal energy adoption for heating purposes, it is crucial to also examine the disadvantages of this solution. The disadvantages of using shallow geothermal energy are limited since geothermal energy is theoretically unlimited over time and produces no significant air or water pollution if treated properly. To this end, involved agencies usually publish specific monitoring guidelines for geothermal development (e.g. EPA/600/7-79/218 – Weiss et al. 2005). The main disadvantages concern the following issues (Ellabban et al., 2014):

- Large development costs of initial construction to exploit shallow geothermal energy. This cost of course can be easily addressed considering the quick depreciation of the initial investment.
- Maintenance costs due to corrosion of the installed system.
- Possible ground subsidence.
- Pollution of waterways that should be checked and prevented.

5. Environmental and social benefits linked to the specific participation of TEICM in the GREEN PUMP project

The aforementioned important beneficial effect of the water conservation system and the use of shallow geothermal energy to cover heating requirements have been presented based on a broad application of the project studies. On the other hand, even in small scale, specific positive effect is expected from the TEICM involvement in the project itself, as well as from a future application of the examined studies.

Since the absolute figures of such benefit would be rather small, probably one of the most important effects would be the proper “advertisement” of environmental beneficial establishments and facilities, such as the ones presented earlier in the current report and briefly summarized below:

- Informing the public of the environmental friendly establishments that have been adopted. In the case of the IHU-former TEICM studies, this could be achieved by proper signs informing of the heating system type in each building and of the secondary water system and presenting in brief the environmental benefits of such actions.
- Trying to encourage and simultaneously educate the citizens to prefer such policies. In the case of the IHU-former TEICM studies, this could be achieved e.g. by offering the choice to use a toilet with flushing system based on the main water network or on the secondary water system that utilizes excessive pumped water, and by informing the public at the same time of the “environmental footprint” (consequence) of both actions (in qualitative terms or in the large scale).

Education of the public on environmental friendly approaches has a multiplying effect since it can encourage such behaviors in the everyday life and practice of the informed citizens. The actual positive effect is even larger, considering that in the case of Universities or other educational institutions, such information targets young citizens in an age range that they are forming their behavioral pattern in many aspects for the years to come.

6. Acknowledgements

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