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How to boost shallow geothermal energy exploitation in the adriatic area: the LEGEND project experience

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HIGHLIGHTS

- The Interregional Adriatic strategy for shallow geothermal energy is presented.
- The strategy speeds up renewable energy introduction in border countries.
- Geological, climate, market and political similarities must be taken into account.
- The preparatory action is the creation of trained market and supply chain.

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ABSTRACT

The evaluation, monitoring and reduction of the heating and cooling consumptions are topics of increasing importance. One promising technology is the geothermal heat pump. Despite its undoubted advantages compared to fossil fuels in terms of RES production, CO_2 reduction and primary energy savings, there are still significant barriers for the creation of sustainable local markets. Many regions present similar conditions in terms of climate, geology, hydrogeology, infrastructure and political

Abbreviations: GSHP, Ground Source Heat Pumps; GCHP, Ground Coupled Heat Pumps; BHE, Borehole Heat Exchanger; HGC, Horizontal Ground Collector; RES, Renewable Energy Source; ICT, Information and Communication Technology; LCA, Life Cycle Assessment; SWOT, Strengths, Weaknesses, Opportunities and Threats; HVAC, Heating, Ventilation and Air Conditioning; GHG, Green-House Gas; IEA, International Energy Agency; ERDF, European Regional Development Fund; EUSAIR, European Union Strategy for the Adriatic and Ionian Region; NREAP, National Renewable Energy Action Plan

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conditions. Because of the context-driven nature of shallow geothermal systems, similarities should be taken into account and strategies shared across borders to foster the introduction and exploitation of shallow geothermal energy.

Focusing on the results of the LEGEND Project, this paper presents an attempt at creating an interregional strategy for the widespread introduction of geothermal heat pumps in the Adriatic area, which includes EU and non-EU countries.

The multi-level approach adopted (a combination of desk studies on the transferability potential, pilot plants across the regions and programs to involve, educate and train stakeholders) allowed to set up the strategy. Therefore, different actions are proposed to stimulate the development of the market, whose interconnection across the Adriatic can accelerate the achievement of the main energy and climate targets for all the countries involved.

1. Introduction

Currently, almost 50% of the total energy consumed in the world is used to produce thermal energy for either domestic, commercial or industrial purposes (IEA, 2014). Because of the predominant use of fossil fuels in the energy transformation process (around 75%, mostly natural gas), heat generation is currently responsible for at least 25% of the global energy-related carbon dioxide emissions. Cooling is, with few exceptions, achieved by processes driven by electricity, which is also still predominantly produced from fossil fuels, even if for most countries, especially within the European Union, this trend is constantly changing (IEA, 2014). It follows that in Europe, as in practically all other parts of the world, both heating and cooling are sectors in which a massive use of renewable energy sources can make an important contribution towards a sustainable, safer, more reliable and stable energy economy (RHC ET-Platform, 2014). At the beginning of the new millennium, the European Commission reported that about 40% of final energy demand and about 30% of greenhouse gas emissions were attributed directly to buildings, of which about two-thirds were residential and one-third commercial buildings (EC, 2000). In 2014, this percentage had changed, in fact heating and cooling in European buildings and industries account for nearly half the EU's entire energy consumption, putting it ahead of transport and electricity which account for 30% and 24%, respectively (EU, 2015a). Moreover, around 85% of heating and cooling is still produced from natural gas, coal and oil products, and only 15% is generated from renewable energy (EU, 2015b).

Yet, renewable thermal energy (geothermal, solar thermal and biomass), used for heating and cooling purposes, can offer effective solutions to the challenges of ensuring energy security and supply, and can help limit the climate change.

The European Union, under the Renewable Energy Directive umbrella, issued in 2009, for the first time deployed mandatory targets for renewable energy for all energy consumptions, including heating and cooling (EU, 2009). In fact, renewable energy use for heating and cooling is an important component of the National Renewable Energy Action Plans (NREAPs) established by each Member states.

Monitoring actual renewable thermal energy production and consumption currently suffers from a number of deficiencies, such as data quality and availability, as well as methodological issues. Renewable thermal energy use is more difficult to monitor and control than renewable electrical energy production. As a result, thermal energy metering is much less widespread than electric energy metering. This makes the development of renewable thermal energy policies, as well as the assessment of their effectiveness, much more difficult (IEA, 2014).

From the customer's standpoint, large urban electricity meter replacement programs for residential buildings have led to a fall in peak demand and overall energy consumption: peak demand reduction (peak lopping) was as much as 20% while peak demand shifting (load shifting) rose by up to 10%, with consequent total energy use reduction up to 10% (Anda and Temmen, 2014). Similar approaches and technologies should also be introduced for heat metering systems to raise customer awareness of the correct use (or interoperation, in the case of a hybrid mode) of fossil fuels and renewables. Such actions could lead to important changes in the perception of building heating systems, a fundamental factor if renewable heating and cooling technologies are to become widespread.

Among all the possible solutions, one of the most promising is the shallow geothermal heat pump system (Ground Source Heat Pumps or GSHP systems). Two major GSHP types exist (Lund, 2000): the ground-coupled (closed loop) heat pump (GCHP) and the water source (open loop). GCHP types are just a subset of GSHPs. GSHPs also include groundwater and lake water heat pumps (water source) (Abesser, 2007; Banks, 2009), while GCHPs are connected to a closed-loop network of underground pipes. The most common method of ground-coupling is to bury thermally-fused plastic pipe whether vertically or horizontally, enabling indirect heat transfer between ground and thermovector fluids, for heating and cooling purposes (Esen et al., 2007; Yang et al., 2010). This technology is suitable for small, individual houses as well as for larger multi-family houses or even for groups of houses and districts.

Shallow geothermal energy systems coupled with heat pumps provide winter heating by extracting heat from a source and transferring it into a building. Heat can be extracted from any source, no matter how cold, but a warmer source allows higher efficiency. Geothermal heat pumps use the ground layers and aquifers contained in the first hundred meters of the earth's crust as a source of heat, thus taking advantage of its temperature, growing with depth. Most common closed loop applications have a depth varying from 80 to 400 m (Rivera et al., 2015), while the open loop applications generally use the topmost aquifers, where seasonal variations may play a role in case of river infiltration and especially anthropogenic variations can be pronounced (García-Gil et al., 2014; Menberg et al., 2013). Regarding very shallow and surface applications, up to 20 m depth, seasonal variations directly influence in thermal sense the underground behavior, and consequently the heat exchange (Tinti et al., 2014a).

In summer, the process can be reversed so that the heat pump extracts heat from the building and transfers it to the ground. Transferring heat to a cooler space consumes less energy than air-to-air systems, since the heat pump has greater cooling efficiency on account of the lower ground temperature. In central and northern European Regions, where building cooling load is not preponderant, the passive cooling technique is commonly used. Conversely, passive cooling is difficult to implement in southern European Regions on account of the widespread use of fan coils for cooling and humidity control that require relatively low temperatures from the distribution system (around 7 °C). As shallow aquifer temperatures in the Adriatic areas generally range between 15 and 20 °C, any geothermal heat pump project must also envisage an active cooling system.