Fostering diffusion of Heating & Cooling technologies using the seawater pump in the Adriatic-Ionian Region

Common strategy to enhance the use of seawater heat pumps for heating and cooling in ADRION region

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Acronyms

ADRION	-	Adriatic-Ionian region (8 countries: Croatia, Greece, Italy, Slovenia, Albania, Montenegro, Serbia, Bosnia and Herzegovina);
BRG	-	BRG Building Solutions;
COP	-	Coefficient of performance;
DNO	-	Distribution Network Operator;
EED	-	Energy Efficiency Directive;
EHPA	-	European Heat Pump Association;
EPBD	-	Energy Performance of Buildings Directive;
GDP	-	Gross domestic product;
GPP	-	Green public procurement;
H&C	-	Heating and cooling;
HP	-	Heat pump;
HVAC	-	Heating, ventilation, and air conditioning;
LTRS	-	Long-term building renovation strategy;
NECP	-	National energy and climate plan;
NREAP	-	National renewable energy action plan;
PV	-	Photovoltaic;
PPI	-	Public procurement of innovation;
RED	-	Renewable Energy Directive;
RES	-	Renewable energy sources;
ROP	-	Regional Operational Programme:
S3	-	Smart specialisation strategy;
SWHP	-	Seawater heat pump;
SWOT	-	Strengths, weaknesses, opportunities, and threats.

1. Introduction

***A common strategy to enhance the use of SWHPs* is one of the main SEADRION project outputs** as well as the project output **based on the activities carried out in the work package T3** - *SEADRION pre-feasibility box*. The common strategy aims to enhance the usage of seawater heat pump technologies for renewable heating and cooling in the ADRION region based on partner cooperation, R&I and policy findings and experience and results acquired through the implementation of the SEADRION pilot plants.

The general aim of the WP T3 is the elaboration of feasibility studies for developing :

- Technical considerations on seawater heat pump use in public, commercial and other facilities;
- Best practices and guidelines to support successful diffusion of the seawater heat pump systems in the ADRION region, in a larger extent, to all European countries.

WP T3 consists of four main activities through which this strategy is concluded:

- Activitiy T3.1 Methodology and building selection;
- Activitiy T3.2 Pre-feasibility studies;
- Activitiy T3.3 Research to innovation recommendation;
- Activitiy T3.4 Policy recommendation.

The activities completed in WP T3 contribute the most to the main results of the project, which are:

- Deeper knowledge about the initial conditions of seawater heat pumps innovation technology and defining development through verification of its efficiency;
- Better understanding of existing RES policies and strategies on a transnational level; Identification of barriers and differences present on territory and outlook on emerging market opportunities (improvement of the framework conditions);
- Joint implementation of pilot plants along the area in question and fostering diffusion;
- Deeper knowledge about technical and regulatory issues regarding the seawater heat pump;
- Mobilization of stakeholders and other involved actors/target groups and enhancement of their competencies and skills.

In this project output, *Common strategy to enhance the use of seawater heat pump based heating and cooling in ADRION region*, all research and analysis of the work package are summarized and structured as follows*:*

- Vision and mission of the strategy;
- Overview of the current state and trends on the SWHP technology, as well as heat pump technology in general;
- SWHP technology potential and opportunities;
- SWOT analysis regarding the installation and operation of SWHPs;

- S3 and long-term goals for development and diffusion of SWHPs;
- Shor-term action plan.

2. Vision

The recent Heating and Cooling Strategy from Commission indicated that emissions related to energy used for heating and cooling buildings can be significantly reduced with technologies that use renewable energy sources and have high efficiency.

Taking this into consideration the SEADRION project aims **to support the development of a regional innovation system for the Adriatic-Ionian (ADRION) region** with the installation of **3 renewable energy facilities in public buildings located in Greece (Alexandroupolis) and the western and south part of the Adriatic Croatia (Crikvenica and Dubrovnik.** These facilities are seawater heat pumps, an innovative system that uses the thermal energy contained in a reservoir (sea) to achieve the cooling and heating energy demand of the buildings which are close to the sea.

The **main objective of the SEADRION is to identify benefits and barriers** associated with the use of this technology and find a system solution designed to improve the use of the seawater heat pump technology and make the buildings energy self-sufficient and independent of fossil fuels.

The **main goal of this strategy is to raise awareness and guide the countries of the ADRION region to increase the implementation of SWHPs in heating and cooling systems** based on the conclusions from research and analysis conducted during the SEADRION project.

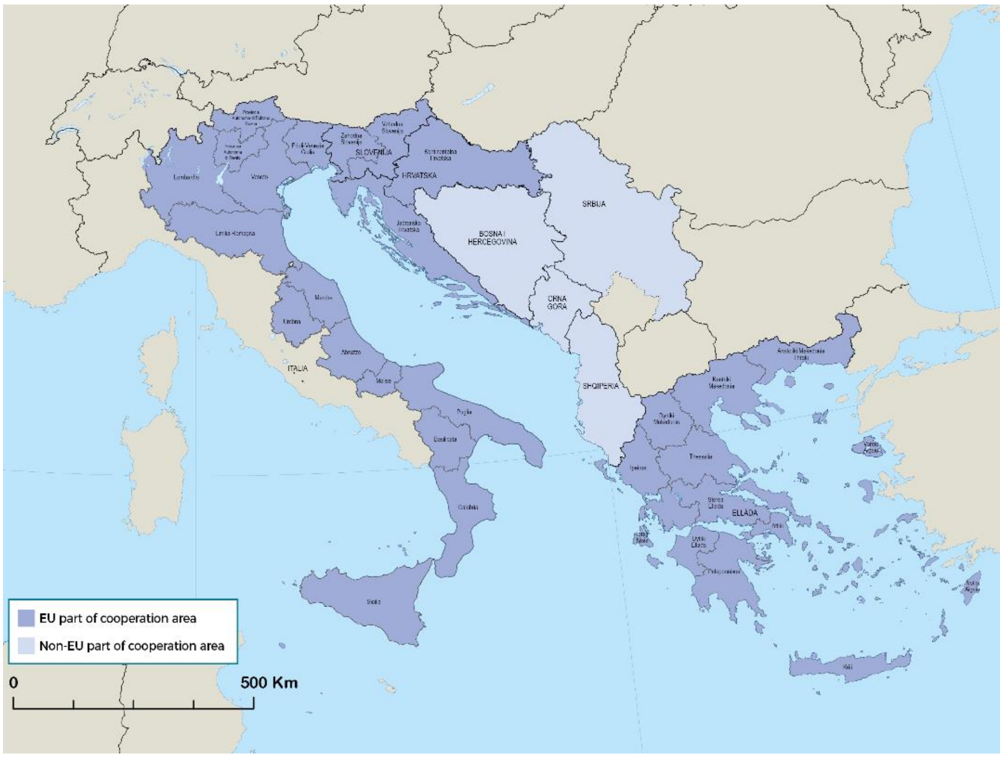


Figure 1: Partner states of the ADRION region

3. Mission

The Axis 1 of the ADRION program's result indicator is “Level of capacity of key innovation actors to be effectively involved in transnational actions for the development of a regional innovation system”.

Based on that, project activities of SEADRION are able to obtain manifold results because the working group consists of technical and scientific institutions, public bodies and their agencies, and they collaborate all together and study the development of a strategic and high potential technology for the Adriatic-Ionian area.

The setting up of pilot plants, monitoring their performances, and the feasibility studies for the most important users will make it possible to structure and realize a dissemination policy of seawater energy.

The **strategy provides an insight into the current state and trends of heat pump technology, specifically SWHP technology**, both in Europe and in the project partner countries of the ADRION region.

The **strengths, weaknesses, opportunities and threats that SWHP technology provides are highlighted,** as well as some specific opportunities, drawing attention to the problems that investors, contractors and designers face.

Some **smart specialization goals** are listed to encourage smart growth in the countries of the ADRION region, along with **long-term goals** related to common problems, and to encourage the development and diffusion of SWHPs.

Finally, a **short-term action plan is given** with a suggestion of where and how to start.

4. Overview of the current situation regarding renewable heating and cooling

Each EU Member State has its own Europe 2020 target regarding share from renewable sources. The national targets take into account the Member States' different starting points, renewable energy potential and economic performance. Among the SEADRION project partners, Croatia, Italy and Greece have already reached and overpassed the level required to meet their national 2020 targets. Moreover, Albania and Slovenia are on the right path of approaching their 2020 target.

Table 1: Share of energy from renewable sources (in % of gross final energy consumption) [1]

	2004	2015	2016	2017	2018	2019	2020 target
EU 27	9.6	17.8	18,0	18.4	18.9	19.7	20
Greece	6.9	15.7	15.4	17.3	18.0	19.7	18
Croatia	23.5	29.0	28.3	27.3	28.0	28.5	20
Italy	6.3	17.5	17.4	18.3	17.8	18.2	17
Slovenia	16.1	21.9	21.3	21.1	21.4	22.0	25
Albania	29.6	34.9	36.9	35.9	36.8	36.7	38

Heating and cooling in buildings and industry accounts for half of the EU's energy consumption.

In EU households, heating and hot water alone account for 79% of total final energy use (192.5 Mtoe). Cooling is a fairly small share of total final energy use, but demand from households and businesses such as the food industry is rising during the summer months. This trend is also linked to climate change and temperature increases.

According to 2019 figures from Eurostat, 79% of heating and cooling is still generated from fossil fuels, while only 20% is generated from renewable energy.

In 2019, renewable energy accounted for 20.6% of the total energy used for heating and cooling in the European Union (EU). This share had increased steadily since the beginning of the data collection in 2004, when the share was 12%. Increases in industry, services and households have all contributed to the growth in renewable energy used for heating and cooling. Among SEADRION partners, Croatia has the largest share of RES in the heating and cooling sector (36.8%), mainly due to biomass heating. Slovenia and Greece follow with a larger share, while Albania has the smallest share (*Figure 2*).

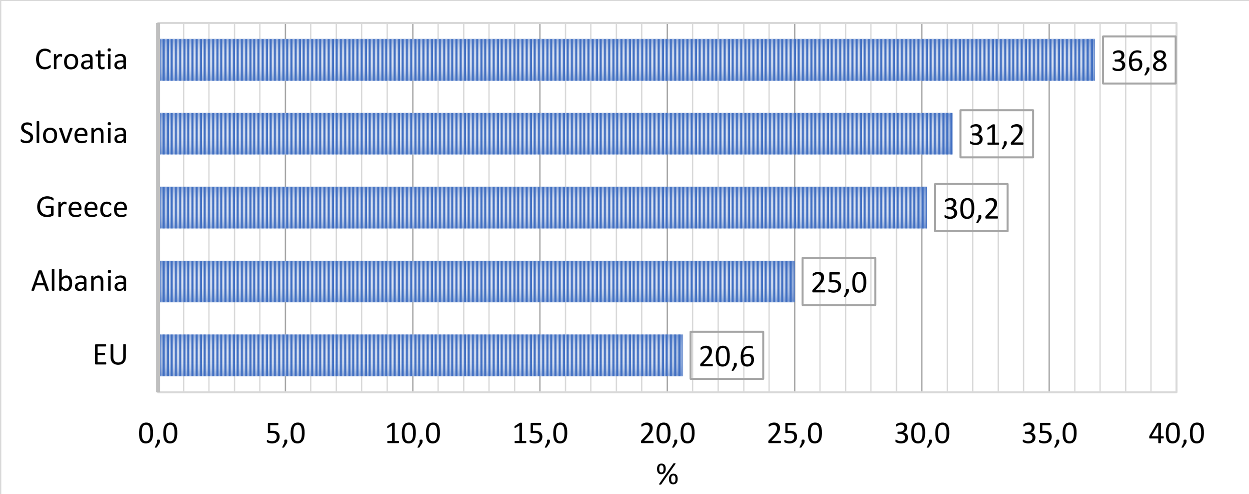


Figure 2: Share of renewable energy in gross final energy consumption in heating and cooling sector for 2019 [3]

4.1 Overview of the existing situation and regulations regarding the building stock and renewable heating and cooling integration, with a focus on heat pumps

According to Eurostat data for 2019, 12.2% of heating and cooling needs are generated by heat pumps. European heat pump sales grew by 17.7% in 2019 – the fourth double-digit growth in a row. With 1.49 million units sold across Europe yet a new sales record has been achieved. Assuming a life expectancy of approx. 20 years, the current European heat pump stock amounts to 13.27 million units (*Table 2*). With approximately 244 million residential buildings in Europe, the heat pump market share in the building stock is about 5%. The increase in the number of annually installed heat pump units until 2017 was linear, while from 2017 to 2019, it is exponential, and it is predicted that it will be the same in the near future (Figure 3).

Geothermal and hydrothermal heat pumps see roughly stable sales (brine-water: 90 122, direct expansion/water: 1 424, water-water: 6 767). While numbers are small, the average capacity of these heat pumps increases, as they are more and more often employed in commercial buildings and industrial processes. *Figure 4* illustrates this trend and shows the difference between air-source systems using air (light blue) and water (darker blue) as heat distribution systems. In the future, sales numbers for ground-coupled heat pumps are expected to remain stable. However, due to an overall increase in the market – driven by aerothermal solutions - their share will decline even further. Yet, the overall contribution to renewable energy from ground-coupled heat pumps increases as more and more larger units are integrated into commercial buildings.

In 2019, heat pumps with a thermal capacity of 12.7 GW were installed, producing approx. 25.1 TWh of useful energy and integrating 15.6 TWh of renewables in heating and cooling while avoiding 4.0 Mt of CO2-equivalent emissions. In order to produce the 2019 sales volume and to maintain the installed stock, a total of 78,969 person-years of employment were necessary. Obviously, real employment related to the heat pump market is larger, as not all employees work full-time on heat pumps only.

Table 2: Number of heat pump units installed over the years in Europe [2]

Year	Newly installed units
2005	1 141 016
2006	1 655 022
2007	2 239 159
2008	3 047 855
2009	3 750 012
2010	4 542 759
2011	5 341 879
2012	6 083 925
2013	6 846 289
2014	7 603 851
2015	8 510 424
2016	9 482 515
2017	10 573 058
2018	11 813 508
2019	13 271 488

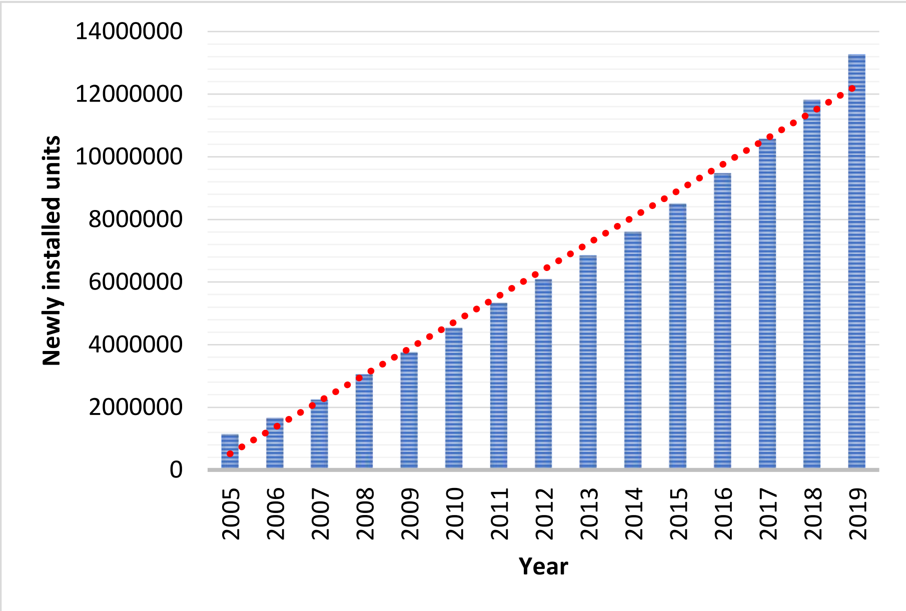


Figure 3: Graphical representation of a number of heat pump units installed over the years in Europe

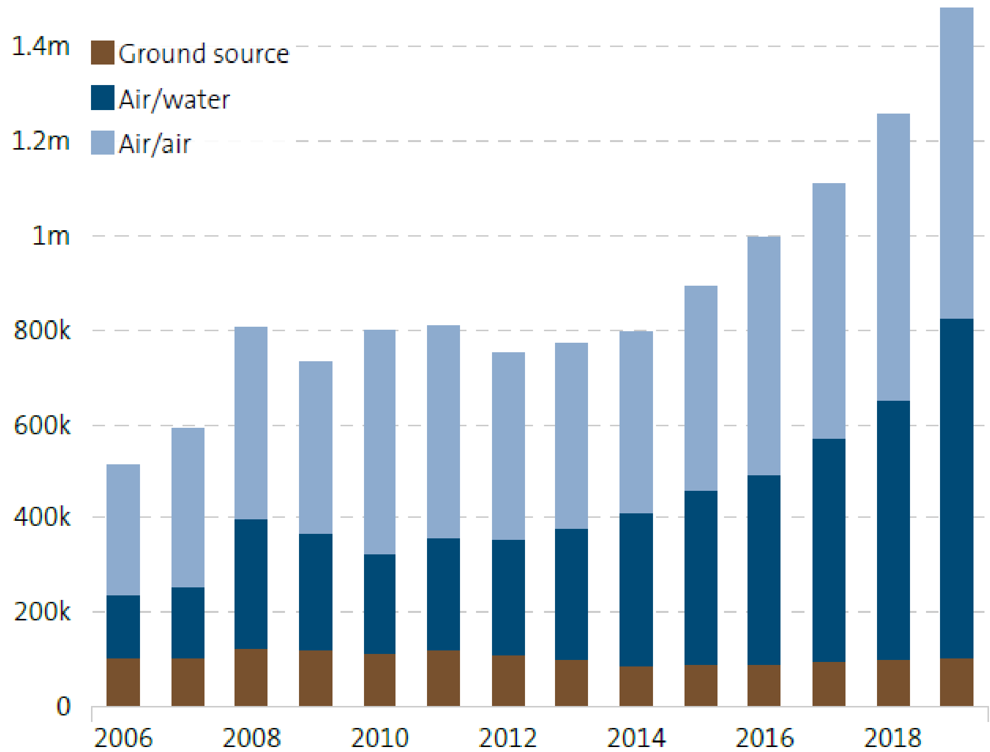


Figure 4: Development of heat pump sales by category, 2006-2019 (EU-21) [2]

For policymakers, this is good news as it shows a huge untapped potential to reduce Europe's energy demand for heating, cooling and hot water production. However, achieving it by 2030 would require an annual 21% growth rate and a tremendous effort with regards to framework conditions, efficiency requirements for buildings, upskilling of installer and planner/architect qualification, as well as the development of flanking measures.

A refurbished and improved building stock in the EU will help pave the way for a decarbonised and clean energy system, as the building sector is one of the largest energy consumers in Europe and is responsible for more than one-third of the EU's emissions. But only 1% of buildings undergo energy-efficient renovation every year, so effective action is crucial to making Europe climate-neutral by 2050. Currently, roughly 75% of the building stock is energy inefficient, yet almost 85-95% of today’s buildings will still be in use in 2050. Given the labour-intensive nature of the building sector, which is largely dominated by local businesses, renovations of buildings also play a crucial role in the European recovery of the COVID-19 pandemic. To kick-start the recovery, the Commission has identified doubling the renovation rate in its dedicated recovery plan. To pursue this ambition of energy gains and economic growth, the Commission published on 14 October 2020 a new strategy to boost renovation called ***"A Renovation Wave for Europe – Greening our buildings, creating jobs, improving lives"***. It aims to double annual energy renovation rates in the next ten years. These renovations will enhance the quality of life for people living in and using the buildings, reduce Europe’s greenhouse gas emissions, and create up to 160,000 additional green jobs in the construction sector. In parallel to the strategy, the Commission adopted new rules for the smart readiness of buildings. Specifically, the smart readiness indicator aims to promote digitally friendly renovations, integrate renewable energy and enable measurements of actual energy consumption. The Commission launched, at the same time as the *Renovation wave strategy*, the initiative on the *New European Bauhaus*. The initiative is both a network and a contact point at the crossroads between culture, social inclusion, science and technology. The New European Bauhaus unfolds in 3 phases: Co-design, Delivery and Dissemination. The design phase was launched on 18 January 2021 and will lead to the opening of calls for proposals later in 2021 to bring New European Bauhaus ideas to life in at least 5 places in EU countries through the use of EU funds at the national and regional level.

The renovation wave initiative will build on measures agreed under the *Clean Energy for all* Europeans package, notably the requirement for each EU country to publish a long-term building renovation strategy (LTRS), other aspects of the amending Directive on the Energy Performance of Buildings ((EU) 2018/844), and building-related aspects of each EU country's national energy and climate plans (NECP). It is **an opportunity for the deployment of SWHPs, but also for the decarbonisation of the sector due to reduced energy consumption**.

None of the SEADRION partners keeps records of the number of heat pump units installed over the years in their country, and therefore data for them is not provided.

If the focus is on seawater heat pumps in SEADRION partner countries, SWHPs are a technology that is still not widely used except in the hotel sector or public buildings on the coast or some islands, and this applies to all partner countries.

Croatia and **Albania** have a broad approach to the development of RES in the heating and cooling sector but without special reference to heat pumps. SWHPs are not mentioned at all. Different financial schemes provide incentives for the RES technology implementation but not specifically for SWHPs.

In **Greece**, there are many opportunities regarding the heat pump sector by the government; however, no separation or differentiation is made regarding the selection of the most appropriate technology, which means that SWHPs are not represented.

Slovenia also includes heat pumps as planned installations of renewable energy technology in the heating and cooling sectors and does not explicitly mention SWHPs. Investments into SWHPs are already incentivised by different existing financial schemes but are not specific to SWHP implementation.

SLOVENIA

The basis for the use of renewable energy sources in Slovenia is defined by different national legislation; the most important between them is the Energy Act.

The objectives of Slovenia's energy policy for renewable energy sources are defined in the National renewable energy action plan (NREAP). The aim is to ensure a 25% share of renewable energy sources in final energy consumption by 2020.

Different existing financial schemes already incentivize the investments into seawater heat pumps, additional funding schemes for investors, or upgrade existing ones, increasing the interest in SWHP technologies.

Slovenia has a short coastline and different natural barriers that limit the use and installation of sweater heat pumps. Some pilot examples have already been installed where appropriate in past years, and there is still the possibility to install some lower number of additional systems. It is crucial to take into account social acceptance and environmental restrictions. To this end, the water and construction permits are requested to be obtained. Anyway, the procedures of permitting should be simplified without reducing environmental protection and other important factors.

GREECE

SWHPs is a technology that is not widely applied in Greece, apart from the hotel sector on some islands utilizing the seawater, an abundant and nearby source.

In general, heat pumps using seawater as a heat source or sink are treated similarly as heat pumps taking advantage of shallow geothermal energy (lower than 30°C) in open-loop systems. Thus, they are not subject to cumbersome licensing, permitting and planning procedures.

The National Energy and Climate Plan (NECP), which has been released in November 2019, indicates many opportunities regarding the heat pump sector (all types), doubling almost the capacity for thermal needs until 2030.

However, no separation or differentiation is done regarding the selection of the most suitable technology. Also, a reference to energy and economic performance evaluations in different country climate zones should be included when shaping relevant strategies.

Consultation with all involved stakeholders should be carried out at different stages of the process of drawing up the policy roadmap for the enhancement of this H&C technology. The recent modification of the RES market seems to be a positive step towards a mature and competitive environment for all the participants.

Barriers exist when it comes to the propagation of this technology. Especially the lack of awareness from the policymakers, but also from the civil society when searching for a good balance between environmental performance, cost considerations, market availability and ease of installation.

A good opportunity to foster the above mention technology is the national action plans for Green Public Procurement. Almost all project partners' states have a national action plan for GPP (Greece just introduced one). Although the NAPs are not legally binding, they provide political impetus to the process of implementing and raising awareness of greener public procurement. They allow the Member States to choose the options that best suit their political framework and the level they have reached.

However, the absence of any enforcement to apply the GPP criteria by the national or regional procuring authorities is enhancing the knowledge gap and low social acceptance level.

CROATIA

Croatia has several documents that represent national legislation on RES with a more generic reference to heat pump technology. Seawater heat pumps are not included in any national legislation documents. The share of renewable energy in heating and cooling (RES-H&C) in gross final energy consumption in the Republic of Croatia is accounted for 36,8 %. In absolute terms, **RES-H&C** remains the dominant RES market sector in Croatia due to the still large number of households heating with biomass. Heat pumps, multi-split systems and solar systems make up a smaller share.

In order to meet the following goals, the Republic of Croatia has adopted an *Integrated National Energy and Climate Plan for the Republic of Croatia for the period 2021-2030*, in which some of the most important set goals are 36.4% share of RES in gross final energy consumption and reduction of greenhouse gas emissions for the ETS sector, compared to 2005, by at least 43%. Several key strategies describe the activities of the Republic of Croatia in the following periods in order to achieve the set decarbonisation and energy efficiency goals as *The Energy Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050*, *The Long-Term Strategy to Encourage Investment in the Renovation of the National Building Stock of the Republic of Croatia by 2050* and others. Measures related to the heating and cooling sector are based on high-efficiency cogeneration and efficient district heating and cooling taken from the document *Programme for the use of efficiency potential in heating and cooling for the period 2016-2030*. Heat pumps are barely mentioned in several parts (measures) of the Republic of Croatia's energy strategy.

Croatia has many barriers that hinder the increase in the implementation of heat pumps, including seawater heat pumps, and the most significant of them are the lack of knowledge and experience in designing as installing and running such systems, lack of legislation governing the installation of seawater intake, bureaucracy, lack of public awareness and incentive subsidies.

ALBANIA

Albania has a broad approach to the development of renewable energy sources (RES) without special reference to heat pumps. In any case, Albania is working to develop a strategy to promote all types of RES.

Regarding the heating and cooling sector, in Albania, through the use of seawater, it's necessary to take into consideration: the increase in oil prices compared to the price of electricity, awareness of public and installers of heating/cooling systems and introduction of the licensing process for the installation of the systems.

Barriers on the national level are:

- Lack of knowledge to the know-how but also experience in installing such kind of systems SWHP.
- The effects on environmental barriers can be recognized on the ecosystems, landscape, and land-use change.
- Excessive bureaucratic obstacles, non-transparent administrative procedures, with lengthy, complex and cumbersome authorization procedures for new RES projects. Acquiring all the necessary documents can take an exceptionally long time, and responsible authorities are not usually required to promptly respond to applications.
- The price difference between the electricity produced with renewable energy sources and that obtained with traditional fossil sources is still the biggest obstacle for further diffusion of the technology in question.
- SWHP development may require several planning permissions. The process can be complex and time-consuming.

4.3 Overview of current trends regarding heat pump technology

Three trends mainly influence heat pump market growth:

1) From a technology perspective, today's heat pumps can cover a wider temperature range. They still operate at -25°C, and increasingly often, they provide hot water at 65°C in an efficient manner. That enables their deployment in a much larger share of buildings than a decade ago. Hybrid systems enable heat pumps even in the renovation segment.
2) The need to accelerate the energy transition in the heating and cooling sector moves heat pumps to the centre of policymakers' attention. Legislation passed in the past 8 years is now transposed in all member states, and it starts to show impact. Building standards limit maximum heat demand per m2, mandate the integration of renewable energy and favour smart buildings. This is often substantiated by institutional and financial subsidies that make market development easier.

3) Continuously larger and growing sales numbers result in lower cost. Economies of scale are materialising on the component and the product level. The fast decline of PV systems' production cost also influences the heating market: using self-produced electricity in combination with a heat pump system provides a very low-cost energy source for buildings. Additional benefits like demand response services provided to the grid (which could become a business model and provide an income for their providers) are on the horizon but have not yet materialised.

The current growth rate of heat pump markets across Europe is insufficient to decarbonise heating and cooling by 2050. It needs brave governmental decision-makers to address the distorted price mechanism that favours the use of fossil fuels and fossil fuel technology. Instead of making the polluter pay for emissions by adding related cost to the price for fossil energy, most governments still support their use – directly or indirectly – and leave the cost of environmental damage of fossil fuel for society to pay. The latest figures show that 6.5% of the global GDP are spent on fossil energy subsidies.

By combining boiler sales data provided by BRG Building Solution with heat pump statistics provided by EHPA (*European Heat Pump Association*), a picture of the market shares and their development over the last years was drawn (*Figure 5*).

After some tough post-crisis years, the heat pumping technology gained market shares from traditional fossil fuel boilers for three years in a row, and it's doing so with increasing speed. Joint data from BRG and EHPA indicates a market share of 15.3% for space heating heat pumps in 2018 - 0.8 percentage points more compared to 2017 (*Figure 5*).

These numbers once more confirm the enormous potential: There are still 85% of the heating market ready to be taken, this makes 5-6 million sold units each year. *Figure 6* shows the sales forecast of the heat pumps for the near future.

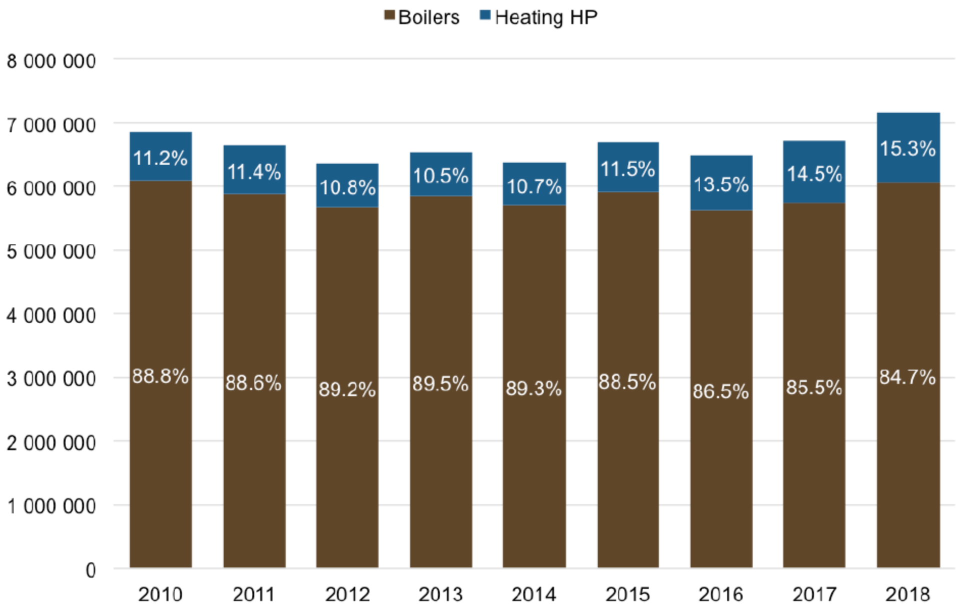


Figure 5: Market shares of BRG Boiler sales vs. EHPA heat pump sales, by year [2]

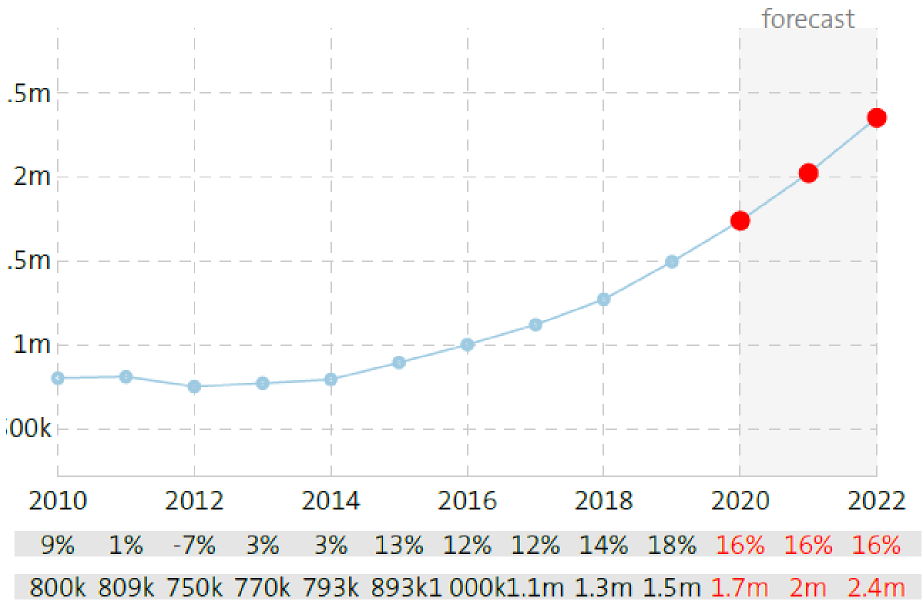


Figure 6: EHPA Sales Forecast based on EHPA assumptions [2]

Heating and cooling industries need to decarbonise over the next 30 years. This is a tremendous challenge that needs to be started as soon as possible. The benefits of heat pumps make this technology a prime candidate for a central role in a sustainable European energy system. Clearly, today's business as usual will not be enough to unearth the technology's potential; instead, significant government intervention is necessary to shape the sustainable energy supply in all Member States of the European Union.

5. Seawater heat pump systems

Seawater heat pump systems are systems in which the heat pump uses the seawater as a heat source or sink, i.e. a heat storage tank. In the heating mode, the system uses the seawater's heating energy as a renewable heat source (*Figure 7*, right), while in the cooling mode, it transfers the heat taken from the space to the seawater as a heat sink (*Figure 7*, left).

SWHP heating mode *SWHP cooling mode*

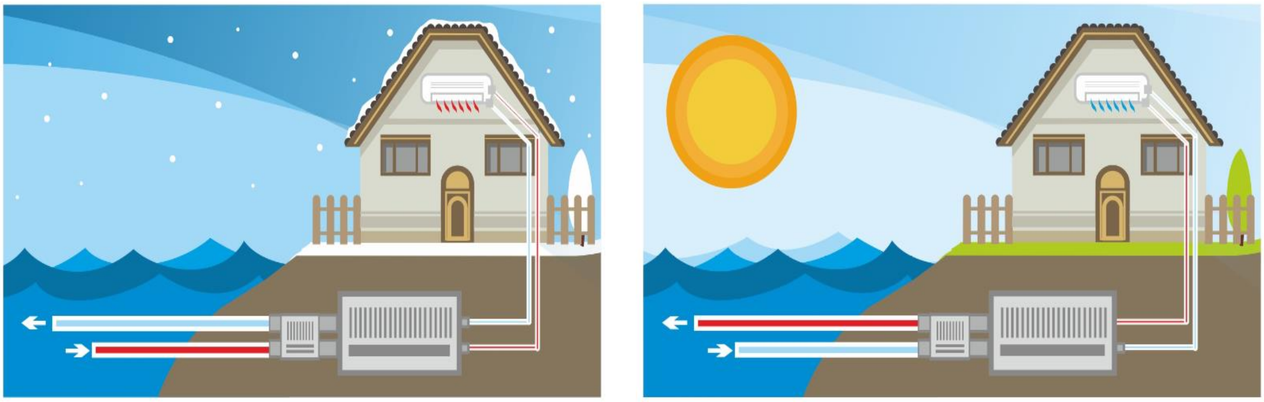


Figure 7: Display of SWHP system operation in heating mode (left) and cooling mode (right)

The current technology of seawater heat pumps (SWHP) is mature and advanced enough for wider application and to be more intensively included in the National Energy and Climate Plans (NECPs), as well as other action plans, of the SEADRION partner countries. The efficiency and adjustment of such systems' operation at various loads are much more advanced than a couple of years ago, resulting in the production of a larger amount of heating / cooling energy for equal generation input. It is also a growing practice in coastal areas to perform a combination of seawater heat pump systems and offshore/onshore wind farms, which then generate electricity to power these heat pumps. As renewable energy sources are increasingly encouraged, including the generation of electricity from RES, it is clear that in the near future, seawater heat pumps, and heat pumps in general, will be powered only by electricity from RES. In general, heat pumps can decarbonize buildings to 100% if operated with green electricity and at least 66 – 80% if no attention is paid to the source of electricity. This decarbonisation goes hand in hand with a reduction of final energy demand. Consequently, the fast deployment of heat pumps should lead to a demand reduction in fossil energy by a similar amount.

The implementation of seawater heat pumps, as well as heat pumps in general, contributes to energy efficiency, quality of life, employment, etc., at the site of its application. Some of its benefits and opportunities are listed below:

- increase in high - skilled jobs and economic opportunities;
- connectivity with offshore and onshore wind farms for the purpose of closed-circuit energy production;
- energy independence;
- increasing the share of RES in the energy network;

    - there are no harmful emissions at the point of energy consumption;
    - reduction of local pollution;
    - positive effects on fisheries and aquaculture;
    - better seawater quality;
- possibility of exploiting wastewater that is being discharged into the sea;
    - decrease in the water temperature being discharged;
    - reduced development of microorganisms that reduce seawater quality.

In the SEADRION partner countries, heat pump technology is still not sufficiently known, and a very small number of users decide to implement such systems, especially large systems. Air-to-air and air-to-water heat pump systems are most commonly used in both residential and non-residential buildings, while water-to-water heat pump systems, including seawater heat pumps, are used at higher building loads but not to the same extent as systems with air as a heat source. **The reason for this is the more demanding design of the system (drilling of pumping and sinking wells), which entails a larger required investment.** Also, seawater heat pump systems, as well all heat pump systems, require knowledge and experience in designing as well as installing and running systems for the system to work properly and successfully. Because there are some administrative barriers to applying this technology, people often opt for other types of technologies that are more suitable for installation (plug and play).

In order to enhance SWHP implementation, the SEADRION partner countries have identified the most significant barriers that designers and contractors face. Most of the partners propose improvements and developments regarding their existing legislation. Therefore changes regarding the legislative framework involving the licencing process for the installation of seawater heat pump systems are recommended concerning inter alia: system definition, installation specifications, clarification of responsibilities of involved departments and technical issues and simplification of the process. More specific the following barriers have been identified on a consortium level.

Technological barriers

- Lack of knowledge to the know-how but also experience in installing such kind of systems.
- Technology is well known in many countries, and copying solutions from other European countries is not an ideal solution.
- Possible issues around potential design versus built performance. Could be caused by: Poor quality design and feasibility studies; poor installation; fragmented supply chain; poor operation and maintenance of systems. May lead to SWHPs not being considered as an option/ being designed out during the development of a project.
- Varying approaches are taken by DNOs[1]/ possible future challenges (i.e. reinforcement of electricity grid) as the number of heat pumps increases.

[1] Distribution Network Operator

Environmental barriers

- The effects on environmental barriers can be recognized on the ecosystems, landscape, and land-use change. More analytically, fauna and flora can change until a project is completed. SWHP developments may encounter resistance at the planning stage for a number of reasons. For example, because they are in a conservation area; on a tourist route; the public concerns the impacts of a 'novel' technology; the site is on a flood plain; and/ or possible wider impacts on the landscape, e.g. tree root systems.
- Effectiveness and sustainability depend on developing the local authorities' capacity to manage natural resources and using appropriate means to prevent and control any environmental concern. There are cases in which a facility proved environmentally unfriendly since the discharge of effluents from the intake pipes' cleaning process was disposed of either onto land or water.

Social and political barriers

- Social and political barriers usually interact with each other; when governmental and/or local authorities are reluctant to make decisions and, through lack of knowledge, they fail to properly inform citizens on the necessity of planned projects. The latter leads to inaccurate opinions expressed by others, which are usually then adopted by citizens.
- The lack of environmental education in the community leads to the unfavourable reaction to plants' construction, and when the latter is combined with contradictory political interests, the procedure may present serious delays.

Economic barriers

- The price difference between the electricity produced with renewable energy sources and that obtained with traditional fossil sources is still the biggest obstacle for further diffusion of the technology in question.
- Absence of economic advantages and motivations for implementing systems in buildings. Moreover, the initial cost is still high both for commercial and domestic use. Only a small effort has been made over the last term to reduce the price of installations, but the overall investment still remains expensive.
- The absence of financial advantages and measures to support RES projects, especially concerning the creation, operation and manufacturing units for equipment as well as the promotion of research, the development of technology and the concretization for commercial applications of local importance.

Legislative and administrative barriers

- Some governmental procurement policies have been developed aiming at the promotion of sustainable commercial development of renewable energy, but the still prevailing inefficient bureaucracy continues to create major obstacles.

- SWHP developments may require a number of planning permissions. The process can be complex and time-consuming.
- The lack of a national spatial master plan for RES is another barrier in many countries. Often, a RES-specific spatial plan was published, but its implementation has shown that there are many questions to be answered before it can help speed up the whole procedure.
- The same projects are simultaneously monitored concerning their operation and performance by different authorities (fragmentation).
- The serious problem is that there is still a lack of compliance control mechanisms in many countries, as well as major capacity and institutional gaps. This situation has resulted partly from a past but still partly prevailing attitude of regarding legislation more as a wish and less as an obligation. To change this, there is a need to both modify administrative structures and put in place effective control mechanisms among all levels of government and raise awareness and build capacities at all levels and in a continuous way.
- Lack of both specialised and administration data (land registry, property and use, and management of protected areas).
- Land ownership can also be an issue as the developer may not own the land next to the sea.

Implementation of the seawater heat pump systems began in the 1970s and 1980s worldwide. With more than 180 large systems installed, northern Europe is at the forefront of implementing this technology, with Sweden and Norway among the largest users. In the ADRION region, such systems are also applied. According to the responsible partners, the type and amount of buildings having SWHPs in each SEADRION partner country are presented in *Figure 8*.

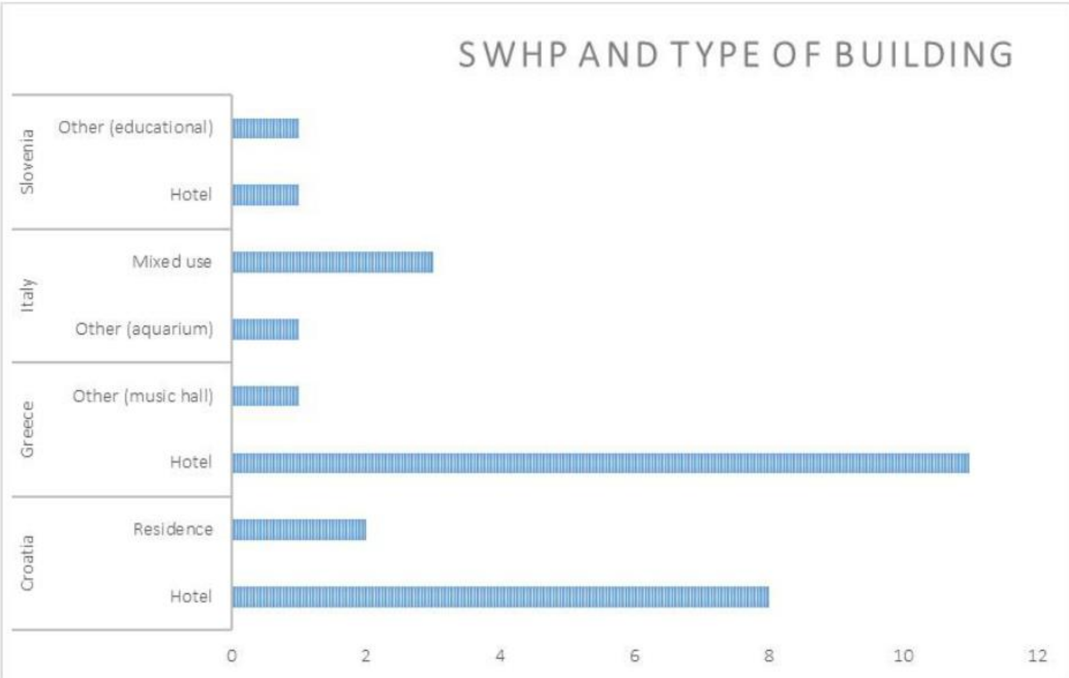


*Figure 8: Type and amount of buildings having SWHPs in each country (no records are existing for Albania) *not including the project's pilots*

5.1 Seawater heat pump potential in the ADRION region

Seawater heat pump potential depends on the seawater temperatures in a particular area. Since the heat pump coefficient of performance (COP) is determined by the temperature of the heat source, measuring the seawater temperature at different locations is of great importance for determining suitable (or not) locations for the installation of seawater heat pumps.

The analysis of seawater temperatures showed that in most countries, the difference between air and seawater temperatures is higher during winter than during summer. All countries show a difference in air and seawater temperatures during winter, even monthly, raising seawater heat pumps' potential. Some countries show the difference in air and seawater temperatures also during winter periods, but some countries have similar monthly seawater and air temperatures during summer. This would initially suggest that that the economic benefits of installing seawater heat pumps would be less, but if going deeper into the temperature data, it can be seen that on an hourly basis, air temperatures rise during the day up to 4 °C higher than the seawater temperatures and that is if the sea temperatures are measured on the surface. The deeper the seawater intake is, the more constant the sea temperature. Analysis of seawater over the air as a heat source/sink is discussed in detail in the previous section. Nevertheless, since the potential is higher for the heating period, further analysis was done for the heating regime.

The data gathered for buildings in partner countries where the seawater heat pumps can be implemented show that altogether heating demand is 4736.08 GWh/year for hotels and 496.73 GWh/year for public buildings. The exact heating demand per country can be seen in *Figure 9*, while heating demand per month can be seen in *Figure 10*

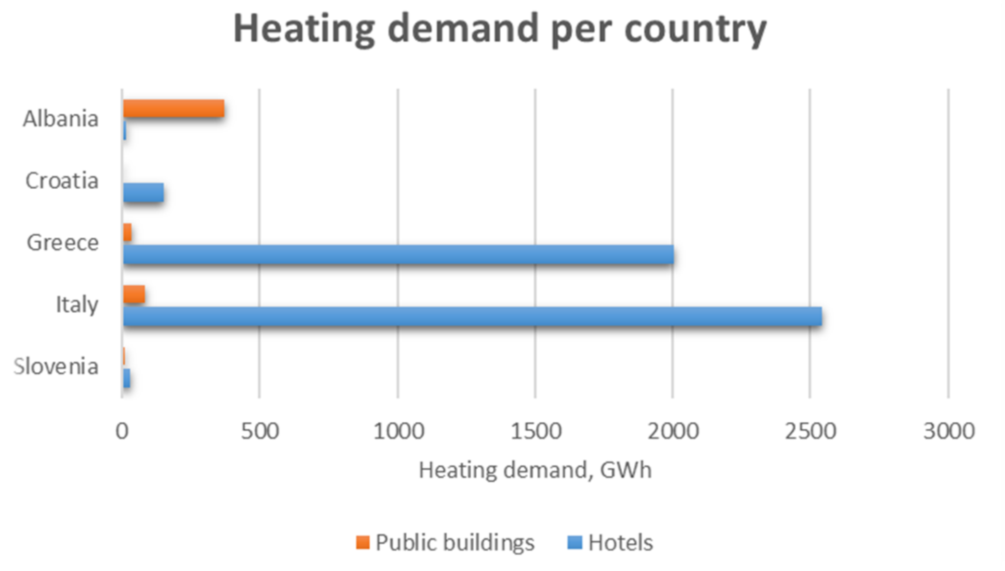


Figure 9: Heating demand per country

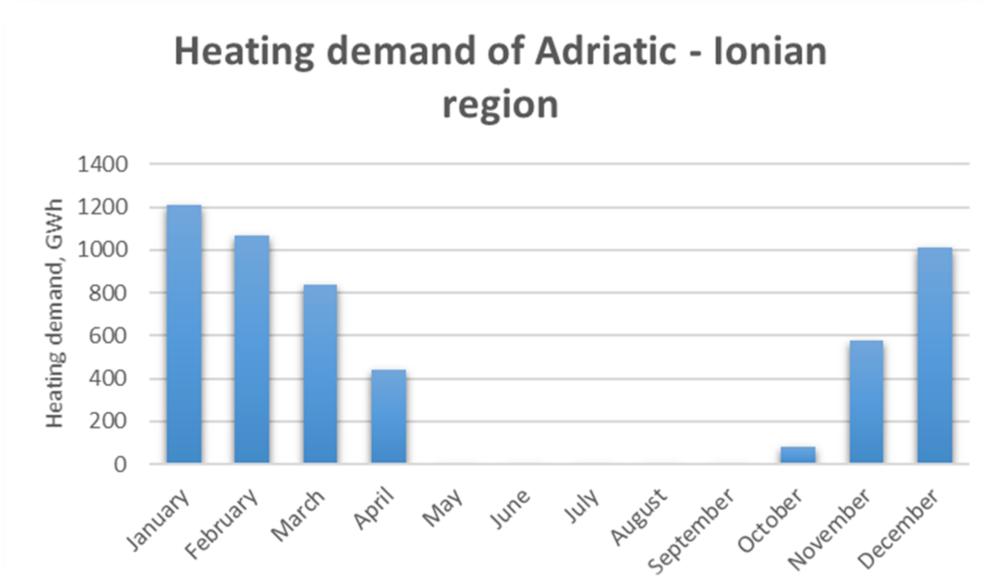


Figure 10: Heating demand of ADRION region per month

Further benefits of using seawater heat pumps for heating purposes is that thanks to their high efficiency, they lead to primary energy reduction and CO2 emission savings, as shown in *Figure 11* and *Figure 12*.

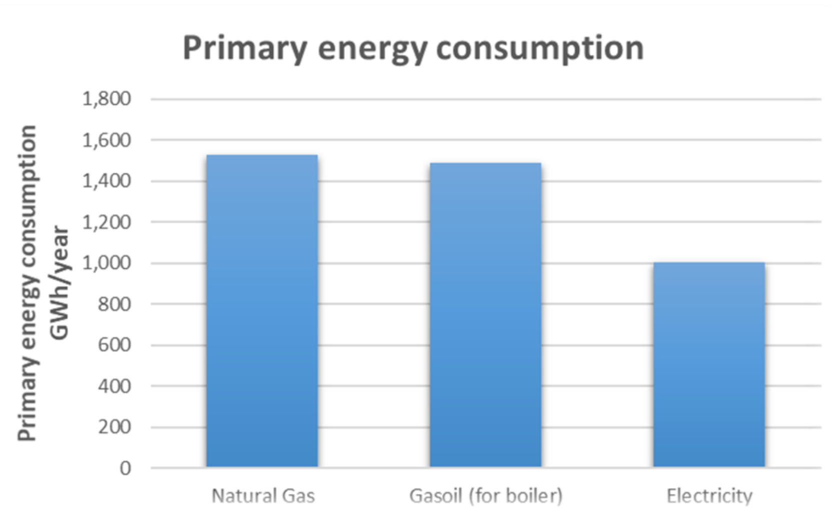


Figure 11: Primary energy consumption of public buildings close to the sea in ADRION region if they would use natural gas boilers, fuel oil boiler or heat pumps for heating

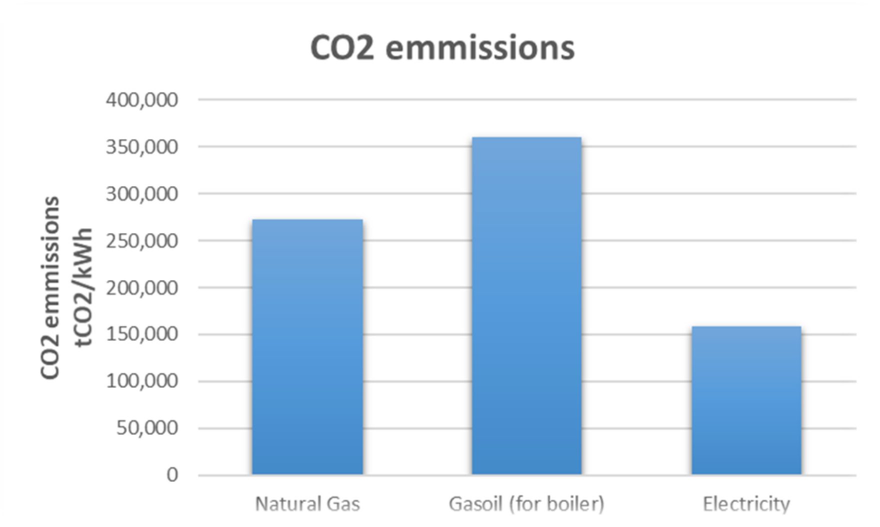


Figure 12: CO2 emissions of public buildings close to the sea in ADRION region if they would use natural gas boilers, fuel oil boiler or heat pumps for heating

There are two most used methods of seawater exploitation. One is direct seawater intake from the sea, and the other is seawater intake from the subsurface wells, as already explained in the previous section. For both cases, it is preferable that the building is as close to the sea as it is possible to reduce the length of the pipes that will need to be installed from the point of seawater intake to the heat pump, and the best would be if the building isn't more than 1000 m away from the sea. Running costs mostly depend on the length of the seawater pipeline to the heat exchanger since the pipelines in which the seawater flows must be constructed of special materials (corrosion), and the water in them must always circulate to prevent biological fouling.

Buildings with the greatest seawater heat pump potential are hotels that are generally very close to the sea and have high cooling needs. Furthermore, public buildings located close to the sea can also be considered. Below are data on hotels and public buildings along the coast of each partner country with seawater exploitation potential.

SLOVENIA

Table 3: Hotel data in Slovenia

Hotels	
Number of hotels	37
Minimum number of rooms in the hotels	16
Average number of rooms in the hotels	146
Maximum number of rooms in the hotels	276
Maximum number of rooms in the hotels	78%
Percentage of hotels with a maximum number of rooms than average	22%

Table 4: Public building data in Slovenia

Public buildings	
Number of public buildings	23
Average area of the building [m^2]	3319
Specific Heat Consumption [kWh/m^2]	101

GREECE

Table 5: Hotel data in Greece

Hotels	
Number of hotels	9604
Average number of rooms in the hotels	42
Minimum number of rooms in the hotels	9
Maximum number of rooms in the hotels	361
Percentage of hotels with a smaller number of rooms than average	75
Percentage of hotels with a bigger number of rooms than average	25

Table 6: Data for public buildings in Greece

Public buildings	
Number of public buildings	2081
Average area of the building [m^2]	2526.3
Specific Heat Consumption [kWh/m^2]	155.9

CROATIA

Table 7: Data for hotels in Croatia

Hotels	
Number of hotels	520
Min. number of rooms in the hotels	2
Average number of rooms in the hotels	98

Max. number of rooms in the hotels	743
Percentage of hotels with a smaller number of rooms than average	67%
Percentage of hotels with a bigger number of rooms than average	33%

Table 8: Data for public buildings in Croatia

Public buildings	
Number of public buildings	320
Average area of the building [m²]	1,826.5
Specific Heat Consumption [kWh/m²]	107.78

ALBANIA

Table 9: Hotel data in Duresi area, Albania

Hotels near the sea in Duresi Area	
Number of hotels	104
Minimum number of rooms in the hotels	15
Average number of rooms in the hotels	28
Maximum number of rooms in the hotels	120
Percentage of hotels with a minimum number of rooms than average	66 %
Percentage of hotels with a maximum number of rooms than average	34 %

Table 10: Hotels near the sea in Vlora Area, Albania

Hotels near the sea in Vlora Area	
Number of hotels	86
Minimum number of rooms in the hotels	12
Average number of rooms in the hotels	30
Maximum number of rooms in the hotels	100
Percentage of hotels with a minimum number of rooms than average	68 %
Percentage of hotels with a maximum number of rooms than average	32 %

Table 11: Hotels near the sea in Saranda Area, Albania

Hotels near the sea in Saranda Area	
Number of hotels	75
Minimum number of rooms in the hotels	14
Average number of rooms in the hotels	27
Maximum number of rooms in the hotels	90
Percentage of hotels with a minimum number of rooms than average	73 %
Percentage of hotels with a maximum number of rooms than average	27 %

Table 12: Hotels near the sea in Shengjin Area, Albania

Hotels near the sea in Shengjin Area	
Number of hotels	32
Minimum number of rooms in the hotels	18
Average number of rooms in the hotels	22
Maximum number of rooms in the hotels	85
Percentage of hotels with a minimum number of rooms than average	69 %
Percentage of hotels with a maximum number of rooms than average	21 %

Table 13: Public building data in Albania

Public buildings data, Albania				
	Durres	Vlora	Saranda	Shengjini
Number of public buildings	8	3	6	2
Average area of the building [m^2]	280	320	270	160
Specific Heat Consumption [kWh/m^2]	440	440	430	450

Additionally, seawater heat pumps can’t be implemented at all locations in the ADRION territory. Namely, at some location, Adriatic and Ionian seas are too shallow, and the seawater's temperature is too variable. Those locations would not be suitable for seawater heat pumps because their efficiency would drop significantly. Regarding the seawater's depths, the most critical for the installation of seawater heat pumps is the north of Italy, where the sea is not deeper than 30 m, as can be seen in *Figure 13*.

The sea gets deeper on the south end of the Adriatic sea and towards the Ionian Sea, but as shown in *Figure 13*, the places close to the coastline still have shallow water. The seawater's depth is important because the deeper the seawater intake is, the more constant the seawater temperature is.

Because of that, it is important to study the temperatures of the seawater at various locations to determine what places are suitable for the installation of seawater heat pumps and what are not, which was done in detailed per country.

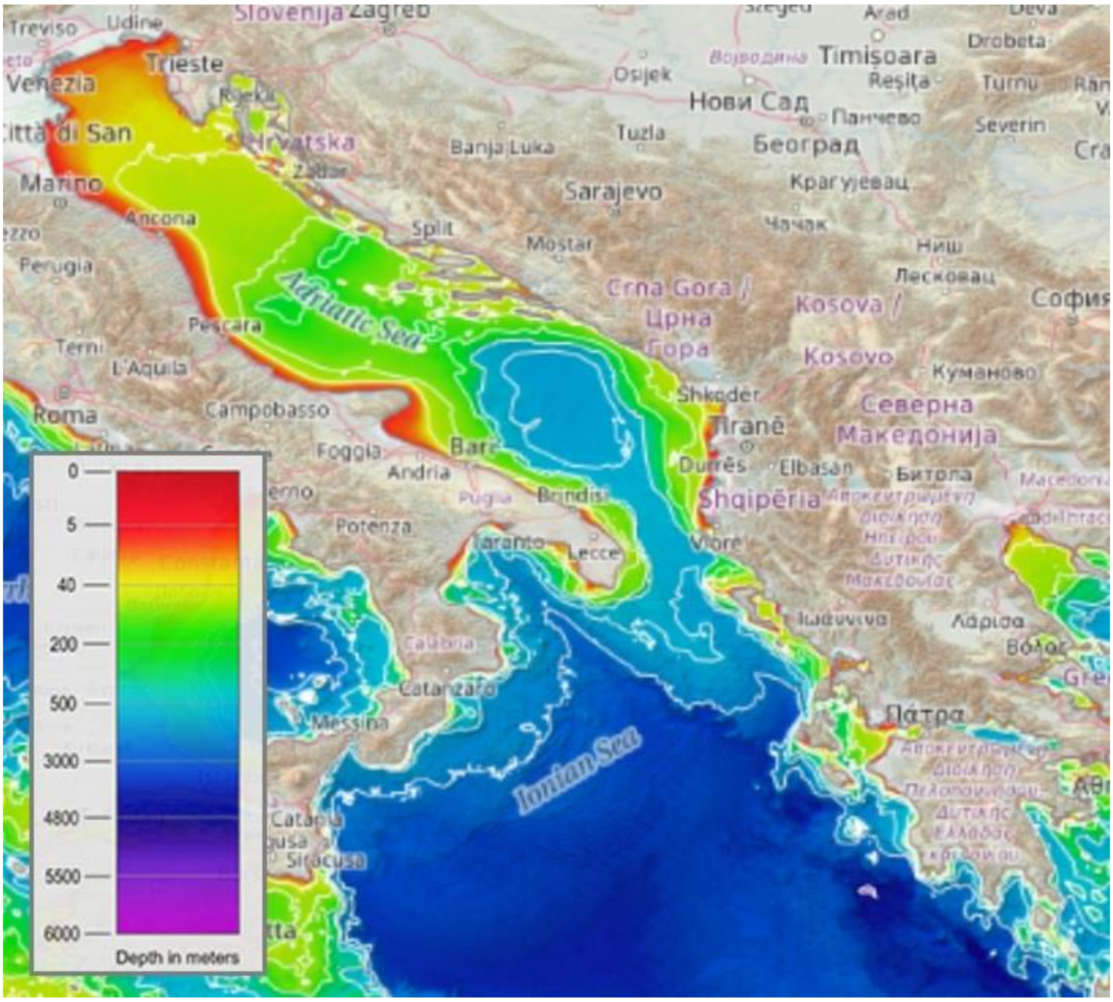


Figure 13: Adriatic-Ionian seawater depth [7]

5.2 Opportunities for the use of seawater for heat pumps

SWHPs for the integration of renewable technologies in historical and heritage buildings

Historical buildings (defined as those built before 1945), which are usually low-performance buildings, represent almost 30–40% of the whole building stock in European countries. Historical buildings often contribute to townscape character. They create urban spaces that are enjoyed by residents and attract tourist visitors. They may be protected by law from alteration not only limited to their visual appearance preservation but also concerning materials and construction techniques to be integrated into original architectures.

In Italy, for instance, heritage buildings built before 1919 are around 19% of the total, and buildings built between 1919 and 1945 are about 12% of the total. In the EU27, 14% of buildings were erected before 1919, and 26% has been built before 1945.

Heat pumps and other HVAC systems seem to be one of the most popular systems to improve energy efficiency in historical buildings without compromising their architecture. Examples can be found in Trieste or Dubrovnik.

A **possible application** in the city of Trieste refers to exploit this energy source to serve buildings characterized by high historical and architectural values. The plant provided for this goal consists of three main parts: an open-loop system that picks up seawater through the main heat exchanger and then restores it to sea; a closed-loop ring in which a heat transfer fluid brings sea - recovered energy to final users' derivations; installations inside buildings, consisting in water - to - water heat pumps in order to meet the energy needs of those buildings.

Particular attention has to be paid to the positioning of heat pumps in historical buildings: complying with rules on safety during operation, there should be considered settings for exclusive use, suitably located and partitioned form the remaining part of the asset. **Similar importance is due to replacements and integration of the technical distribution facilities in historical buildings**. The proposed system must then interface with architectural features, distribution network and plant of each building.

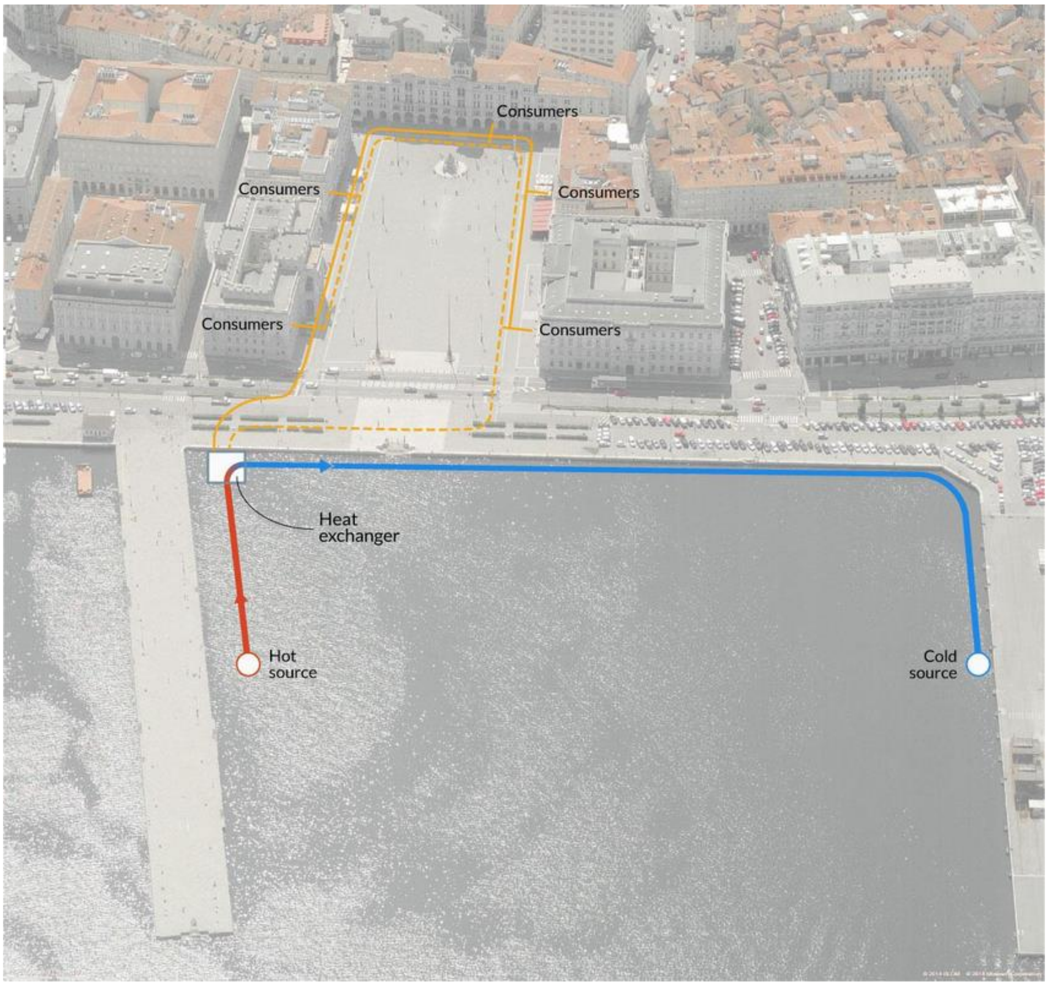


Figure 14: Design concept for an open-loop ring for seawater sampling and secondary closed -loop ring in Piazza dell'Unità d'Italia in Trieste old town [8]

Another application of the seawater heating and cooling technology was applied in the historical town of Dubrovnik.

Works were financed from the SEADRION project, in which Dubrovnik Development Agency, DURA, participated. It was backed by the European Union. Six heat pumps were installed to exchange energy with seawater and enable heating and cooling. The intake is in the old port, and the recirculation is conducted in the station. The substations are in the Rector's palace, the city hall and the theatre.

The endeavour cost HRK 3.19 million (EUR 428,100) before value-added tax. The local authority stressed the pilot project was executed in a protected area, designated by Unesco.

Figure 15: Seawater heat pump system in the historical town of Dubrovnik

SWHPs as part of district heating/cooling systems

Coastal areas are ideal sites for the application of seawater-source heat pump technology (SWHP) to provide district cooling and heating. Design of central heating stations with seawater heat pumps provides space heating and cooling of several buildings at the same time.

As in this case, the heat pumps are located in the same central space; the intake of seawater from coastal wells or directly from the sea occurs in one place. This reduces the required investment cost for seawater intake systems, and the investment cost in general, as it is not necessary to drill wells or lay pipes in the sea for each building separately. In addition, the application of electricity produced from RES and smart regulation in such district heating and cooling systems makes them energy independent and efficient.

One of the most representative examples of district heating/cooling with implemented seawater heat pumps, ie. SWHP facility is installed at the Värtan Ropsten plant in Sweden. At the beginning of the 1980s, rising oil prices and cheap electricity led to a growth of interest in heat pumps.

SWHP facility in Ropsten, Sweeden, is the largest system of its kind and is used for district heating and cooling of the city of Stockholm. The 180 MW heating system covers 60% of Stockholm's thermal energy needs and has the capacity to operate autonomously during spring, summer and early autumn. It has been in operation since 1987 and can provide the district heating system's flow temperature up to 80 ° C. The system uses multi-stage compression processes and consists of a total of 10 heat pumps that achieve a heat pump efficiency value of around 3 and can utilize heat from 2 °C seawater. There is also the possibility of direct district cooling from the sea, and then the cooling capacity equals 74 MW.

Figure 16: General view of an HP unit (left) and the machine room building (right) [10]

5.3 SWOT analysis regarding the installation and operation of SWHP

STRENGTH (+)	WEAKNESSES (-)
• **high HP efficiency** compared to conventional heat sources and compared to heat pumps that use ambient air as a heat source/sink • **local resources** - allows the use of available renewable energy sources at the site of application • **multipurpose device** - one device provides space heating during the winter, space cooling during the summer and preparation of domestic hot water (subcoller, desuperheater) • **suitability of heat pumps for thermally insulated buildings** • **economic benefit to end-users** • **environmental protection** - reduction of greenhouse gas emissions • **safety** - no fuel combustion, no harmful gas emissions • **advances in technology development and availability**	• **application potential** in relation to total demand is limited by the distance from the seashore • **required space for the installation of equipment** - available space within the block or building to accommodate new equipment • **ownership and right to use land plots** - implementation of the system and associated distribution, as well as seawater intake system, must take place with the consent of the holders of the right to use the plot • **existing buildings** - energy characteristics of thermally uninsulated buildings are unfavourable for low-temperature heating systems • **investment and installation costs** • **expensive in case of reconstruction of the existing system** • **suitability of heat pumps for thermally insulated buildings** • **knowledge and skills of the installers, designers and contractors**
OPPORTUNITIES (+)	**THREATS (-)**
• **policy and legislation** - incentives to increase energy efficiency and use renewable energy sources at the national and EU level • **research and development** - increasing the energy efficiency of heat pumps, new refrigerants • **promoting the use of locally available RES** • **market for the construction of new buildings and renovation of existing buildings** • **integration of other forms of RES** - driving energy to operate the system can be obtained from photovoltaic power plants • **SWHPs as a part of district heating/cooling systems** - covering the needs of several consumers with one system • **energy renovation of buildings** - the potential of the application after renovation increases with lower energy consumption • **use of Public Procurement of Innovation (PPI)** to stimulate the adoption of innovative products and services related to energy-efficient materials and processes for public building's energy refurbishment, including SWHP	• **enhanced requirements for refrigerants** (EU F-GAS Regulation 517/2014) • **a combination of rising electricity prices and falling natural gas prices** • **existing installations and facilities** - limit the available space for installation work and system implementation • **awareness of residents** - education about technology and involvement of residents is necessary • **limited access to the considered location** - city and municipal centres for equipment and machinery • **complex administrative and legal procedures for direct seawater intake**

5.4 Smart Specialisation Strategic (S3) goals

The European Union has launched an initiative to **develop smart specialization strategies (RIS3) as a new approach to economic development based on targeted support for research and development activities and innovation.** EU cohesion policy, as an ex-ante condition, **required the Member States to identify areas of specialization that best suit their innovation potential.**

Research and analysis conducted during the SEADRION project can be used as a basis for the smart growth of ADRION countries and regions. Given the size, division and geographical location of ADRION countries, as well as the thematic priority areas of existing smart specialization strategies, S3 goals/measures can be implemented at a regional or national level. The **main instruments for the successful implementation of smart specialization are considered to be cooperation and education of key players** with the same interest.

Below are the proposed S3 strategic goals/measures based on the research and analysis conducted within the T3 work package.

a) ***Connection of responsible institutions and business sector in order to create databases (RES potential map) that would serve as a basis for the development and implementation of technologies and products*** based on *T3.1.1 Building selection methodology*, *T3.1.2 Seawater heat pump potential*.

The documents provide data on seawater temperature for different locations in partner countries, as well as for mapped buildings applicable for SWHP implementation. The importance of having a database (suitable buildings and associated seawater temperatures) for the application of such systems, as well as for the application of all other RES systems, has been recognized.

b) ***Cooperation of IT and technical profession in order to develop quick check (evaluation) tools of cost-effectiveness and applicability of certain technologies and products*** based on *T3.2.1 Case study report*.

Each of the documents reports on technical and economic feasibility studies and the sensitivity analysis regarding the installation of seawater heat pump. Case study reports consist of economic, energy and environmental analysis. The importance of conducting a cost-effectiveness and applicability analysis of system installation was recognized.

c) ***Cooperation between scientific institutions and the business sector (contractors, manufacturers, designers) in order to solve common problems in practice (R&I improvements)*** based on *T3.3.1 R&I recommendations to accelerate the development of the seawater heat pump sector*.

The document identifies many problems that occur in SWHP operation, such as lower system efficiency due to corrosion and biological fouling. Some specific recommendations with an emphasis on research and innovation activities that will ensure the acceleration of the integration of seawater heat pump technology in the building sector for cooling and heating are elaborated in the paper, such as the development of special material heat exchangers with the aim of increasing system efficiency and reducing problems in the system operation as well as development in dealing with pipe and heat exchanger biofouling due to seawater content.

d) ***Cooperation between competent institutions and investors in order to overcome, resolve and regulate legislative obstacles that hinder research and development*** based on *T3.4.1 Policy Roadmap for the enhancement of H&C technologies through innovative seawater heat pump technologies.*

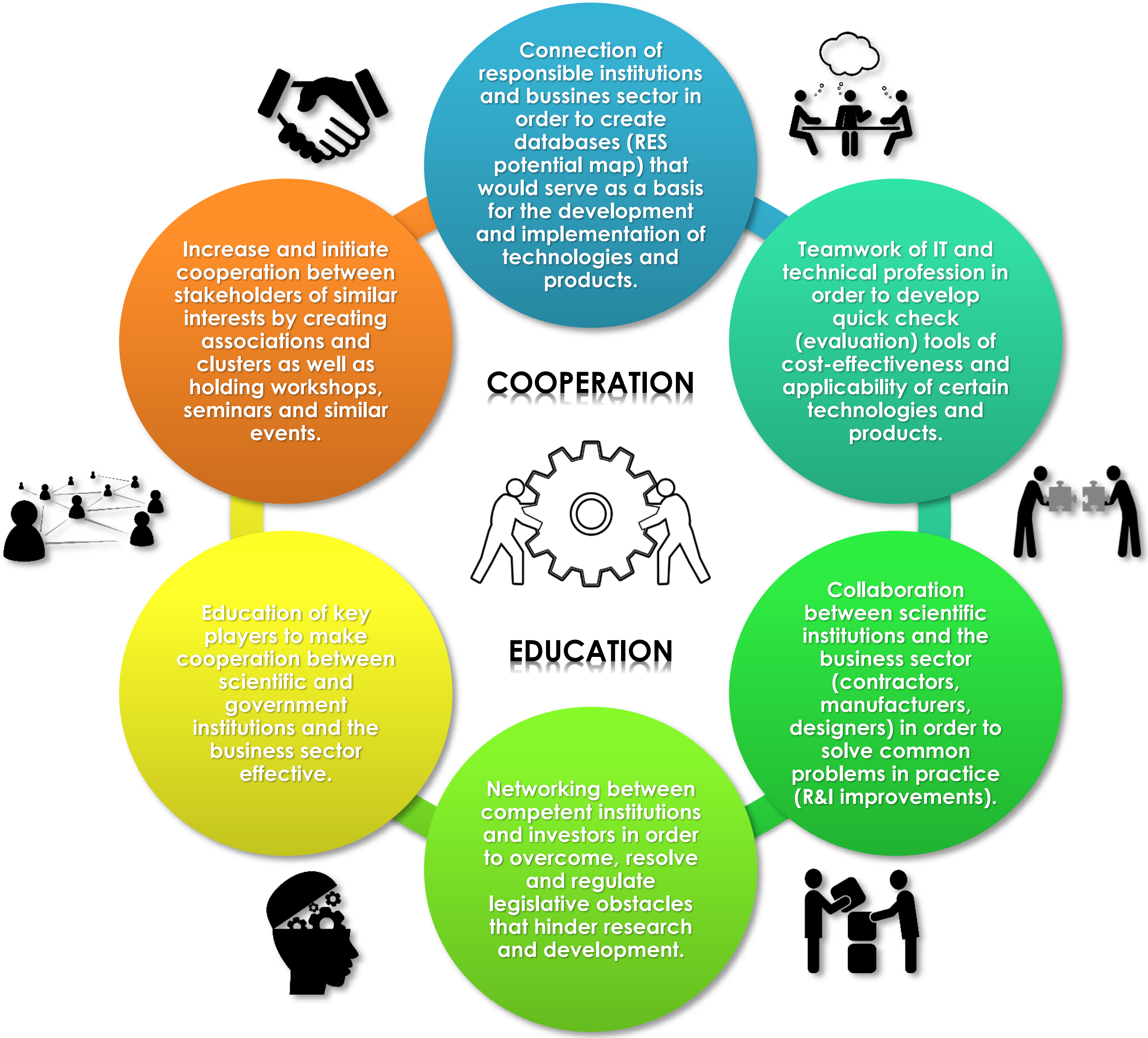
Many barriers that hinder the increase in the implementation of heat pumps, including seawater heat pumps, are encountered in all partner countries and are mostly similar. The document proposes measures and activities that could facilitate the implementation of such systems such as standardization of the seawater intake system installation, promotion of heat pump technology, the involvement of heat pumps in the energy strategies, application of district heating and cooling systems, new corrosion and maintenance-friendly materials, engagement of policymakers around structuring the process of implementation of heat pumps and many others.

e) ***Education of key players to make cooperation between scientific and government institutions and the business sector effective*** based on *T3.4.1 Policy Roadmap for the enhancement of H&C technologies through innovative seawater heat pump technologies.*

It is important to educate the professions involved in order to see progress in the implementation of seawater heat pumps, as well as heat pumps in general, with an emphasis on successful implementation and subsequent operation such as training programmes for RES-installers, EHPA Eucert, a European training and certification program for heat pump installers etc.

f) ***Increase and initiate cooperation between stakeholders of similar interests by creating associations and clusters as well as holding workshops, seminars and similar events*** based on *T3.4.2 Blue Growth Strategy for Ionian Adriatic Region*.

The document elaborates the potential of seawater heat pumps as part of the Blue Growth pillar and identifies areas (access to finance, technological infrastructure, labour market and employment, awareness and knowledge, cooperation among stakeholders, legal framework) where there is potential for increased Blue Growth, including obstacles that may be encountered as well as possible interventions to solve them. Knowledge sharing platforms, building bridges and collaborations with and among involved stakeholders have been identified as the most important factors in the further development and dissemination of technology.


Connection of responsible institutions and bussines sector in order to create databases (RES potential map) that would serve as a basis for the development and implementation of technologies and products.
Teamwork of IT and technical profession in order to develop quick check (evaluation) tools of cost-effectiveness and applicability of certain technologies and products.
Collaboration between scientific institutions and the business sector (contractors, manufacturers, designers) in order to solve common problems in practice (R&I improvements).
Networking between competent institutions and investors in order to overcome, resolve and regulate legislative obstacles that hinder research and development.
Education of key players to make cooperation between scientific and government institutions and the business sector effective.
Increase and initiate cooperation between stakeholders of similar interests by creating associations and clusters as well as holding workshops, seminars and similar events.
COOPERATION
EDUCATION

6. Long-term goals for development and diffusion of SWHPs

On 28 November 2018, the Commission presented its strategic **long-term vision for a prosperous, modern, competitive and climate-neutral economy by 2050 - A Clean Planet for All**. The Commission's vision for a climate-neutral future covers nearly all EU policies and is in line with the Paris Agreement objective to keep the global temperature increase to well below 2°C and pursue efforts to keep it to 1.5°C. The long-term strategy also seeks to ensure that this transition is socially fair and enhances the competitiveness of the EU economy and industry on global markets, securing high-quality jobs and sustainable growth in Europe, while also helping address other environmental challenges, such as air quality or biodiversity loss.

The European heat pump industry welcomes the EU 2050 Strategy, pointing that its successful realisation presupposes the full decarbonisation of heating and cooling by 2050. This has not been expressed clearly enough in the document. Heating and cooling deserves more visibility in the EU 2050 Strategy and should become the new EU priority for the following reasons:

- The sector is responsible for more than 50% of final energy demand and 27% of CO_2 emissions;
- Modernising this sector will also foster Europe's steady economic growth, creating investment flows within the EU, supporting the local economy, and creating skilled jobs safe from delocalisation. It will also increase the competitive advantage of the wider EU industry on global markets, shielding it from the woes of volatile fossil energy prices;
- The sector is fit for digitalisation, with sector-integration potential in smart cities;
- The sector also copes with other health and environmental challenges, such as reducing local air pollution and increasing indoor air quality. It showcases the application of circular economy principles;
- All the technologies needed for the transition are available today. Current limitations are not technical but political, starting with the lack of visibility given to the sector.

Standing out as the smartest, most sustainable and efficient solutions for heating and cooling, **heat pumps should become the new role model for decarbonisation**.

European policies on the product and building level are increasingly successful in regulating the use of renewable energy, acceptable energy demand and CO_2 emission levels. The package of Directives and Regulations (RED, EED, EPBD) is implemented in most member states and is currently under revision for an even better fit with the need to decarbonise heating and cooling by 2050. While heat pumps are recognised as a helpful technology to achieve the targets set in the overall climate and energy strategy, the distorted energy price limits market forces to function properly. In many markets, fewer heat pumps are sold than would be necessary to decarbonise the sector with the required speed.

Key recommendations and objectives for achieving long-term goals for development and diffusion of SWHPs, as well as heat pumps in general, in the ADRION region, are given below:

POLICY FRAMEWORK	FINANCIAL FRAMEWORK
▪ counteract both overregulation and the lack of specific policies in the field; ▪ inclusion of SWHPs in NECPs implementing the *2030 Clean Energy Package*; ▪ promotion of SWHPs, as well as heat pumps in general, as leading technologies towards full decarbonisation of heating and cooling by 2050 (*Green Deal*); ▪ development of a national spatial master plan for RES (including SWHP potential); ▪ official monitoring of the heat pump implementation (mapping of installed heat pumps); ▪ stimulation of cooperation between countries in the ADRION region to promote long-term certainty and predictability for investors, foster jobs, growth and social cohesion; ▪ address the distorted price mechanism that favours the use of fossil fuels and fossil fuel technology.	▪ identification of heat pump market drivers and stoppers; ▪ inclusion of SWHPs in ROPs, national funding programmes and RIS3 or inclusion in Green Public/Pre-commercial/Innovation Procurement; ▪ creation of an EU heating and cooling market where carbon prices are internalised (and with the right balance between electricity and heat) in order to provide a level playing field and increase the competitiveness of RES based alternatives compared to fossil-based solutions. Taxes, support and subsidies could be possible tools in this direction; ▪ financial tools as a decision aid (e.g. warranty for studies, test drilling) to cover the risk in case the implementation is not possible; ▪ investment grants for renewable heating installations, i.e. funding for the utilisation of renewable energies for heat generation (impose limits for a seasonal performance of heat pumps in order to benefit from the support incentives); ▪ tax deductions offered by the Government for energy-saving measures (deduction also cover the expenses related to installing these systems to substitute existing systems).
TECHNOLOGICAL FRAMEWORK	**SOCIAL FRAMEWORK**
▪ development of special materials to increase system efficiency and reduce problems in the operation of the system; ▪ introduction of multi-source energy systems (photovoltaic/wind/thermal cogeneration) in order to utilize the same area both for producing electricity and heat; ▪ design and installation of pilot projects to develop and test new solutions; ▪ promoting seawater heat pumps as a heat storage mechanism (in combination with wind farms); ▪ continuous training for heat pump designers, contractors and installers.	▪ increase awareness and knowledge on existing regulatory frameworks impacting the development; ▪ inclusion of SWHPs in the national/regional energy strategies; ▪ promotion and diffusion of technology to targeted end-users (medium to large consumers, preferably hotel complexes and public administration buildings); ▪ installation and monitoring of pilot project plants in order to make operation parameters visible to potentially interested investors (insight into system efficiency and consumption); ▪ achieve the reputation of heat pumps, especially SWHPs, as reliable, efficient and good solutions for heating and cooling; ▪ promotion of heat pump technology through brochures, pilot plants and media attention; ▪ public register of installed heat pumps.

7. Short-term action plan

In order **to achieve the long-term goals for the development and diffusion of SWHP technology, a short-term action plan for the ADRION region has been developed**. The basic step that all countries would need to take is to **establish a national heat pumps association**, representing the official and competent institutions for the promotion of heat pump technology, SWHP technology, regulation of related legislation, education, and cooperation with stakeholders. It is recommended that national heat pump associations **join the European Heat Pump Associatio**n (*EHPA*) to jointly implement targeted steps to increase the implementation of the SWHP systems and heat pump systems in general. During the SEADRION project implementation, the need for such an organization was noticed by the project partners. For these reasons, Croatia founded the Croatian Heat Pump Association in the spring of 2019.

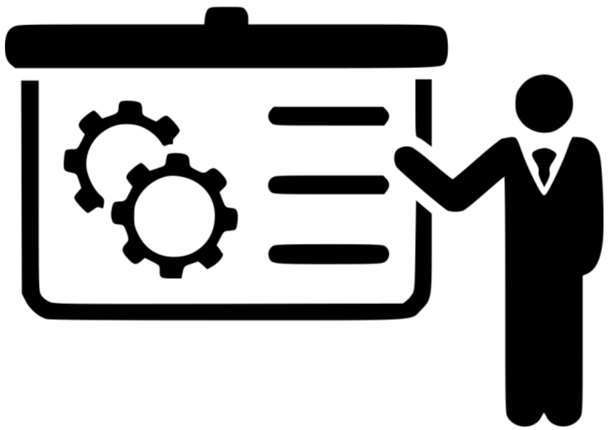
The vision and mission of the Croatian Heat Pump Association Association (CHPA) are to:

- promote the use of heat pumps in heating and cooling systems in all segments of society, locally, regionally and globally;
- protect the interests of the profession involved in all forms of related business and consumers as participants in the heat pump market;
- promote other renewable energy sources, energy efficiency and rational use of energy, and other technologies and measures that contribute to sustainable development and reduction of environmental pollution;
- provide professional support to the institutionalization of the area in the field of heat pumps and the creation of national legislation in this area.

Associations represent a community of subjects of the same or similar interests and can thus be called the voice of the profession. Thus, they have a greater impact on institutions, so they can directly and quickly point out the problems encountered in practice, and then prompt them to solve them.

Below is a graphical presentation of the short term action plan recommended to the countries of the ADRION region for the promotion of SWHPs, and heat pumps in general, as well as for increasing their implementation in heating and cooling systems.

1. Establishment of national heat pump associations bringing together all interested stakeholders.
2. Membership in the European Heat Pump Association (EHPA).
3. Initiation of official national registers of installed heat pump units based on EHPA sales data acquisition and processing methodology.
4. Establishing committee within the association with the aim to enhance the use of SWHPs.
5. Promotion and diffusion of technology to targeted end-users.
6. Temperature and bathymetry analysis of the coastal area of the sea.
7. Mapping of buildings suitable for SWHP application.
8. Setting a building case study template - quick check tool to see if the SWHP implementation is cost-effective.
9. Establishment of a working group to counteract both overregulation and the lack of specific policies in the field regarding SWHPs (seawater intake).
10. Defining instructions on the existing legal framework related to the implementation of the SWHP (step flow chart).



Conclusion

The **common strategy aims to enhance the usage of seawater heat pump technologies for renewable heating and cooling in the ADRION region based on partner cooperation, R&I and policy findings and experience and results acquired** through the implementation of the SEADRION pilot plants.

In 2019, heat pumps with a thermal capacity of 12.7 GW were installed, producing approx. 25.1 TWh of useful energy and integrating 15.6 TWh of renewables in heating and cooling while avoiding 4.0 Mt of CO2-equivalent emissions. In order to produce the 2019 sales volume and to maintain the installed stock, a total of 78,969 person-years of employment were necessary. **According to Eurostat data for 2019, 12.2% of heating and cooling needs are generated by heat pumps**. European heat pump sales grew by 17.7% in 2019 – the fourth double-digit growth in a row.

These numbers once more confirm the enormous potential: There are **still 85% of the heating market ready to be taken**, this makes 5-6 million sold units each year. Heating and cooling industries need to decarbonise over the next 30 years. This is a tremendous challenge that needs to be started as soon as possible. The **benefits of heat pumps make this technology a prime candidate for a central role in a sustainable European energy system**.

The current technology of seawater heat pumps is mature and advanced enough for wider application and to be more intensively included in the National Energy and Climate Plans (NECPs), as well as other action plans, of the SEADRION partner countries. The implementation of seawater heat pumps, as well as heat pumps in general, contributes to energy efficiency, quality of life, employment, etc., at the site of its application. **The data gathered for buildings in partner countries where the seawater heat pumps can be implemented show that altogether heating demand is 4736.08 GWh/year for hotels and 496.73 GWh/year for public buildings, which represents the potential for SWHP implementation.**

There are many opportunities for the use of seawater for heat pumps, such as for the integration of renewable technologies in historical and heritage buildings, as part of district heating/cooling systems or as a heating/cooling storage mechanism etc. **SWHPs have a high efficiency** compared to conventional heat sources and compared to heat pumps that use ambient air as a heat source/sink. Also, **they allow the use of available renewable energy sources at the site of application and provide both space heating and cooling. On the other hand, investment and installation costs are high, the necessary administrative and legal procedures are complex and time-consuming**, and designers, contractors and installers have little experience with such systems.

Due to the mentioned flaws and other weaknesses and disadvantages of technology and its application**, the document proposes measures and goals based on research and analysis conducted in the SEADRION project** to overcome them.

Cooperation between scientific research institutions, the business sector and related professions, as well **as the education of key players** with the same interest, **is proposed as the main factors in the smart growth of the ADRION region**.

Long-term goals for the development and diffusion of SWHPs are defined through the policy, financial, technological and social framework, and based on conducted research and analysis.

To begin with, i.e. where and how to start, **a short-term action plan was presented with an emphasis on the establishment of national heat pump associations** that would represent a community of subjects of the same or similar interests and can thus be **called the voice of the profession**. **Step-by-step activities were presented** with the aim of encouraging the implementation of seawater heat pumps as well as solving related problems. In general, **the community of profession, business and science has a greater impact on authority and its institutions**, so it can directly and quickly point out the problems encountered in practice, and then prompt them to solve them.

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