climate

Review

Seaside Renewable Energy Resources Literature Review

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Abstract: This review paper describes seaside renewable energy resources. The motivation and need behind this work are to give background literature on the use of climate change effects as a resource support for shallow geothermal-energy (seaside energy solutions) production. This leads to combating and mitigating climate change by using its effect to our advantage. As a part of my literature review as a report series, this report gives some background about seaside energy solutions relating to water quality and climate change. This review paper addresses all aspects of renewable energy. The methodology implemented in this review paper and other series was a systematic literature review process. After searching and collecting articles from three databases, they were evaluated by title, abstract and whole article then synthesized into the literature review. The key conclusion is that seaside renewable energy is mainly shallow geothermal-energy and most of the methods use climate change effects to their advantage such as sediment heat energy production. The main recommendation is to use the effects of climate change to combat and mitigate its causes and further consequences. The overall conclusions are built on the relationships between different aspects of the topics. The paper contributes a precise current review of renewable energy. It is the last part of a series of four review papers on climate change, land uplift, water resources, and these seaside energy solutions.

Keywords: seaside energy; renewable energy; climate change; energy storage; energy transitions

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1. Introduction

Energy is defined as the ability to do work. Moreover, "energy is the convertible currency of technology" [1]. Protecting the environment from greenhouse gas emissions caused by energy production can be achieved by replacing fossil fuel energy with renewable energy resources. A broad definition of renewable energy sources from the environmental movement that started in the 1960s includes "any energy source that is 'alternative' to 'conventional' fossil (and, for some, nuclear) fuels" [2]. Based on this book, this definition includes geothermal energy, which is not a renewable resource because it takes hundreds to thousands of years for the heat to be extracted from the geothermal deposits. Sustainable development is an important aspect of energy demand stabilization. Renewable energy resources not only help in achieving sustainability or declining emissions but also in utilizing the available energy resources in local areas. They might even be less expensive and more efficient resources for what is needed. Hybrid renewable energy systems are more cost-effective and energy-efficient over time.

Energy is essential. Without energy, the entire fabric of society as we know it would crumble with time [1]. If energy is this important and we cannot live without it, making it environmentally friendly and sustainable is essential. A well-known solution to achieve this goal is replacing our energy with renewable energy resources. Based on Dincer's [1] explanations, global warming is not the only environmental problem with energy supply and use. Other concerns include air pollution, acid precipitation, ozone depletion, forest destruction, and emissions of radioactive substances, to mention a few. As described in the climate change section of this literature review, the main cause of GHGs is fossil fuel usage. Replacing these fossil fuel energy resources with renewable energy is necessary, there is no question about it.

Seaside energy solutions can be replaced by renewable energy by improving the diversity of usage of renewable energy in all aspects in different locations, including the city of Vaasa's renewable energy installation locations. This issue is important because the city of Vaasa's location does not seem to be addressed in comparison to the city's use of renewable energy. Even if the use of renewable energy in cities is limited and it represents much more of the population in developed nations than in undeveloped nations. Sustainable development is intimately related to renewable energy resources and utilization [1]. This means that planning and addressing sustainable development and environmental protection can be achieved by implementing renewable energy resources on a massive scale. Other types of integrated development methods are essential for improving those renewable energy resources with high operating costs [3].

Electricity, bioenergy, hydrogen and hydrogen-based fuels with net zero emissions would replace the vast majority of fossil fuels [4]. Renewable energy implementation on massive scales can be achieved over time through policy development, as seen in the EU. This issue is very important; hence, nations or people intend to use old fossil fuel energy resources because they are used to them. Research and development of renewable energy is a way to improve the resources and initiate people's use of these energy resources. People are aware of, to some extent, the research development, at least in Finland. This awareness makes our job easy because people having environmental awareness encourages them to use renewable energy more often, as noticed throughout history. At the University of Vaasa, there has been a study going on for a few decades now on those contributions towards renewable energy, which are very high. As seen in the following paragraphs, the use and improvement study of Nordic renewable energy will be mentioned and shows the base of the research on which it is built.

Renewable Energy Implementation in Nordics

This sub-section of the introduction delivers the renewable energy implementation in Nordics as part of history and shows the research on which it is built. The sub-section also shows the implementation and connection of mitigation strategies for climate change in the EU after the agreements of world protocols. The EU commission has strategies for implementing world agreements in its nations. The EU's commitment is to reduce greenhouse gas (GHG) emissions from 85% to 90% below 1990 levels by 2050 [5]. One of the most active groups of nations in the EU for adapting climate change, mitigating and combating it in different ways, is the Nordic nations.

Nordics are implementing the diverse capacity of renewable energy (RE) to be an energy source for their countries. The usage of renewable energy increased from 1973 to 2009 in Nordic nations, with higher diversity of renewable energy implemented by Finland and Sweden [6]. The replacement of fossil fuels for energy production is not only to be in the Nordics, but it is an example for others to follow. The various encouragements include a subsidy to replace house windows to increase energy efficiency in Sweden; tax minimization in Nordic countries for those that use RE; CO_2 reduction policy, as well as other points and encouragements that help society and business companies to work and use RE much more [6,7].

The dimensions of policy-making in Nordic countries (NCs) are sustainability, self-sufficiency and balancing trade-offs. The objective of diffusion RE policy in NCs includes: (1) energy efficiency; (2) economic efficiency; (3) CO_2 reduction; and d) energy security and diversification [6]. These next descriptions, classifications and explanations are mainly based on [6,7].

Energy efficiency: Means using the maximum output, reducing waste to a minimum and minimizing energy usage. Energy use in NCs is very high due to the following reasons: (1) the presence of winter; (2) high standard of living; (3) high consumption intensity (higher industry energy consumption); and (4) larger distance between houses (few people but dispersed throughout the nations).

Economic efficiency: Maximum output from a given amount of input or minimizing input while obtaining enough output. There are two types of efficiency related to diffusion RE in Nordics:

Technical efficiency: By implementing the lowest possible cost obtaining an efficient output by using the possible techniques and environmental possibilities. For example, in Finland, the use of heaters on wind turbine blades during winter to avoid the freezing problem. Consequently, the current project instruments, such as water heat exchangers, are considered technical efficiency improvements.

Allocative efficiency: To allocate resources and knowledge to maximize the result for the user. For example, there are different types of electricity offering companies in NCs delivering green or normal electricity. Customers can choose what they want.

CO_2 reduction: This is to reduce the usage of fossil fuels to minimize pollution or emission reduction. By allocating technologies and using clean/carbon-free energy sources (renewable energy resources as this research is doing). A lot has been achieved in NCs in different nations with the introduction of climate strategies/greenhouse emission strategies for future efforts; for example, in Denmark and Norway.

Energy security and diversification: As the solution to climate change is expected to deliver, the use of energy diversification is important, and it is at the heart of implementing strategies. The best examples are Finland and Sweden, the two countries with the most diverse type of energy production methods implemented [6] (Figures 1–3). The new water heat exchanger and the previous sediment heat energy production introductions can help increase the diversification of renewable energy solution types in seaside implementations.

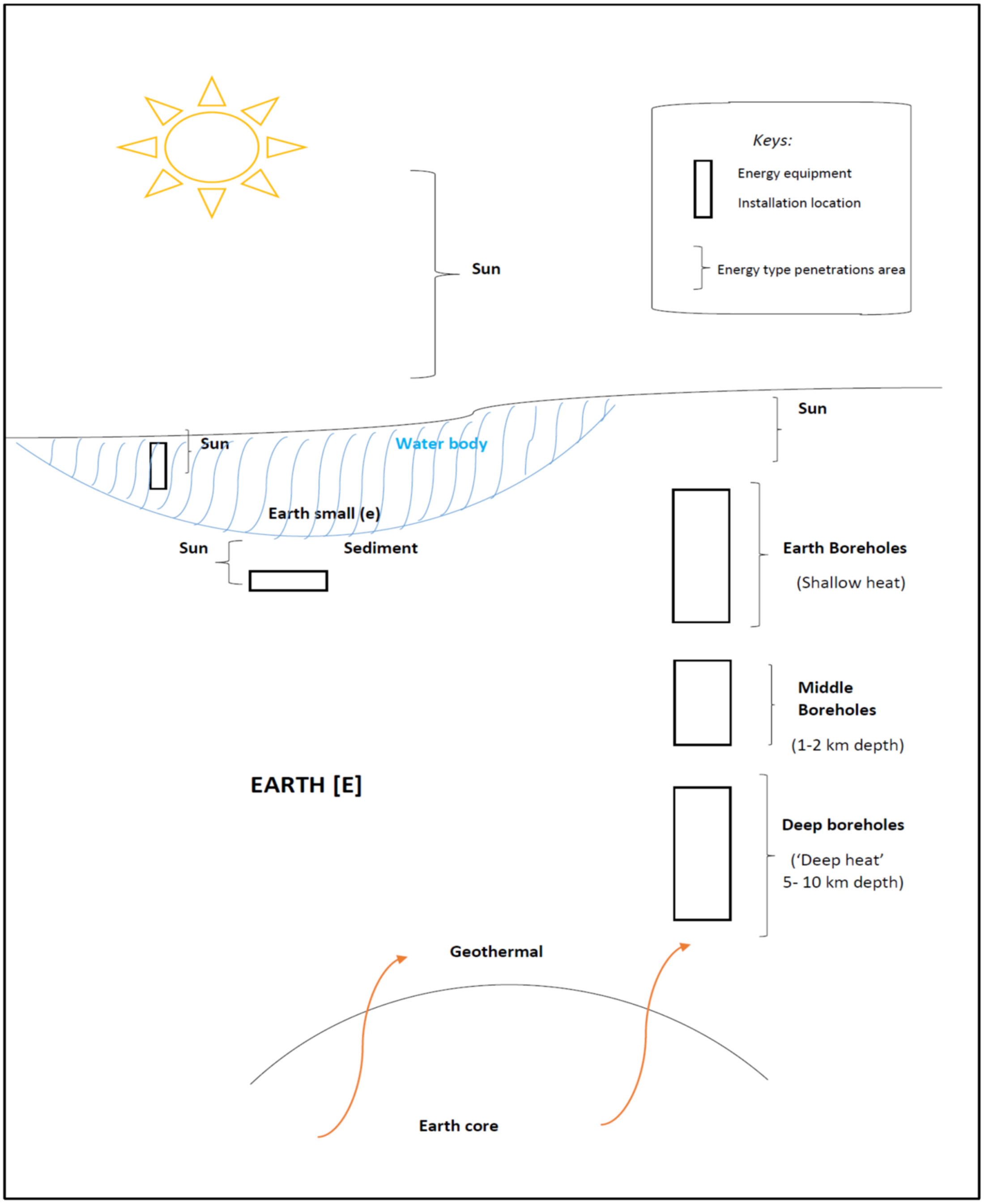

Figure 1. Sketch figure showing possible geothermal-energy solution for installation near seaside or water body areas (e.g., near a lake or sea).

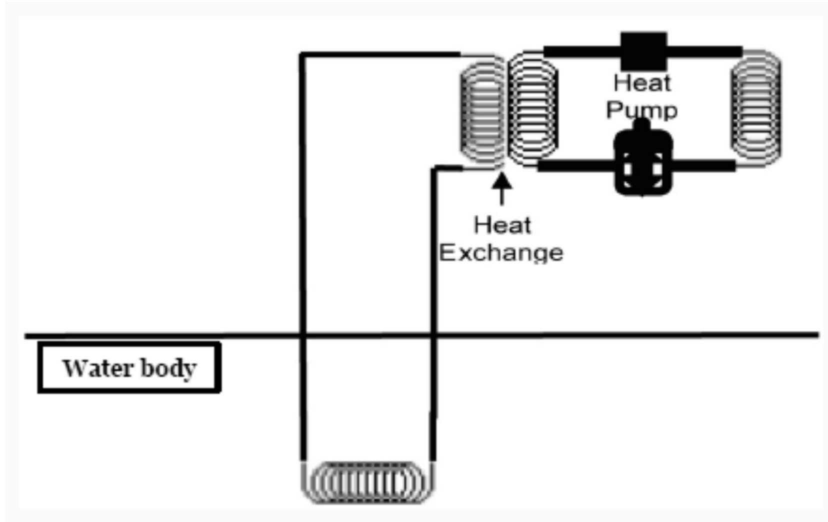

Figure 2. In closed loop geothermal heat pump system, in this picture in our installation, seawater was utilised as a heat source (modified from [8]).

Figure 3. The water heat exchanger that was planned to be installed in Merten Talo is connected to the tubes (of the heat pump in the home), which are insulated. The red wire is the temperature sensors (Picture taken by Anne Mäkiranta during installation process 18 October 2018).

Using the above-mentioned dimensions and objectives will lead to sustainable energy efficiency where green energy or RE is the focus. The idea of the "Drop in sea" project, the Merten Talo projects at the University of Vaasa, and their usage of the water body for heat exchangers was the way to satisfy this policy. Moreover, we need to use RE as a solution to the climate change problem and adapt to climate change/use it as an advantage. The solutions to the climate change problem are diverse and locally based. They say ''a lot of spider tread together can hold a lion'' or in other words ''unity is strength''.

The use of small and diverse solutions in local areas such as replacing energy usage with RE solutions and others will solve climate change worldwide if adapted over time. This study also satisfies and tries to address the need for a CO_2 reduction policy in NCs.

Based on this goal, Finland's National Energy and Climate Strategy is increasing its share of renewable energy sources [5]. The Vaasa region has been active in energy solutions implementations and studies. Renewable energy is one of the focuses, and the seaside energy solutions study was the focus of this paper. One of the main ideas was implementing different resources for a particular area in the Vaasa region. The energy demand and supply differ from place to place due to climate change. Some places require more energy, others might face less energy demand, and some might experience more cooling demand than heating, as noticed in Midwest U.S.A. discussed by [9]. The same or relative situations are expected to vary place to place in Finland as well. The conclusion of [10] reports that except for heating demand, for the remaining methods of energy production, 50% of them increase at a minimum of 6% in the climatological potential of wind power and a maximum of 21% in the climatological potential of peat production.

The objective of this review paper is to review the seaside renewable energy solutions and present them in one figure. Moreover, we aim to connect all aspects of renewable energy to the energy transition caused by climate change towards sustainable development. As well as giving background literature from the past, current and future renewable energy projects conducted at the University of Vaasa, these projects are representative types; thus, they can be adapted and expanded to other locations such as Africa.

The contributions of this review paper are: illustrating the seaside geo-energy renewable resources in one figure (Figure 1 in this paper); suggesting and showing the expansion of local seaside renewable energy implementation to local areas and other worldwide locations to facilitate combating and mitigating climate change; showing possible future renewable energy solutions in seaside areas and suggesting seaside renewable energy solutions for local area use and gives background literature for seaside renewable energy and their connection to climate change, water resources and land uplift.

The novelty of this study is seeing a problematic effect as an advantage to overcome the problem by itself. In other words, using the effects of climate change to our advantage and using them to generate seaside renewable energy resources to combat and mitigate it.

2. Seaside Renewable Energy Resources

2.1. Possible Types of Seaside Energy Solutions

The cost of energy on islands is higher compared to other areas. Regional differences exist in using different renewable energies [11]. Here, we focused on seaside renewable energy resources. The main types of energy sources in seaside locations are renewable energy, mainly water-based and borehole systems. Both are the geo-energy types of resources located near water bodies. Figure 1 shows the possible geo-energy solution for installation near seaside or water body areas. This is one of the main contributions of this review paper. In water bodies, there can be installation of water heat exchange. At the bottom of the waterbody are possibilities for installations of sediment energy. Nearby to the water body, there can be different depths of borehole systems: 1. shallow borehole; 2. middle deep borehole (1–2 km depth) and; 3. deep borehole ("deep heat" 5–10 km depth). This study emphasizes water heat exchangers, shallow boreholes, and sediment energy suggested in seaside areas such as the Merten Talo project site. The main solutions that were planned to be installed first were water heat exchangers and borehole systems. However, the water heat exchanger has to be lifted after installation because of a disagreement between the Merten Talo project owners and the University of Vaasa.

Seaside areas and islands are sensitive to climate change, especially sea-level rise and flooding. Even though in Finland, especially in the city of Vaasa borders, land uplift is higher than sea-level rise, the area is also affected by the sea-level rise to some extent. In addition to climate change effects, there are other difficulties and challenges present at the seaside for utilizing energy resources.

2.2. Seaside Difficulties and Challenges for Energy, Especially on Islands

The difficulties noticed in the Kvarken archipelago were based on the "Drop in Sea" project outcomes and other discussions: (1) The cost of oil is expensive due to the additional cost bought transportation to islands by boat. (2) Difficulties to install borehole energy storage systems because the islands are usually rocky. (3) Sediment energy is not visible, at least not near the city of Vaasa (Kvarken Archipelago), because there are many rocks at the bottom of the sea. (4) Island energy production is more expensive than in other areas. (5) Land uplift shifts the harbor over time so that installing, for example, a "water heat exchanger" is disrupted after many years of use because the 'water heat exchanger' is not in seawater anymore if it is not installed deep in seawater at the time of installation.

2.3. The Possible Future Renewable Energy Solutions in Seaside Areas

This seaside renewable energy solution uses climate change as an advantage. Climate change is a change in the current climate mainly due to CO_2 emissions in the late 20th century. Some say climate change is a hoax, but I am not in those groups. The group I belong to is those who believe climate change is real and that a need for action by the entire population is essential. Knowing that there is controversy among different people, even scholars are showing how much people overlooking evidence. The report by the IPCC group is enough to not only make us believe but also act to create solutions and save the future world climate for the next generation. One way to do that future work would be to adopt renewable energy solutions. For example, in the ethylene industry, new technology (EOD-Ethylene oxide dehydration) can substantially reduce energy and GHG emissions [12]. Implementing various energy solutions in any potential polluting industry can provide great results in reducing global emissions from industries.

Girgibo [10] presents renewable energy resources that use climate change as an advantage by answering the following question. What energy usage methods may be used to extract renewable energy in the Merten Talo area? The possible seaside renewable, advantageous energy alternatives in the Merten Talo Project area would be: UTES (underground thermal energy storage), a water heat exchanger in the sea, ATES (aquifer thermal energy storage), wind energy, BTES (borehole thermal energy storage), solar energy, GEU (groundwater energy utilization) and asphalt energy. Sediment energy can benefit from global warming, but it was not found suitable to be installed at the Merten Talo project site. However, here in the city of Vaasa, Suvilähti area, sediment energy has been installed and experimented with by our renewable energy research group members.

Shrestha et al. [13] said that global warming technology innovations could minimize GHG. In addition, according to [14], some of the solutions to combat climate change are using and installing renewable energy resources as widely as possible. Doing so benefits us and helps save the world from climate change problems. There are various choices for the use of renewable energy, among them, the ones explained in this paper are the new methods for seaside areas. These include water heat exchangers, sediment energy, wave energy and deep wave energy, asphalt energy, GEU (groundwater energy utilization) and BTES (borehole thermal energy storage systems), wind turbines, KNBNNO-material and solar systems.

2.3.1. Water Heat Exchanger

The development of renewable energy that can be used as seaside energy solutions has been progressing in the University of Vaasa renewable energy research group with promising experiments and publications. For example, these publications show a new way of looking and thinking about renewable energy utilization: Refs. [15–17] in sediment energy, ref. [18,19] in asphalt energy, ref. [20] in biofuel energy at University of Vaasa renewable energy research group. The installed water heat exchanger's main principle is shown in Figure 2. However, in the picture, the ground was replaced by a seawater heat source in our case.

Currently, water heat exchanger renewable energy utilization is continuing to make promising progress at the University of Vaasa. It provides a way to source new and innovative renewable energy resources from our environment that can possibly be utilized as seaside energy solutions. The main energy source for water heat comes from the sun and earth, called geo-energy, as shown in Figure 1 at the beginning of the seaside renewable energy resources section. The hot carrier fluid, mainly water, can be stored in bedrock batteries for different times or seasons of usage. This water heat exchanger was installed and removed from Merten Talo shown in the next picture (Figure 3). It is a new type of water heat exchanger that has been used only a few times in Sweden and now in Finland. According to the description given during installation, the water heat exchanger is safe for the environment. It is made from Polyamide-100 (PA-100) plastic-type, with thermal conductivity of 0.40.3 (W m^{-1} K^{-1}). It will not build ice inside even in (−2 °C) and is approximately 109 m long when stretched from the circular structure (see Figure 3) to parallel length. Figure 3 shows the water heat exchanger installed in Merten Talo connected to the tubes (of the heat pump), which are insulated (picture taken on 18 October 2018). Moreover, Figure 4 shows this water heat exchanger inside the seashore at Merten Talo. Table 1 shows the water heat exchange installed with a potential supplier, the GeoPipe water heat exchanger product list given below [21].

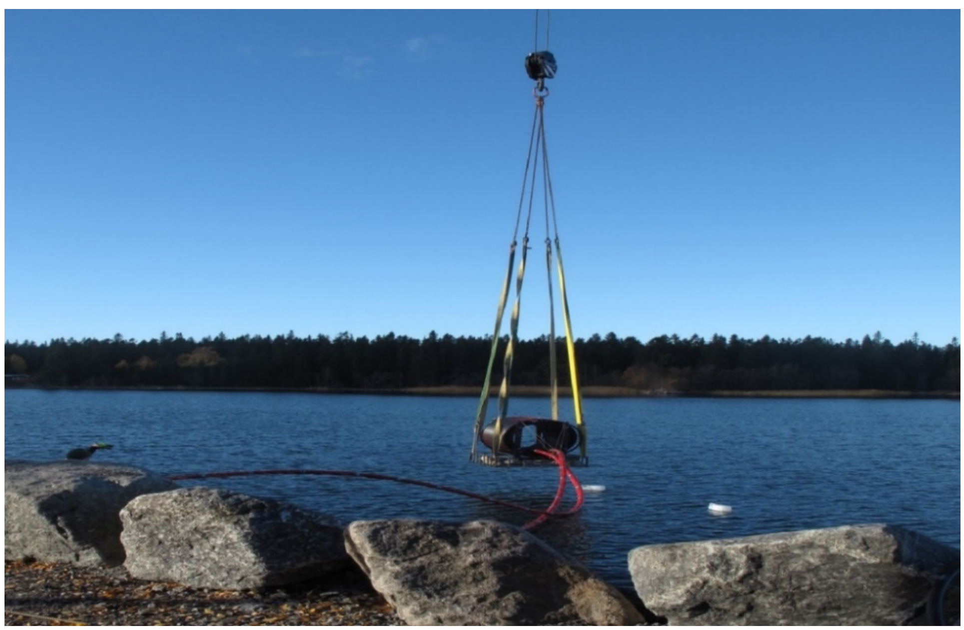

Figure 4. The water heat exchanger being put inside the sea shore at Merten Talo (Picture taken by Anne Mäkiranta during installation process 18 October 2018).

Table 1. Shows a potential supplier of the GeoPipe water heat exchanger product list [21].

Descriptions of Water Heat Exchanger Size (mm)/Energy Production Capacity in (kW)	
Water heat exchanger	9.6 kW
Length	1450 mm
Diameter about	1300 mm
Installation depth minimum	3000 mm
The ice margin is about	600 mm
Water level variation of about	1000 mm
The diameter of the exchanger is about	1300 mm
Heat pump	13 kW

Distribute temperature sensing (DTS) wire was also installed along with a water heat exchanger. The red wire circled the water heat exchanger is a DTS wire (see Figure 3). Temperature measurement is distributed along the wire, which can be used for several kilometers [22]. Light emitted along the wire and the ratio between anti-stokes and stokes scattered light spectrum gives the temperature; location can be found by measuring the round trip by computer (Figure 6 of ref. [22] Figure 14 and explanations and of ref. [23]). It was installed to record the temperature of the water near the water heat exchanger to study the process. Anne Mäkrianta studied the DTS technology use in asphalt and sediment energy in depth in our research group (the University of Vaasa, Renewable energy research group) [22].

In Hiltunen et al. [16], they discussed different types of ground source heat systems. Among those, the open and closed loop lake or sea water heating systems were described. The installed water heat exchanger is a closed loop water heating system where the heating carrier flood circulates in a closed loop. The open loop systems use the lake or seawater described by [16]. This article seems to be the starting paper for the installation plan and buying the water heat exchanger from the Geo-pipe Company. Banks [24] also described these methods to some extent. The other description of [16] was that the installation has to be 3–4 m deep to avoid the risk of ice buildup in the system. Because of this risk, this system is said to be sensitive to damage. In the Merten Talo installed water heat exchanger, there is no ice buildup risk which was not expected because the water exchanger was installed around an 8–12-m-deep section of the nearby seawater. It was also mentioned that 2–3 m deep below the surface of the water is the depth to obtain heat from the waterbody [8].

After the installation of the water heat exchanger at the Merten Talo project site, disagreement started between Merten Talo project leaders and the University of Vaasa. Therefore, the water heat exchanger has been lifted and brought to the University of Vaasa to be used in the Meri-campus project. Hence, the Merten Talo project leaders would not like to connect the water heat exchanger to the heat pump on the site. The climate energy causing water temperaturee to increase is creating an opportunity to use water heat exchange much more in the future as seaside energy solutions.

According to an internet search and our contacts, there is no literature material for our type of water heat exchanger. On the other hand, other water heat exchangers have been studied in many nations. Two examples are [25], a simulation and experiment study in earth water heat exchanger for cooling can be noticed which was conducted in India at a soil depth of 3.5 m and [26] simulation study on U-tube underground heat exchanger is another example. The [25] study shows an inverse correlation between the pipe length and the earth water heat exchanger. In addition, they noticed that in this water heat exchanger, when the mass flow rate increased from 0.008 kg/s to 0.05 kg/s, the performance decreased and what they had proposed seemed to work better than other literature studies they looked at Jakhar [25] and his team found that an earth water heat exchanger with a 60 m pipe length would be sufficient to cool from 48.5 °C to 25.5 °C per existing photovoltaic cooling system. Compared to our water heat exchanger installed in Metern Talo, which has a pipe length of more than 100 m, it is visible for sufficient heat production and cooling purposes. It was found by [25] that the property of the earth heat exchanger does not affect its performance. This result might be the case for our water heat exchanger too.

In the Jakhar et al. [25] study, they had varied burial depth, pipe material, pipe length, pipe diameter and mass flow in their experiment. They found out the burial depth variation was high with a small depth, but when it goes deeper, i.e., a depth of 3.5 m, the temperature variation is small. This fact is true for all earth soil because the temperature profile becomes constant after some depth without being influenced by the weather conditions. On the other hand, when considering our water heat exchanger, the sea depth profile varies from time to time based on weather (such as air temperature) conditions. The property of material does not show in Jakhar's study on earth water heat exchanger performance, and other studies show similar findings on the property of the material. Increasing pipe length increases performance (meaning decreasing temperature, which is what they look for), which decreases with increasing mass flow. Increasing pipe diameter benefits the performance (temperature decrease) in the long run, but the economic factor increased in their study with increasing diameter. Increasing mass flow rate increases the outlet temperature, according to their text; this is because with increasing the flow rate fluid, the contact time to soli, which cools it, decreases significantly. In their study, simulation was also used to compare with reference earth water heat exchangers found to have better performance and the use of them for cooling purposes by a concentrating photovoltaic system.

On the other hand, in Yang et al. [26] simulation study, they used the user interface tool-pdetool of MatLab software to simulate temperature distribution in the soil near the underground heat exchanger (on adjacent borehole systems). They used a two-dimensional model based on MatLab's column heat source theory. The borehole system, a groundwater heat pump, uses the solar energy stored in summer and extracted in winter based on this study description. Their experimental result revealed that the energy efficiency ratio (EER) could rise to 4 by using a hybrid system with the highest value. They described that EER decreases less and less with running time, and the average EER was 2.28. According to this study, figures presented the temperature distribution in simulation increases for both single and multiple boreholes with increasing running periods. In addition, multiple boreholes had a slightly higher temperature distribution level in the same sunning period than that of the single borehole, which is obvious because the adjacent boreholes support each other in temperature difference in multiple boreholes. A water heat exchanger might be advantageous by taking heat energy from the sea and building much more suitable living temperatures near it. It is ideal for creating an experiment by varying burial depth, pipe material, pipe length, pipe diameter and mass flow. Other studies, such as [27], studied the solar pond heat and mass transfer in salinity gradient, which limited the use of the seaside solutions proposed in this work.

2.3.2. Sediment Heat Energy

The sediment energy heat source is from geo-energy, as shown in Figure 1 at the beginning of the seaside renewable energy resources section. '' 'Sediment energy' is renewable: the heat energy of the sediment layer comes mainly from the sun, and only a minor part is from the Earth's geothermal energy'' [15,28]. It is important to notice what energy is available in each location and the combination of sun and geothermal energy as an energy source called 'Geo-energy'. The method of collecting the sediment heat is by installing pipes at the bottom sediment and by circulating heat extracting liquids. The heat carrier fluid can be stored in bedrock batteries. Based on Likens and Johnson [29], the major sources of heat available to the bottom sediments of a lake are (1) solar energy (seasonal storage and loss) and (2) geothermal energy. The same article stated that the flux of solar energy is 4 to 5 orders of larger magnitude than the flux of geothermal heat on a normal land surface. However, in sediment, the geothermal heat source is more significant than solar heat because it is covered by water.

Hiltunen et al. [15] publication shows the potential of sediment renewable carbon-free energy for heat production in the local area. The use of solid, organic sediment layer at the bottom of water bodies and heat carrier liquid; is one of the new ways investigated and shown by our university of renewable energy group, which is carbon-free. The sediment energy can be used for cooling in summer and heating in winter, as shown on the Suvilahti shore in the city of Vaasa, Finland [15,16,28,30]. Mäkiranta et al. [17] further study the correlation between temperatures of air, heat carrier liquid and seabed sediment in the renewable, low-energy network. In their investigation, they confirmed that the air temperature, water temperature (after two months), and sediment temperature indicated by carrier fluid had both Pearson's and Spearman's rank positive correlations.

A further study on seabed energy in annual renewable heat sources conducted in our renewable energy group in the past at the University of Vaasa has been published [31]. The results in this study demonstrate that collecting the heat energy does not cause permanent cooling of the sediment, and the energy is sustainable. Air temperature influences the water and sediment temperatures [31]. This point is important in our climate change and water quality analysis. Hence, one of the results of that analysis shows that global warming causes air temperature to increase, and it causes an increase in the water temperature. Thus, water quality is influenced by water temperature change. It is important to notice on the other side of the city of Vaasa is not the sampling point for water quality data. The conclusion of Mäkiranta et al. [31] was that sediment heat is a potential energy source in the city of Vaasa, and the depth has to be kept at least 3 m downward from the sea bottom. They also noticed that ''the value of the maximum sediment temperature per month was calculated as an average of temperatures at a distance of 280–300 m from the shore.'' [32] presents both sediment energy and asphalt energy studies results in combination, which was experimented within the city of Vaasa, Finland.

Golosov and Kirillin [33] studied two lakes from Russia and Germany for their sediment conductivity based on the model that uses lake water temperature without any data on sediment thermal property. This approach seems very useful for sediment-heat energy analysis—the model, at least some parts, can be found online freely according to their description. Lake sediments play an interesting and appreciable role in heat transfer and exchange between lakes and the lower atmosphere (ground earth) based on the suggestion in most lakes [33]. In addition, they stated that the model could be used effectively to estimate the effects of climate change on lakes, and can be used to analyze the backward effect of lakes on the climate system. The benefits of near-bottom temperature (at leak sediment boundary) include crustal for the activity of the benthic community and biochemical process, which is especially important in ice-covered lakes and is the major heat source in those periods controlling various important processes [33].

According to Likens and Johnson's [29] article, the heat stored in the bottom sediment of a lake can be an important source of heat during the winter. Depending on the lake type, the mixing and penetration of the sun to the bottom of the lake differ. For example, in the meromictic lake used in [29] experiment, the low or non-mixing conditions of the lake water cause fewer annual temperature fluctuations in deep water. In addition, in that particular lake water (Stewart's Dark Lake), due to the high concentration of humic colloids or colored materials, the solar radiation penetration is low. This result shows that the sediment-water energy that builds up from geothermal and solar depends on the type of water bodies. Solar energy is predominant for the overall heat budget of a lake [29]. Mixing circulation patterns in the lake and direct solar energy through direct isolation can heat and/or cool the bottom water of a lake, from the same article descriptions. Moreover, direct heating from solar energy is influenced by how deep the lake water is. Shallow water lakes can heat up easily on their water body and at the bottom.

The sediment heat budget becomes more significant as the average depth of a lake decreases and is nearer the shores than in deep water [29]. Smith [34] found that yearly differences in the measurement of water-sediment heat exchange can show the difference in temperature value due to different time (year) recordings, making it difficult to compare them. Some studies show that activities and construction in a water body can affect the water quality for some periods. The construction of sediment heat can affect water quality as well. This can be considered one kind of risk to the environment caused by renewable energy use and production. Past conference papers of Ostrobothnia indicated that constrictions in water areas influence water quality parameters. Sediment energy is one of the important types of seaside energy solutions. Its use is important with further developments.

2.3.3. Wave Energy

Tide waves can be generated from the attraction between the moon and earth, as stated by [35]. The tidal wave is the energy source for wave energy production. The method to collect it is by using different mechanical systems above and under the tidal wave. See [10,36] for the types of equipment used. The electrical energy produced in small mechanical turbines can be stored in batteries. Open oceans have much more tidal waves than seas. The tide of the northern Baltic Sea might not be significant, only 1–2 cm [37]. However, from a wave energy production perspective, the Baltic Sea is a promising water body having an economic potential of 24 TWh of energy [38].

The Baltic Sea can contribute to future renewable energy production by wave energy [10]. In addition, the tide wave energy can be collected in several ways, as described in [10]. For more descriptions and discussion of wave energy, see this publication. The collected energy can be transferred to electricity by using different types of turbines and can possibly be stored in batteries. According to Heino [36], the environmental effect of wave energy is that it might enhance the ecosystem by creating shelter so seaweed, branches, and other invertebrates can flourish. In addition, there is the possibility of using fishing nets in the area to increase the abundance of fish. It generates some noise, which is a frequency of 50 Hz, but the noise is not much louder than the ocean water noise. The foundations of the wave equipment can create artificial reefs, which enhance biomass for several sessile or motile organisms. On the other hand, wave energy devices are a potential treatment for marine birds. Direct negative impacts include the risk of collusion (such as underwater collisions), disturbance, and redirecting during construction and operation.

The wave climate affects the wave energy converter, which can be a global influence or local condition [39]. Moreover, to maximize the wave energy converter's power absorption, the local wave climate must be considered. A wave energy converter's annual power production depends on the power matrix of the wave energy converter and the local wave climate [39]. Tuning the wave energy converter to the local sea wave state frequency is essential in energy production from wave energy. According to Rajasree et al. [40], climate change affects the current wave pattern. It is good to see the future predictions of wave data. In addition, they suggest that predicting the shoreline shift, erosion, and accretion over a specified time is traditionally performed based on past wave data. An experiment conducted on the shoreline of India by [40] found that sea waves will increase in the future. Due to this increase, there is a substantial increase in the volume of annual sediment transport in the future on the Indian shoreline. This result might be more or less the same for most parts of the world's shorelines. Because of climate change, the overall wind speed and sea level rise is increasing. This result means these increases can substantially increase wave power, causing sediment transport from shores.

According to Rajasree et al. [40], the result of erosion on the shoreline of India is continuous erosion with an annual average rate of -1.46 m/yr maximum and the average maximum is -2.21 m/yr. In India, on the shoreline under study, there is three times more sediment transport. On the other hand, the wave height increases annually. It was found that in the past, the wave height maximum was 0.016 m/yr, but in the future, it is predicted to be 0.042 m/yr. This result is a good global data example of a substantial wave height increase in the future. This study was performed by using Geo-referencing low-resolution satellite imaging analysis. There is a difficulty, as seen in this article, that a shortage in storm effects can make one unable to ageist the wave analysis. To include the climate change effects, it is possible to increase the numerical wave model empirically by a certain amount [40]. According to the same article, different references indicate that the occurrence of waves and their intensity (magnitude) would change (probably increase) over time for the entire world.

Girgibo [10] and Heino [36] describe the different types of wave energy production and equipment. Heino [36] explains the types of equipment used in wave energy production. Among the different types of wave energy equipment, the hexagonal types are much more efficient [38]. These developed equipment and methods can generate a useful amount of energy in seaside areas. In addition, the newly developed deep-water wave energy utilization system [41] can help extract more energy from deep sections of the sea and ocean. Such developments help us use more wave energy in the future. The seaside or deep-water areas can now generate wave energy efficiently. The advantages of climate change, mainly freeing up seas from ice, can help generate more wave energy in the future. Wave energy is one of the main types of energy production methods in the seaside, along with sediment energy and water heat energy production. There has been some progress in wave energy compared to water heat exchanges and sediment energy. Therefore, utilizing wave energy can be highly recommended.

2.3.4. Asphalt Energy Resources

Asphalt and sediment energy is noteworthy to be used even in northern climate countries such as Finland [32]. The main source of energy for asphalt is solar energy and, to some extent, geothermal energy. The way to collect the asphalt heat is by installing heat carrier liquid under the asphalt at different depths. Asphalt energy can be stored in bedrock heat battery systems [42]. There are increasing studies about asphalt energy, including at the University of Vaasa [18,43].

Further depth analyses and experiments were conducted in different seasons and the asphalt energy potential is published in our university [19]. They concluded that there is a potential for heat energy to be gathered from asphalt layers in Finland in most months except wintertime. Çuhac et al.'s [44] publication further explored and improved the asphalt heat measurements at the University of Vaasa. According to Çuhac et al.'s [44] findings, provided that the night losses can be properly handled, their result implies that the asphalt layer could potentially collect up to 670 kWh/m^2.

2.3.5. GEU (Groundwater Energy Utilization)

The presence of heat convection can facilitate groundwater usage as GEU (groundwater energy utilization), and conduction from bedrock heated by magma or other possible heat sources mainly generated heat from magma [45]. The heat source is geothermal energy. There might be an exceptional possibility that the sun can affect it if is not too deep and located not more than 10 m from the surface of the earth. The method to collect heat from it can be by withdrawing from one groundwater, then using the heat and then dumping the cold water in other locations [46]. The heat is exchanged in the land to other liquids in the heat exchanger, and the warmed liquid can be stored in bedrock batteries.

Grant and Bixley [45] described the fact that the various conditions of fluid or rock heat development and accumulations in groundwater and aquifers could facilitate their chance to be a source of heat for the local community. This kind of source is used as a source in many areas of the world, such as Iceland. The book shows the connection between groundwater and aquifer with geothermal reservoir engineering. Such a geothermal reservoir might not be available here in Vaasa, even in most parts of Finland. However, it gives a side view of the possibility in other nations, e.g., Iceland. The idea of using GEU in Vaasa was recommended based on the graph [5] presented in his dissertation.

On the other hand, according to Watzlaf and Ackman [8], flooding mines, which can be found in many regions of the world, are a cost-effective option for heating and cooling using geothermal heat pump systems. This fact is important because operational costs are much lower than that of conventional heating and cooling (costs of using mine cooling system is less than 50 % conventional one) options, as the same article mentioned. However, how far the mines are from the city or living towns is also a good question to raise when considering this system for heating and cooling, which is a renewable energy source. Based on the groundwater access, land availability and drilling cost, a ground source heat pump can be designed in various styles [8]. Using heat pumps as an underground water heat source, a mine water heat source, or a water heat exchanger makes gaining heat energy much more efficient. The two common ground source heat pumps are closed and open loop systems [8].

The GEU (Groundwater Energy Utilization) system is ideal for utilizing climate change effects as an advantage and can be one of the relations between water resources, climate change and energy. GEU is an open-loop system where the groundwater will be pumped to the surface. Then, thermal energy will be transferred to energy systems, and the cooled water will be pumped back to aquifers [5]. This system can be used for cooling and heating as ATES (aquifer thermal energy systems). UTES refers to underground thermal energy storage systems where heat accumulated by the earth's soil is used as a heating source, based on Girgibo [10], and it is one of the solutions recommended in that paper.

This system comes in two versions; ATES and BTES [10]. ATES refers to aquifer thermal energy storage systems where aquifer water circulates in tube heat exchangers, where heat is exchanged into liquid or air, and where cooled water is dumped in another aquifer. The cool water is kept in the new aquifer until it recharges for the next circulation. BTES are systems that heat liquids such as water in boreholes, pump the liquid to the surface heat, exchange it for another medium then pump it back to the same boreholes to heat up. These systems (especially GEU) are useful because they can adapt to climate change, such as global warming, which causes an increase in temperature. All systems use renewable energy sources, in this way, they contribute to CO_2 emission reduction and avoid leaks of oil to aquifers. This study shows that the effect of climate change or global warming is possible to be used as an energy source and warmer water resources (such as aquifers).

The main source of BTES is geothermal energy. The heat is collected by keeping hot water in the ground at a constant temperature or warming up the heat, transferring liquids into the borehole. It acts as the heat storage system for water or other heat carrier liquids. Because the winter conditions make some areas of the soil below zero, there is a need to use carrier liquid. Some studies have been conducted in our department at the University of Vaasa on borehole systems, such as in [47,48]. Boreholes also act as cold storage for cooling purposes. One example of this was the study and publication by [49] about a preliminary test for using a borehole as cool storage. This study was also performed by the University of Vaasa in Renewable energy research group members. Their study shows that the borehole can be used for cool storage and loaded into the borehole similarly to heat. One of the constraints of building decentralized energy storage is reducing the cost of in-ground heat storage [48]. In addition, Haq and Hiltunen [48] stated that ''to increase the temperature of the ground heat storage concerning the injection power, the volume of the ground heat storage needs to be increased''. Mostly gneiss and granite without volcanic activity is Finland's bedrock property [23].

2.3.6. Wind Turbines

The wind energy conversion system converts the wind kinetic energy into electric energy or another form of energy [50]. The source of energy is the kinetic energy in the wind. The kinetic energy in the wind is collected by the wind turbine, which can be a horizontal axis wind turbine (HAWT) or a vertical axis wind turbine (VAWT). The electrical energy produced in wind turbines can be stored in batteries or other storage systems. Wind turbines were first commercialized in Denmark in the 1980s, and this nation is the global leader in this technology [51]. There are various advantages to VAWT over HAWT. The different aspects of VAWT were studied by two dissertations here at the University of Vaasa [52,53]. The use of vertical wind turbines is encouraged to be used in rush windy conditions. The world-wind conditions are expected to change in the future in most areas and decline in their strength. However, some areas might benefit from the cause of climate change [10]. The suggestion that can be made to VAWT for seaside resources is its ability to be used in windy rush areas and its capacity to be used for local electricity production even if the energy amount is low in the current VAWT studied at the University of Vaasa.

Wind turbines can be installed onshore or offshore. Offshore wind energy can be a suitable energy source in a seaside area. This suggested type of renewable energy in seaside energy solutions by my studies. Wind power is higher usually in water bodies than in lands. This fact benefits the production of energy from offshore wind turbines. However, the installation and running of offshore wind energy production can be difficult, and the cost is also high compared to inland wind energy production.

2.3.7. KNBNNO-Material

KBNNO and KNBNNO do not differ significantly from each other. The production of KBNNO ($[KNbO_3]_{0.9}[BaNi_{1/2}Nb_{1/2}O_{3-\delta}]_{0.1}$) material by the PLD (pulse laser deposition) method was developed for the first time [54]. This finding leads to the University of Oulu finding KNBNNO material [55]. According to the news, the KNBNNO material can produce electricity from motion, light, and heat. This result was hailed as a completely new finding in the area of energy collection. Girgibo [10] described that the applications of this material are in watches, mobile phones, textiles, shoes, replacing batteries, and sidewalk areas. Energy can be gathered from the motion created by walkers and sunshine simultaneously. The cost now for a piece of material the size of a coin can be only a few cents, and additional costs are expected from manufacturing, labor and electricity [10]. More information can be found about this material in the articles of [54,56] and the report [10].

2.3.8. Solar Systems

Kneifel [57] showed in their study that using solar Photovoltaics (PV) in households had a significant increase in energy efficiency, embodied energy (greater contribution) and lifetime cost management. This result was consistent with other publication results. It was planned first in the Merten Talo project, but unfortunately, the solar PV panels were not installed because of disagreements among the project leaders. However, the use of solar energy is important, whether solar thermal energy or Photovoltaics (PV). The main source of energy is the sun's radiation. It can be collected as heat by solar thermal energy systems or Photovoltaics (PV) to produce electricity from the sun's energy. Thermal solar energy can be stored in bedrock boreholes, and PV electricity production can be stored in batteries. Both these systems were planned to be implemented in the Merten Talo project. Solar energy is one of the main energy resources that will benefit from global warming due to the effects of climate change. A combination of solar and wind energy for charging electric vehicles was recommended by [58]. More descriptions of this combination can be found in the recent report published by Girgibo [10].

3. Sustainable Development

Generally, energy resources are necessary for an adequate amount but are not a sufficient requirement for development in society [1]. To generate energy, sustainable renewable energy resources are great options. Converting waste to energy and biofuels are also considered sustainable energy resources [1]. The same article also stated that sustainability is very concerned with environmental protection, which is important because humans all want to overcome environmental pollution as much as possible as long as we live on our planet, the only living place we have. As this study tried to show in the climate change literature review report series, a large amount of environmental impact is generated from energy. Therefore, it is important to convert our energy resources to renewable energy. Dincer [1] stated that there is a clear and strong relationship between energy efficiency and environmental impacts. For the same products or services, increased energy efficiency is associated with less resource utilization and pollution. Understanding and working on renewable energy efficiency is important in gaining more energy and environmental protection.

All renewable energy resources are not inherently clean [1]. Therefore, it is important to choose better renewable energy resources and advance those renewables that generate pollution to decrease their pollution. This study's main energy solution proposed, the 'water heat exchanger', is completely pollution free, which is important in future shoreline areas, where the water depth (>4–5 m) is sufficient enough to install it depending on the size of the water heat exchanger. Going back to Dincer's [1] discussion, decentralizing energy resources will help users to use both positive and negative externalities of energy consumption. In addition, it discussed that the small equipment is easier in its availability because it is easy to design in a short amount of time and use quickly, providing greater adaptability.

Some of the important aspects of renewable energy resources and technology in helping sustainable development are [1]: (1) Less environmental impact and diversity of their sources helps reduce the environmental impacts. (2) Renewable energy resources cannot be depleted, unlike other non-renewable energy resources such as fossil fuels and uranium. (3) The centralized systems might not require renewable energy resource usage, which is why they are more potentially useful in urban use. This factor helps reduce pollution, and it furthers climate change. The use of renewable energy is encouraged to be used worldwide widely to some level to secure sustainable development. However, there are other factors that influence sustainable development. Dincer [1] stated some of these factors are: (1) public awareness, (2) information, (3) environmental education and training, (4) innovations energy strategies, (5) promoting renewable energy resources, (6) financing, and (7) monitoring and evaluation tools. See the article of [1] for further description of these points.

Climate change is a driving source for renewable energy resource transitions. The driving forces of renewable energy rapid deployment are: declining cost, pollution and climate change, renewable energy targets, technology innovation, corporate and investor action and public opinion. Among the reasons why energy transition is happening, climate change is one of the main ones. More studies for a 100 % transition to renewable electric systems by 2050 were made, and the cost for transition capital expenditure is a maximum of 25.5 trillion € [59].

3.1. Efficiency and Challenges for Future Energy Solutions

Energy efficiency and savings are very important aspects of climate change mitigation. Energy efficiency has been acknowledged globally, and the EU ambitiously established the Energy Efficiency Directive 2012 [60]. The report also stated that efficient energy and saving it are key premises for the climate and energy policy. Therefore, focusing on energy efficiency, storage and saving is very important to all aspects of mitigating climate change. Using less energy than before refers to energy efficiency, whereas giving up entirely a system that requires energy defines energy savings [60]. The cost of new technology comes into the picture when considering energy efficiency. Because most savings with energy efficiency comes with new technologies, which require additional costs [60]. Energy efficiency is expected to contribute to CO_2 emissions reduction by 40% in 2070 [4]. Therefore, it is very important to also focus on energy efficiency.

Based on IEA [4], energy contributes to lower CO_2 emissions in two ways: (1) Reducing total energy use and (2) placing downward pressure on upstream supply systems. Energy efficiency increment in households by choosing various parameters and sealing insulations (3) referenced below: Sweden increases household efficiency by insulation sealings in windows and doors [6], Sukhatme [61] book for basics of how to use solar in household efficiency and ventilation without air conditioning systems and [57] house building energy and emission efficiency. Kneifel et al. [57] stated that when considering energy efficiency application, it is important to consider the effect on operating and embodied carbon emissions. In their study, life-cycle energy is not quite proportional to life-cycle carbon, which is consistent with other discoveries. There is some difficulty in studying energy-related emissions in considering embodied emissions.

Moreover, life-cycle energy and life-cycle carbon emissions are driven mainly by operating energy. It was also stated in this article that, in terms of the technology and economics perspective, it is difficult to change from net-zero operation flows to net-zero life cycle flows in their experimental site investigation. All in all, increasing the efficiency of energy production and use can help reduce much of the emissions. Therefore, it is very important to address efficiency in new projects or renewable energy installations and use.

3.2. Energy Storage

A part of the renewable energy system is energy storage, which is one of the main issues. This includes short-term periods and seasonal storage systems. The book from Huggins [62] gives a depth of knowledge in energy storage systems. It is worth looking at his book to understand the concept of energy storage: fundamentals, materials and applications. Here, only a few energy storage types are presented, mainly thermal energy storage systems.

3.2.1. Thermal Energy Storage Systems

In thermodynamics, the inertial energy present in the system due to temperature is Thermal Energy. According to Hauer et al. [63], a thermal energy system (TES) is a technology that stores thermal energy so that the stored energy is used in later periods. The thermal energy is possibly stored by heating or cooling a later storage medium for heating and cooling applications and power generation. There are three kinds of TES systems as stated by [63]. (1) The sensible thermal storage system (STES) which is based on storing thermal energy by heating or cooling a liquid or solid medium (e.g., in our case, ice thermal storage system for cooling [64]). The compressed air energy storage system [65] and ATES (aquifer thermal energy system) for heat or cool thermal storage in aquifers) [66]. (2) Latent heat storage using phase change materials or PCMs (e.g., forming a solid state into a liquid state [67] for buildings). (3) Thermochemical storage (TCS), using chemical reactions to store and release thermal energy (e.g., in our case cryo-adsorptive hydrogen storage tank) [68].

3.2.2. What Are the Possibilities of Thermal Energy Systems? What Is the Best Technology and Why?

Among the three explained kinds (STES, PCMs and TCS) of thermal energy storage systems in the above section, some options are chosen. From the STES, the possible solutions for us can be: (1) ATES (aquifer thermal energy systems) for cooling and heating depending on the season; (2) borehole storage systems; (3) the ice thermal storage tank for cooling; (4) advanced adiabatic-compressed air-energy storage system (AA-CAES). There was a non-choice made among the PCM system, but the cryo-adsorptive hydrogen storage tank was chosen from the TCS system. These listed technologies are some of the best and most applicable in the area of large industries and commercial buildings.

The best choice for us is ATES for both cooling and heating. Then, the other options are used.

ATES (Aquifer thermal energy storage system) [10,66,69,70]: This is the first type of UTES (underground thermal energy storage system) where it uses aquifer as heat storage. An aquifer is defined as the underground water storage between rocks and land faults. It can function without the connection of the water table (unconfined aquifer) and with a connection to the water table (confined aquifer). The hot water can be pumped from an aquifer and then dumped in another location after heating or cooling. Then, dumped or allocated aquifer water can be used as another circulation when it gets recharged. In winter, the aquifer temperature is higher, so it can be used as a heater; in summer as a cooler.

This approach is mainly utilized for heating and cooling households but is also applicable for industrial use. The only limitation is that the location has to have a geological formation of aquifers. At least in the city of Vaasa, there are some groundwater and aquifers. It is believed that in the city of Vaasa, the use of GEU (groundwater energy utilization) is ideal [5]. Therefore, the use of ATES is possible, and it is one of the energy solutions proposed in my research to adapt to climate change water temperature increase in groundwater and aquifers if they are nearby the land surface. As land depth increases, the ground temperature becomes constant and is hardly affected by climate change. ATES is renewable and minimizes CO_2 emissions. Consequently, it helps the community utilize renewable energy to combat climate change.

Borehole storage systems [24,69]: The other proposed solution for energy storage and generation. It is a type of UTES (Underground thermal energy storage system). Activated by installing at least a 2 m deep pipe which is circulated under soli for heat absorption from the ground to liquid then pumped to surface then used. The circulated liquid can be water or other heat carrier solutions with or without water. The pipe installations can be in different patterns; there are some energy-saving types of installations that save money, space, and heating time. The uses of borehole systems are mainly ideal for heating, but ATES can be used both for heating and cooling in different seasons, as mentioned in Section 1 (See [24,69] books for further reading). Borehole heat storage was installed in the Merten Talo project. Borehole systems have been tested to be used as cool storage in our renewable energy research group at the University of Vaasa.

Ice thermal storage tank for cooling [64]: This is a system that can be used combined with other parts in plants for cooling (see Figure 1 in [64]). Built-in ice storage is ideal for IST (ice storage tank). The hybrid option of the TES system of water-phase transition, solid-melting liquid, and liquid freezing solid accomplish energy-efficient control. At the time of off-peak electricity hours, the ice is built and stored in tanks. Then, at high-peak electricity time, it can be utilized for cooling, saving energy for cooling purposes. A sophisticated routine can be used to achieve higher savings on power and cost. The energy conversion rate is high; hence, it can minimize electricity use at high-peak times.

Advanced adiabatic-compressed air energy storage system (AA-CAES) [65]: The method works by storing compressed air deep, e.g., in salt reservoirs when the electricity is at its peak, underground after passing through on compressor and tightly insulated tanks in a tube. The stored temperature underground is around 40 °C. Then, when grid electricity is in shortage, for example, there is no wind for wind energy turbines, the compressed unground air can be pumped back to rotate the turbine after heating. This method can generate and supply the grid electricity shortage when needed. The usage can be, for example, in food and agriculture industries when electricity shortage can be used to generate electricity. Hence, if it can store the overload electricity power, its energy conversion rate is great.

Cryo-adsorptive hydrogen storage tank [68]: The storage system where it can store hydrogen, metal-hydride, and liquid-hydrogen through adsorption. The renewable energy source hydrogen can be used to produce electricity, heat, and a well-run car. Cryo-adsorptive hydrogen storage is useful because of its high capacity in low pressure. Storing hydrogen in pressure requires much space and higher pressure, which is a costly and risky situation. However, the new solutions, metal-hydride hydrogen and cryo-adsorptive, can minimize this risk of high pressure and cost to some level.

3.2.3. State-of-the-Art Promising Features

Here, the most promising features are described by the same list as above. The state of art means the newly developed mechanisms and installations for all chosen types of TES (thermal energy storage systems). (See also [67] about state-of-the-art thermal energy storage PCM (phase change materials) for buildings).

ATES: The most promising future is the combined heating and cooling systems in the same installation for the building. Hot water is pumped from one aquifer and dumped in another in one direction. In winter, the ice coverage preventing the heat from escaping to the surroundings causes much warmer water underground in aquifers as well. In summer, the utilized and dumped cold water can be pumped and used for cooling purposes in the opposite direction-descriptions and illustrations presented in [46], unpublished report, and groundwater report.

Borehole storage system: The solenoid tube structure is the most energy and space-saving tube installation method. This method will save space for installation, and depth and energy efficiency also increases [69]. The installation method is the best way to do it in our case as well.

IST-ice storage tank: In Wu et al. [64] paper, the authors suggest using three combined IST storages along with other parts. The combined central plant systems are one air handling unit, one heat exchanger, one chiller plant, different pipe configurations and four pumps for circulating along with these three IST storages. This structure can be considered state of the art from this paper's suggestion. However, the latest ideas and combinations can be gathered in the future.

Advanced adiabatic-compressed air energy storage system (AA-CAES): This case is based on the latest literature [65]. Among the options listed, the best and most advanced option can be chosen as state-of-the-art. AA-CAES is one of the options in the reference. There is also a solar-AA-CAES method, but the most efficient one is the poly-generation CAES system. State of the art can be chosen from those options described.

Cryo-adsorptive hydrogen storage tank: The combined storage of hydrogen and metal-hydrides can minimize the usage of space and pressure capacity, but the problem with this technology is that the hydrides are much more expensive. However, it is said that hydrogen is an ideal source of energy. For example, 3000 cars' suspension power is needed to lift 300 L and 500 bar compressed hydrogen in a tank. Therefore, lots of energy is stored in a tank. Cryo-adsorptive hydrogen storage has a high storage capacity at low pressure. Both hydrogen metal-hydrides storage and cryo-adsorptive hydrogens storage tank can be considered state of the art for this technology.

3.2.4. Energy Efficiency and Cost of Thermal Energy Systems (TES)

The possible energy efficiency, cost, power and storage period are listed below. We hope Table 2 can show a partial view of the described type of TES. More and more efficiency profiles and other lists can be collected from different resources, but here, half of the boxes are filled from five different pieces of literature.

Table 2. Thermal storage system typical parameters (compiled from [63–66,68]).

TES Systems	Chosen System	Capacity (KWh/t)	Power (MW)	Efficiency (%)	Storage Period (h, d, m)	Cost (€/KWh)
STES	Sensible (hot water)	1050	0.00110	5090	d/m	0.110
	Ice thermal storage system	~3.5	-	-	h/d	0.11
	Advanced adiabatic-compressed air energy storage system (AA-CAES)	-	2	6065	h/d	-
	Borehole storage	-	-	-	d/m	-
	ATES (Aquifer thermal storage system)-Hot	-	0.2512.5	-	d/m	-
	ATES-cold	-	7	-	d/m	-
PCM	PCM	50,150	0.0011	7990	h/m	1050
Chemical reaction	Chemical reaction	120,150	0.011	75,100	h/d	8100
	Cryo-adsorptive hydrogen storage tank	-	-	-	h/d	-

3.2.5. What Can Be Implemented Here in the City of Vaasa and for Industries?

The application of ATES and borehole energy storage systems seems ideal for Vaasa. It is known that the city of Vaasa is one of the potentials for GEU (Ground energy utilization), according to [5]. Therefore, plenty of groundwater resources in the area means we can implement this method without geological problems for Vaasa. The other solutions described need innovation and thinking to install them for industries. For example, ideally, ice tank storage can be very useful in dairy industries where there is a much higher need for cooling, freezing and chilling mechanisms for milk production. Other industries such as meat production also require cooling systems for meat storage. Using TES can save energy and provide more energy when there is a shortage in industrial sites.

Heating and cooling can be necessary all over in industries for heating in wintertime and cooling in summer to stabilize room temperature for food and agricultural products, e.g., keeping vegetables in food and agriculture factories. Some industries, mainly food industries, require freezing and chilling. IST-ice storage tanks can provide this freezing and chilling. ATES and borehole storage systems can combine projects (the Merten Talo and other new thermal energy system projects) hand-to-hand. This study focused on community renewable energy utilization increase and sustainability by minimizing climate change and using climate change effects as an advantage (e.g., water and ground temperature increase at the time and in the future), but not for industrial applications as described in this paragraph.

4. Projects as an Application in Installing Seaside and Renewable Energy Solutions (Projects: 'Drop in Sea', 'Merten Talo', and Future Work at 'Energy Village in Africa')

Next, the descriptions of the three projects: 'Drop in the sea', 'Merten Talon' and 'Energy village in Africa' are presented. These projects plan and/or implement renewable energy resources mainly to combat climate change and to utilize local energy resources.

4.1."Drop in Sea": The Project of Renewable Energy Installation on Islands of the Archipelago

Here, the 'Drop in Sea' project is described [71]. This project took place in Kvarken Archipelago and was interested in real estate and managed by Metsähallitus, private single-family houses and farms in Central Finland. Drop in the sea is the Vaasa Energy Institute and the University of Jyväskylä joint venture. The Vaasa Energy Institute managed the project, and the Levön Institute was attended by the Faculty of the University of Vaasa, Novia University of Applied Sciences, Vaasa University of Applied Sciences and an expert in Metsähallitus. The purpose of the project was to develop a hybrid model service concept for energy self-sufficiency, the implementation of which would be decentralized and constitute several destinations for smart packaging management. The island destination is coastguard and pilot stations, mainly used as tourist destinations. The project was funded by the Mainland Finland Rural Development Programme 2007–2013. The actual time the project is performed is a one-year transfer from the original 1 January 2011 and up to 31 December 2014. The project used less money than was provided by the fund. This project was a very good initiative that helps the islands of Kvarken Archipelago to be self-sufficient by using renewable energy resources. Such projects are very important in encouraging the local areas to utilize renewable energy resources and become self-sufficient, securing or overcoming the energy shortage and minimizing the cost of other fossil fuel energy sources such as oil for heating.

4.2. Merten Talo Project about the Installation of Renewable Energy Solutions on a Local Site

''Merten Talo'' means ''House of the sea'' in English, which is a nice name presenting the use of the nearby sea as an energy resource, other renewable energy resources and building and introducing an exhibition center for the UNESCO World Heritage site. The Merten Talo project site is located at Raippaluoto, an island in the western Finland archipelago on the shore of Vaasa. The next paragraphs are presented to highlight some of the installations and buildings for the exhibition center.

The first step toward renewable energy installations was the initial plan and proposal of the possible solutions to the project leaders. Some of the solutions proposed were: water heat exchanger, borehole systems, heat pump, solar photovoltaics and solar thermal connected to boreholes for storage and asphalt energy. The overall idea was a solar system (photocell) combining boreholes, solar collectors, and water heat exchangers as heat and light sources for household use for exhibition and restaurant buildings. However, the only renewable solution left on the site is borehole systems and a heat pump. The water heat exchanger was installed and then had to be uninstalled because of financial shortage issues for the controlling system to be installed. ''One of the most important issues for the continued growth of most renewable options is their relative cost'' [11]. This statement is seen in this project. The water heat exchanger controlling system cost was high, so the project leaders did not allow it to be used on that site. The solar energy systems were not installed even if they were proposed in the proposal. Asphalt energy and sediment heat energy production was not possible to install because the area is very rocky, so it is not suitable to use asphalt energy near the doors.

The current site is very good as an exhibition center. The ability to see what is present in the UNESCO World Protected Heritage Site is clear now. It will surely increase the number of local citizens and national and international tourists to the protected heritage site, the project's main idea in terms of the exhibition center. In addition, it is expected to facilitate business activity in the local city and area.

The University of Vaasa renewable energy research group was an active member of this project. One renewable energy installation was a water heat exchanger in the sea. However, this equipment has been lifted and returned to the University of Vaasa for another project. The water heat exchanger uses the sea water temperature for heating or cooling purposes. Figure 5 shows the water temperature on Raippaluoto shore. This temperature is expected to rise with the continuation of climate change effects. Thus, the water heat exchanger uses climate change to its advantage. The next Figure 5 shows the temperature profile of the Merten Talo sea shore.

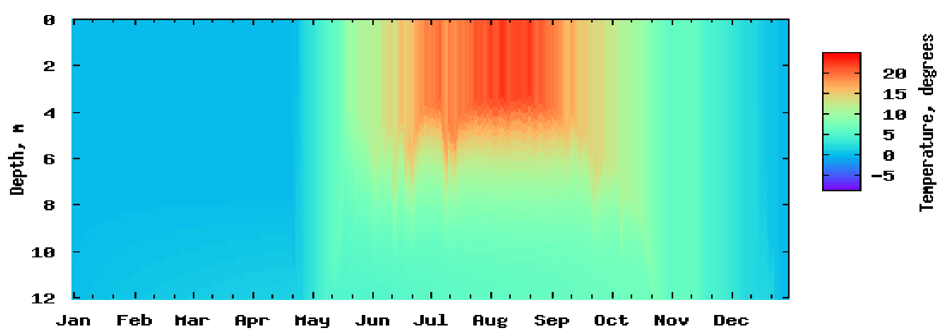

Figure 5. The temperature profile of Merten Talo sea shore (Latitude (−90–90): 63 and Longitude (−180–180): 21) was made by an online model called Flake Global lakes model [72].

The Merten Talo project suggestions, installations and possible experiments were presented in the Results section. The Merten Talo project is the main project that this study considers an installation site and it is a site for this whole doctoral study analyses. The water quality sampling points were designed to be around the Merten Talo project site at the Kvarken Archipelago of the city of Vaasa. The analysis of water quality and climate change can show the effect of climate change on water quality in a naturally protected area. Thus, we can discriminate the effect of pollution in the analysis because the sampling area is naturally kept enough to avoid human interference or pollution.

4.3. LEAP-RE Project Only one Work Package (WP14) on 'Energy Village Concept in Africa' (Current and Future Continuation of Research Work)

The full name of the whole Horizon 2020 project is Long-Term Joint Europa Union (EU)-Africa Union (AU) Research and Innovation Partnership on Renewable Energy (LEAP-RE). Work package number 14 is our section where the ''Energy Village (EV)'' concept in Africa is implemented. The partner countries in this work package 14 are Finland, Ethiopia, Kenya, Botswana and Uganda. The main work package objective is: to further develop the Energy Village concept and test it in developing nations together with project partners, to create 16–20 energy self-sufficient villages in the target countries and to create an Africa-wide network of energy village experts who can utilize the method in their countries. These objectives and the overall work package initiates a smooth transition to zero-emission energy resources in Africa.

The University of Vaasa started to work on the Energy Village concept in 2003. There have been different kinds of projects implementing Energy Villages in Finland, including the EU-funded project ASPIRE project 2006–2009. These projects targeted work on around 30 energy villages mainly in Finland. The Energy Village idea is to create energy self-sufficient villages which produce their energy from local renewable energy sources + for sale. Renewable energy resources can be Photovoltaic (PV), wind, water, bioenergy… etc. Moreover, the energy applications are in all energy vectors: traffic fuels, electricity and heat. In addition, the idea is to take villagers into the development process in the beginning and work together with them to ensure a smooth process and create local income and welfare: work for the people, money spent for energy ''stays'' in the village, rural welfare and vitality and less coal and oil to be burnt. The working time of the project is 4 years (June 2021–May 2025).

The main expected results are: to modify and create a set of tools to serve Energy Village-concept utilization in developing countries; to test the created tools and establish Energy Village in target countries (Kenya, Uganda, Ethiopia and Botswana); to create an Africa-Wide Network to utilize the Energy Village concept and; to identify and suggest tools and options to the barriers and obstacles that need to be removed and the drivers and opportunities that will need to be supported. There are four main tasks in this work package 14 (Energy Village concept). Those are (1) The Energy Village concept and methodology. (2) The development of sustainable energy communities. (3) The Energy Village-wide network, and (4) Policies and recommendations.

''After establishing a vision of the future, governments need to continuously track progress and assess the impact of the adopted measures to deliver net-zero emissions, and to re-prioritise efforts as necessary along the way'' [4]. This statement of IEA is a very important message, especially for developing nations involved in the Energy Village concept work package in terms of this project. This is because if there is no continuation in the energy villages established and if they are not replicated it will be difficult to see a concrete result in combating climate change and making the energy of the village self-sufficient. Therefore, the local governments and leaders must follow the steps described in Figure 6. Figure 6 shows the governing process for a strategy toward net-zero emission [4] and this is similar to the steps that must be used in the Energy Village project.

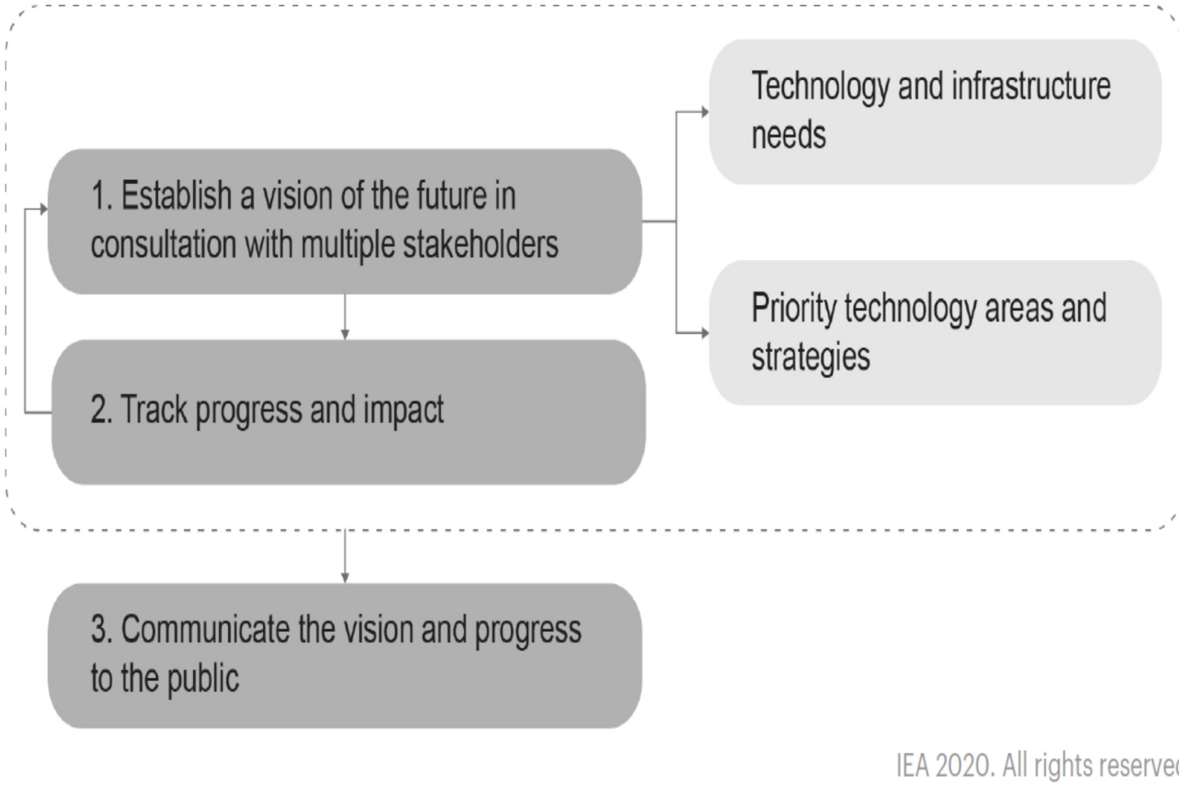

Figure 6. Governing process for a strategy towards net-zero emission [4] and this is similar steps must be used in Energy Village projects.

In the above figure, step one is mainly the work package 14 or 'Energy Village concept' works. The second and third steps had to be developed and adapted by local authorities and the government.

The LEAP-RE Project work package 14 or 'Energy Village concept' project implementation had anticipated possible risk types. These are lack of availability/openness in the data for the definition of Energy Villages; not enough social intervention or lack of agreement in villages in the definition process of roadmap and vision; proactive participation of local inhabitants and private property owners and; interoperability and scalability issues of the ICT tools. These expected risks are planned to be solved throughout the project implementation process.

5. Methodological Lit and Research Gaps Addressed

5.1. Methodological Lit

The databases used in this literature review report series 1 up to 4 were: Scopus, Google scholar, science direct Elsevier journals, Nature Journal, and Google search engine. Scopus, Google scholar and Google search engines are not limited only to specific journals. For example, Scopus has more than 25,000 journals and Google sources are unlimited and it is not known how many journals it can find. These databases provided a lot of search results for some search words. The search words or descriptors used vary for the four topics of this literature review chapter. The main search descriptors used searches were listed as follows.

For the climate change literature review, there were more than 29 descriptors used in the search process the main ones were: climate change, green emissions, flooding, sea level rise, global warming, energy solutions for climate change, metrology change/fluctuations, the relevance of climate change, climate change relevance on energy management, climate change effect on energy sections, temperature variation in climate change, climate change and Finland, and climate change and city of Vaasa were some of them.

For the seaside energy solutions literature review, the main descriptors were: renewable replacement in islands; challenges on using renewable in islands, islands and climate change, islands difficulties, efficiency management in islands, and energy solutions effect on energy sectors on islands.

For the renewable energy resources literature review, the main descriptors used for searching those were: water heat exchanger, GEU (groundwater energy utilization), vertical wind turbines, Borehole thermal energy storage system (BTES), wave energy, challenges with renewables, the efficiency of renewable resources on seaside area, the most economic renewable energy resources, the best renewable resource, climate change risk on renewable energy, renewable energy risk to the environment, renewable energy effect on energy sectors, energy opportunity due to climate change, and renewable energy as combating climate change.

For land uplift, the main descriptors used for searching those were: Land rising and climate change connection, measurement of land uplift, compensation in land uplift, land uplift phenomena in Europe, Land uplift in Vaasa region, Kvarken land uplift, and inclinations in land uplift.

For metrology, a few descriptors used for searching those were: Parameters of metrology, climate change and metrology, patterns in metrology, the study of metrology change and time serious study in metrology.

For water quality, a few descriptors used in the searching process were: Climate change and water quality and water resources and climate change.

For road in ice and the Gulf stream, some descriptors used in the searching process were: Road in ice: ice road availability, ice melting effect, sea ice and climate change, the land rising and sea ice, the decline in ice level and energy opportunity due to climate change wave energy.

For the Gulf Steam: Gulf Steam in Bothnia, Gulf steam forecast, future condition of Bothnia Gulf Stream, coldness in land due to Gulf Stream and Gulf Steam and global warming.

The searching process was very intense and took a lot of time. In this process, more than 380 articles were downloaded in only the main searching time. After a while, there was searching due to the process of the 'snow bowl method'. However, the literature process does not use all of these articles in the full article reading process because of time-limited and unrelated research areas. There were three main steps in the searching process: (1) Defining the parameters of search by the language of publication, subject area, sector and subsector, geographical area, publication period and literature type. (2) Defining my search terms and building relations between them. The main method used in the second step were: brainstorming and relevance tree building. (3) Searching from online databases for full text, abstracts and indexes.

Rational selection and additional searching were performed by seeing relations between different publications. To some extent 'The snow bowl method' was used, meaning that finding one article and looking at the references for other sources led to finding other articles. The same procedure continued until there was no relevant article present in the last article reference. The method used in the literature was the systematic literature review analysis process. In this process, Booth et al. [73] describe procedures utilized as much as possible. The process involved a search for possible articles, followed by a selection of articles using a multi-stage evaluation process. This started with evaluation based on title, then evaluation based on abstract, then evaluation based on a reading of the whole article. That was followed by all the literature review process for four topics of literature review. These are Climate change, land uplift, water resources and seaside energy solutions. Figure 7 was taken from [74] to show the procedure used in systematic literature rereview for the land uplift framework chart development process as an example for one of the topics (land uplift). Similar procedures were used for the rest of the literature review reports.

The criteria ultimately used to select a source to use were the relations between the title, abstract and/or full text and the topic that is intended to be reviewed. This means first we check the relation between the title and the topic to be reviewed if there is a clear relationship it will be taken to the next step. If no relation exists the article will be discarded. If a relation between title and topic exists, then the next step will be checking the relation between abstract and topic. If there is a relationship that exists it will pass to the next step to full-text relation checking. If no relation exists then the article will be discarded. In the last step, the full text and topic to be reviewed will be checked, and if there is a relation, it will be used in the literature review. If not, the article will be discarded. These were the steps used by criteria of the relation between the topic to be reviewed and different sections of articles/papers.

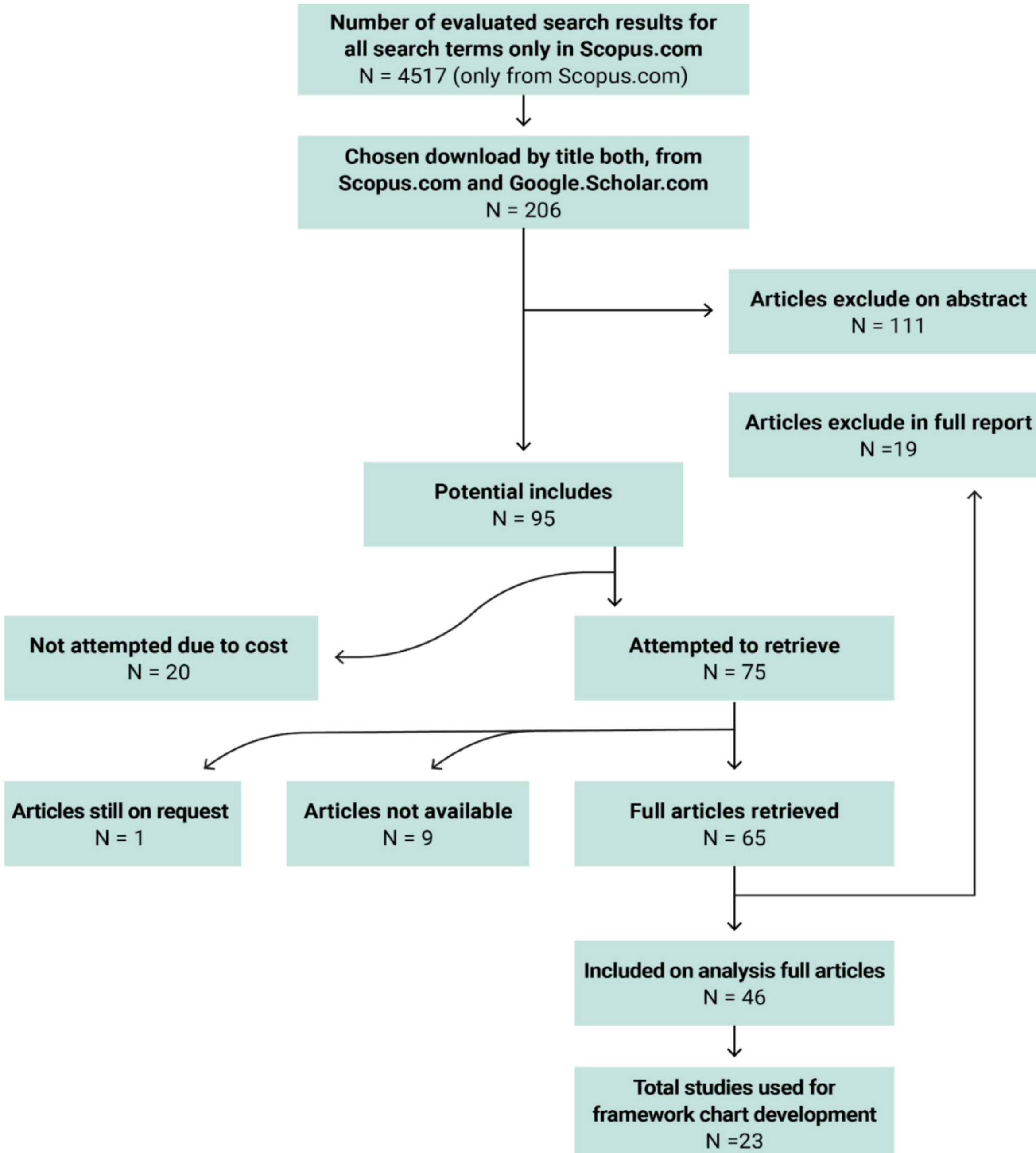

Figure 7. A synthesis of research addressing land uplift, sea-level rise and their relationship. Chart showing the flow of the literature search and evaluation procedure. N = number of articles and books used for synthesis [74].

5.2. Ethical Issues

Hence, this work is not related to human contact and does not use humans as a data source which limits the ethical concerns of the study. The main ethical issue is a human concern about how to combat climate change and how to motivate them towards participation to combat it. The other ethical issue can be related to a literature review by avoiding plagiarism and recognizing all the work of others appropriately. This might be the main reason that references were included after all sentences that were not the idea of the author. All concerns of ethics are applied in this work not only in the literature review but in other sections of the whole study.

5.3. Analysis of the Gap in the Literature

Climate change effects as an advantage for energy solutions. This is one of the new ideas presented in this dissertation. Not only combating climate change and mitigating it but using changes due to climate change to our advantage. One example is using the increased water temperature in water bodies to extract heat with the water heat exchanger. The reason why filling this gap is important and interesting is because as far as climate change effects are present in our environment we have to use it to our advantage. This is one innovative way of solving the problem by using the consequences of the problem towards creating solutions. Introducing the new type of energy solutions, which uses climate change as an advantage for climate change combating is the research gaps. The water heat exchanger is a new solution for using water bodies as an energy source. This technology uses water temperature increases due to climate change to its advantage. The seaside solutions can represent one kind of gap in the field as well. There has been much study in the area of seaside solutions. Therefore, this study helps to fulfil the gap in information and technology in seaside energy solution kinds and uses. The lack of combating climate change with energy solutions and adaptation measures in local seaside areas by the education sector and local community is important as well. CO_2 emission reduction is addressed.

There are suggestions about energy solutions for CO_2 reduction in both books of [14,75]. The gap is that they did not suggest some energy solutions addressed here. For example, the new solutions suggested here are: a water heat exchanger, sediment energy, GEU (Groundwater energy utilization), wave energy, asphalt energy and boreholes. This is important and interesting in knowing the exact solutions to use in seaside areas. Land uplift and climate change combined forecasts in the local area. The reason why filling this gap is important and interesting is because the local effect can be surprising to locals if it is not analyzed in depth. Therefore, they know what to expect in the future. Additionally, the development of sediment heat energy by using climate change as an advantage is also suggested first in this paperwork and confirmed by [28].

One of the gaps in Rankiene et al. [76] article is that they only identified the phosphorus and nitrogen flux from climate and land use. However, this study tried to see behind phosphorus and nitrogen changes; we use all the available data on water quality parameters that are available from ELY-keskus, where they are the control center for the Kvarken area, the data was taken since 1962 at latest and most of the data started to be taken in other locations from 1974. Clear analysis of the effect of climate change on water quality and what kind of effects are expected in the future due to climate change in naturally kept areas such Kvarken archipelago is one of the research gaps that is not addressed. Addressing this gap helps us to see the exact effect of climate change on water quality without being influenced by human pollution and disturbance. The reason why filling this gap is important and interesting is because it is a new area of research, which is hardly addressed in depth in the local non-polluted area to identify the exact effect of climate change only.

The risks of renewable energy use and production to the environment have been touched on by [77]. In my studies, in addition to addressing the above risk, I tried to bring a new dimension, which is the risk of climate change to renewable energy resources. The reason why filling this gap is important and interesting is because the risk of climate change in renewable energy resources brings an eye-opening view of climate change risk and creates more initiation and awareness of people to actively combating climate change.

5.4. Related Works

The University of Vaasa renewable energy research group works on (1) Alireza Aslani's [78] PhD study performed on Nordic Renewable utilization and evaluation of renewable energy studies; (2) Pekka Peura's [79] PhD dissertation shows a start and development of sustainability and somehow the Energy Village concept and; (3) Anne Mäkiranta's [32] PhD dissertation about renewable energy solutions: sediment energy and asphalt energy had an influence and are the best-related works in our research group to my study. These dissertations contributed to this study on energy solution sources, Nordic renewable utilization ideas and sustainability guidance. Climate change studies were used and the most influencer-related work was IPCC studies [80–84] and TAR (third assessment report) which used quantitative evaluation. Risk analysis has one main contributor and related work of [77] on renewable energy risks to the environment. Land uplift had similar discoveries performed by [85], an article in land uplift and sea-level rise relation in the Vaasa area. Additionally, [86] studied Kvarken archipelago land uplift. Renewable energy was influenced by the related PhD study on the GEU (groundwater utilization) study by Arola [5].

Data analyses on climate change and water quality (limnology) areas background literature have been related and influenced by several wide ranges of resources. These are (1) Kauppila's [37] PhD study on water quality. (2) Räike et al.'s [87] water analysis study. (3) Korhonen's [88] PhD study in snow patterns in water systems. (4) Huck's [89] data analysis background book. (5) Helsel and Hirsch's [90,91] data analysis background book. (6) Hirsch et al.'s [91] trend analysis article. (7) Wetzel's [92] limnology book as the background of water science. (8) Fan and Shibata's [93] example of analysis between water quality land use and climate change scenarios. (9) Rankinen et al.'s [77] influence of climate and land use change on nutrient fluxes from Finnish rivers to Baltic sea. (10) Huttunen et al.'s [94] analysis of the effect of climate change. (11) Paudel et al.'s [95] water quality change in seasonal variation in root respiration. (12) Pearl's [96] what causality means source. (13) Ylhäisi et al.'s [97] precipitation analysis in Finland and. (14) Peura and Sevola's [98]) acidification in lakes of Kvaken archipelago in the Gulf of Bothnia (Finland and Sweden). These books, dissertations, articles and papers have been the main related documents in the area of my study.

5.5. Issues of Policy

Influencing Finland's energy policy by 2030, Finland plans for over 50% of all energy consumption to be shared from renewable energy. Moreover, 100% renewable energy is aimed at Finland in 2050, which is a more ambitious vision [99]. As described in Haukkala [99], it is important to ask who are the actors in the coalition and their core beliefs to analyze their impact on policy.

According to Haukkala [99], in Finland, the core motivation for energy transition is (1) concern for nature and care for the environment and (2) the need to find a new energy source to replace the use of fossil fuels. The Finnish green-transition coalition shares a vision that the whole countries run by renewable energy and includes NGOs and other clean energy organizations. These members might differ in opinions such as on the use and buildup of nuclear energy in Finland. Influenced by which type of energy use in companies will win, the same was noticed in Switzerland. The energy transition can take decades and should be accelerated due to the need for climate change mitigations. Policy in Finland is influenced somehow by green-transitions coalitions and the change in the community's view of renewable energy use. In addition, the green-transition coalition's impact weakened because of divergent views on the actual energy transition and its relations [99].

Based on Yao et al. [12], analyzing the life-cycle energy environmental impacts of emerging technology and promoting sustainable chemical production is critical. This is because policymakers can receive such assessments with useful insight for future technology and investment development. The framework developed in the ethylene industry by [12] can be used by researchers, environment/energy analysis, and by policymakers to evaluate various aspects of decisions.

According to IEA [4], effective policy toolkits must be built around five core areas to support clean energy transitions: (1) Tackle emissions from existing assets. (2) Strengthen markets for technologies at an early stage of adoption. (3) Develop and upgrade infrastructure that enables technology deployment. (4) Boost support for research, development and demonstration. (5) Expand international technology collaboration. These are the core areas of facilitating useful policy developments toward combating climate change by replacing fossil fuels with renewable energy resources.

Directorate-General [100] presents the 2020 vision of the EU concerning saving energy. They presented in this report the policy initiation and action plan for energy efficiency and saving. Directive 2002/91/EC [101] gives the policy on the energy performance of buildings. As stated in this policy: the objective of this directive was to promote the improvement of the energy performance of buildings within the community accounting for local indoor and outdoor climate conditions. Directive 2006/32/EC [102] policy aims to ''improve energy end-use efficiency which also contributes to the reduction in primary energy consumption, to the mitigation of CO_2 and other greenhouse gases emissions and thereby to the prevention of dangerous climate change. The aims of this directive are not only to continue to promote the supply side of energy services but also to create stronger incentives for the demand side''.

Green paper [102] sketched out the bare bones of a long-term energy strategy in the EU. It is very scary that only 6% (including 2% just for hydroelectricity) of EU energy consumption is projected to be by 2030 based on [102]. There should be a lot of work on the use and policy developments towards using renewable in the EU and the whole world. The EU is still dependent on oil, natural gas is rising, coal and solid fuels dependency is expected to decline in the future and nuclear-expected phaseout in some nations, but some are still using it and even building new facilities in 2000 [103]. Supporting the need for energy in the EU, renewable energy is very essential to the security of the energy supply in Europe. However, these efforts can only become reality if they are supported by real policies of demand geared toward rationalizing and stabilizing energy consumption [103]. Hence, renewable energy must not be neglected because it is the only source of energy in which the EU has a certain amount of room to maneuver in supply [103].

Climate change and the establishment of a progressively integrated energy market are the new two factors that recently emerged during consideration for the future of European energy supply, especially options for its diversification [103]. The same paper says that to combat climate change, Europe has to set an example to the rest of the world by setting a strong policy aimed at reducing gas emissions as well as reducing oil dependency and transport energy efficiency because the biggest or 84% of CO_2 emissions in the EU is from transport. Thus, it is an important step in making a road to combating climate change. However, to tackle climate change, an ambitious policy should not endanger economic development [103]. SAVE and ALT-ENTER directives are important and must be initiated again in the future further even though they are implemented inefficiently in the EU in the past [103].

6. Conclusions

The relation between renewable energy and seaside energy solutions in this literature review report series is addressed. Seaside energy solutions were mainly proposed as renewable energy resources. This creates connections between seaside energy solutions and renewable energy resources. The most effective renewable seaside energy solutions were proposed and some installed. Among those, sediment heat energy production and water heat exchangers were the main solutions in this study.

Seaside energy solutions installed in water resources were appreciated and expected to use climate change effects on the water temperature increase to our advantage (sediment heat energy and water heat exchanger). Creating the connection between climate change effects as a heat energy source and water resources at the installation location. Using the climate change effects to our advantage leads to adaption, combating and mitigating climate change. Towards land uplift, their connection is renewable energy installation as seaside solutions faced difficulties because of land uplift. By causing the shoreline to increase towards the too deep sea and travel to islands become inaccurate by boat because the sea water becomes too shallow. The main conclusion of the overall literature series 1 up to 4 is that renewable energy can be used efficiently for the development of a region and even by using climate change effects to our advantage. This is a new way of solving problems by using the created climate change effects as a source of renewable energy production such as by using a water heat exchanger and/or sediment heat production.

The future direction is expanding the renewable energy knowledge and example projects to other nations such as Africa. For example, implementing the Energy Village concept in Africa by using the LEAP-RE project work package 14. The key conclusion of this review paper is that seaside renewable energy is mainly geo-energy and most of them use climate change effects to their advantage, such as sediment heat energy production. The main recommendation is to use the effects of climate change to combat and mitigate its causes and further consequences. The overall conclusions build on the relationships between different aspects of the topics. The paper contributes a precise current review of renewable energy. The novelty of this study is seeing a problem effect as an advantage to overcome the problem by itself. In other words, using the effects of climate change to our advantage and using it to generate seaside renewable energy resources to combat and mitigate it.

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