



## Article

# A Concept for Solving the Sustainability of Cities Worldwide

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**Abstract:** Considering that more than half of the world's population today lives in cities and consumes about 80% of the world's energy and that there is a problem with drinking water supply, this paper presents a way to solve the problem of the sustainability of cities by enabling their complete independence from external sources of energy and drinking water. The proposed solution entails the use of Seawater Steam Engine (SSE) technology to supply cities with electricity, thermal energy and drinking water. The system would involve the seasonal storage of electricity and thermal energy, supported by geothermal heat pumps. The strategy of the distribution network would be based on the original concept of the "loop". In cities that do not have enough space, SSE collectors would be placed above the lower parts of the city like "canopies". The city of Zagreb (Croatia) was selected as a case study due to its size, climate and vulnerability to natural disasters. The results show that Zagreb could become sustainable in 30 years with the allocation of less than 2% of GDP and could become a paradigm of sustainability for cities worldwide. This paper encourages the development of the "Philosophy of Sustainability" because the stated goals cannot be achieved without a change in consciousness.

**Keywords:** sustainable city; climate change; Seawater Steam Engine; renewable energy sources; drinking water; heating and cooling; electricity



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## 1. Introduction

The IPCC report (2021), Summary for Policymakers [1], once again shows that the UN has no successful response to climate change as global temperatures continue to rise and extreme weather conditions become more frequent. In this sense, the authors of this paper also doubt the reality of the IPCC's new forecasts/scenarios of slow global temperature growth that extends until 2100. That is, nowhere in this IPCC report (as in most previous reports) is climate breakdown predicted. This could be a realistic possibility, not because the geological history of the Earth lacks higher concentrations of CO<sub>2</sub> and global temperatures, but because the climate system does not have the "elasticity" to withstand such a sudden rise in temperature in such a short period of time. On the other hand, even assuming that a slow temperature increase of 3.3–5.7 °C will occur until 2100 (according to the worst IPCC scenario "3.3–5.7 °C under SSP5-8.5" [1]), this increase will have dramatic consequences on human health and lives and biodiversity. A temperature of 48.8 °C was measured in Sicily (Italy) on 11.08.2021 [2], and an increase in global temperature in 2020 of "only" 1.2 (±0.1) °C [3] was observed. These figures show that temperature extremes, which will (in the event that the year 2100 is "peacefully welcomed"—that is, without climate breakdown) obviously become more frequent and, with higher temperatures and longer durations, could significantly increase human mortality [4]. Therefore, the

authors believe that the appeal by over 230 editors of scientific journals in the field of medicine should be taken extremely seriously: “Call for emergency action to limit global temperature increases, restore biodiversity, and protect health”, published on 6 September 2021 [5], citing: “Indeed, no temperature rise is ‘safe’. In the past 20 years, heat related mortality among people aged over 65 has increased by more than 50%. Higher temperatures have brought increased dehydration and renal function loss, dermatological malignancies, tropical infections, adverse mental health outcomes, pregnancy complications, allergies, and cardiovascular and pulmonary morbidity and mortality. Harms disproportionately affect the most vulnerable, including children, older populations, ethnic minorities, poorer communities, and those with underlying health problems”. Thus, the situation is alarming, and decisive action needs to be taken to halt the further rise in global temperature.

Alternative solutions listed in the IPCC report (2021) that would reduce CO<sub>2</sub> emissions, such as the so-called “Most strong-mitigation scenarios” that use “geoengineering” or “climate engineering” methods, which are mostly related to so-called “Carbon Dioxide Removal” (CDR) and “Solar Radiation Modification” (SRM), can hardly be expected to have sufficiently large effects in the radical reduction of CO<sub>2</sub>.

It is unrealistic to expect that CDR methods could remove such large amounts of CO<sub>2</sub> from the atmosphere, especially not at the rate at which CO<sub>2</sub> is emitted into the atmosphere, so it is logical to ask: What is the purpose of developing CDR methods to remove CO<sub>2</sub> from the atmosphere when much larger amounts of CO<sub>2</sub> are still emitted into the atmosphere at a much faster rate, and can such methods even overcome the climate breakdown, especially since the removal and emission of CO<sub>2</sub> are not correlated? Such methods of removing CO<sub>2</sub> from the atmosphere while CO<sub>2</sub> emissions into the atmosphere increase could have a countereffect, which is to further encourage the fossil fuel industry to continue emitting CO<sub>2</sub>, which would be in line with the substantial aid given to this industry in the form of subsidies; thus, the arguments advocating such methods (under the auspices that they will reduce global temperature) seem extremely unconvincing. Therefore, these trends are opposite to the proclaimed “mitigation”. They could only add to the possible healing of the atmosphere in a carbon-neutral era.

Furthermore, SRM methods, i.e., methods that would reduce solar radiation, are even more problematic, because no one can predict the short-term effects of such interventions, nor their long-term effects and consequences on the climate and ecosystem. These could also be very dangerous experiments with unpredictable implications.

The authors are of the opinion that we should not continue to hope for salvation from climate change by geoengineering methods, because the efficiencies of the application of these technological solutions have not yet been determined. Decisive actions should be taken, primarily in the form of new policies, but also in the form of new, economically viable and environmentally friendly technologies that allow a more realistic assessment of whether they can produce results in the expected time period [6].

In attempts to solve the problem of climate change, the proposed economic methods and measures have a significant impact. They were first incorporated into the Kyoto Protocol [7] and proposed by prominent world economists, such as Stern [8], who proposed three measures as a solution: (1) pricing carbon, (2) supporting innovation and (3) acting to remove barriers to energy efficiency; Nordhaus (Nobel laureate for economics in 2008 “for integrating climate change into long-run macroeconomic analysis”), who proposed a global taxing policy, convinced that taxes are proven instruments that will deliver results; and Romer (also Nobel laureate for economics in 2008 “for integrating technological innovations into long-run macroeconomic analysis”), who sought to encourage new ideas and long-term development. These measures were incorporated into the Paris Agreement [9] (whose “key architect” is the eminent French economist Laurence Tubiana), and all methods and measures seek to sustain economic growth. However, it is clear that permanent economic growth (with further growth of the world population) is not possible with limited natural resources. Therefore, it will be necessary to establish different economic theories and

methods by which human civilization will be harmonized with the environment in order to achieve sustainability.

It is clear that the IPCC, among other things, uncritically adopts economic models that project a reduction in CO<sub>2</sub> emissions by about 50% by 2030 (which is already contrary to the trends of further temperature increase and CO<sub>2</sub> emissions). The UN does not actually have a solution to tackle climate change, and such reports [1] (which are based on projections instead of concrete actions) are just wasting valuable time. The first step in solving the problem of climate change should be an official admission by the UN itself that it is not able to solve such a complex problem with current tools and approaches.

The proof that the UN is not able to solve this problem was expressed through the media by the UN Secretary-General himself, with the statement “We’re losing the battle” (Independent, 17 May 2019) or “We’re losing the race” (Guardian, 18 September 2019), which is a definitive recognition that the UN is aware of the problem. This is why the Secretary-General also publicly seeks “meaningful plans”, i.e., cit. “I expect there will be an announcement and unveiling of a number of meaningful plans on dramatically reducing emissions over the next decade, and on reaching carbon neutrality by 2050” (BBC News, 22 September 2019). In response to the appeal of the UN Secretary-General, the first three authors of this paper have provided such a meaningful plan and technological solutions [6] that would radically reduce emissions by 2050 to achieve carbon neutrality.

However, despite the aforementioned weaknesses of the UN in terms of insufficient knowledge and capacity to tackle climate change, there are clearly no instruments to force countries (parties) to abide by any international climate agreement, as these countries are largely governed by interests that are opposed to stopping climate change.

The proof of this is the BloombergNEF report [10], which showed that the 20 strongest economies in the G20 (which are responsible for almost  $\frac{3}{4}$  of CO<sub>2</sub> emissions) have directly supported fossil fuels with as much as USD 3.3 trillion since 2015 (since the adoption of the Paris Agreement), which clearly indicates the hypocrisy in the policy for preventing climate change, i.e., the fact that some of these countries are publicly advocating for preventing climate change and transitioning to “green economies” while, on the other hand, significantly and directly supporting fossil fuels (the question arises as to what the term “mitigation” means in general, i.e., what does “reduction” relate to if energy production from fossil fuels, and thus CO<sub>2</sub> emissions, increases?). In this sense, the Paris Agreement becomes a meaningless document, because, apart from setting the wrong targets (global temperature cannot be stopped through our will because the Earth is not a boiler that can be turned off when the global temperature reaches 2 °C, which is explained in detail in [6]), there are no sanctions for countries (parties) that do not adhere to this agreement.

The responsibility of the UN, whose action should be more decisive and courageous in addressing problems and pursuing more responsible policies, is great, but it is equal to, if not greater than, that of the G20 countries because stopping climate change is a matter of human survival.

All of these failures of the UN more than clearly indicate the fact that humanity today, in 2021, is not only far from achieving sustainability but also facing a climate breakdown and its own disappearance and that it is necessary to urgently abandon the inappropriate objectives of the Paris Agreement and strategies to address the biggest problem facing humanity, which, in its essence, comes down to adaptation and mitigation; these strategies are even quantified in *The Value of Sustainable Urbanization* [11] as follows: 75% climate change mitigation (51% RES, 13% green buildings, 6% urban transport, 5% energy efficiency) and 25% climate change adaptation (10% coastal protection, 6% flood control, 5% drought/agriculture, 4% heat/greening). These estimates are utterly arbitrary and unrealistic, so such plans will make it virtually impossible to defend cities from climate change. In addition, supporting fossil fuels should be abandoned (the authors are aware that this will be the most difficult to achieve, but in a previous paper [6], they proposed a solution to this problem based on reorientation so that economies would not suffer damage) and completely different goals and strategies should be set as soon as possible, as well as

sanctions for irresponsible parties. Decisive actions should be taken that could reverse these trends in the direction of achieving sustainability and stopping climate change, because we must not forget that the climate system has a huge inertia and that it will be horribly difficult to reverse these negative flows.

This paper presents an original concept for realizing the sustainability of cities worldwide using innovative technology (Seawater Steam Engine) for energy and water production and “distribution loops” for energy and water distribution in the city itself. The proposed concept can maintain a balance between the economy, society and the environment as fundamental components of sustainable development. The city of Zagreb (Croatia) was selected as a case study on the basis of three criteria: its size, geographical position and climate and vulnerability to natural disasters, and it could become a paradigm for other cities worldwide.

The term sustainability is used quite imprecisely in the literature, especially when it comes to sustainable communities (“sustainable cities”, “green cities”, “smart cities” and “sustainable smart cities”), which are graded from lower to higher sustainability. However, there are also opinions that a city can be either only sustainable or not sustainable at all, and it is very important to determine what is actually meant by the sustainability of cities, which currently account for as much as 78% of the world energy consumption [12] and whose population tends to grow, which contributes to the increase in CO<sub>2</sub> emissions.

On the other hand, cities are ranked by sustainability according to the following criteria: “Based on energy, transportation infrastructure, affordability, pollution, air quality, CO<sub>2</sub> emissions and % of green space” [13]. Each city is given a percentage of sustainability for some of these indicators, which is another indication that there is actually no city in the world that is sustainable. In this regard, the authors find this ranking problematic, because sustainability is not compatible with competition, but it should be an imposed obligation/command from above (“top-down” principle); otherwise, there will be no success.

For the overall sustainability of Earth, it is insufficient that only one or some cities are fully sustainable while others remain far from it. There is no sense in countries competing on sustainability because the climate is common to all cities and countries, and therefore, the same/common criteria that lead in the direction of sustainability should be established for all of them. Given that not all cities and countries are equally developed, the criterion of fairness on the way to achieving sustainability should certainly be respected [6].

Therefore, to achieve overall sustainability on Earth, which is *conditio sine qua non* of human survival, it is crucial to stop CO<sub>2</sub> emissions from cities because they are also the largest consumers of energy. As cities without drinking water (as another key criterion for achieving sustainability) cannot be sustainable, in this paper, the sustainability of cities will mean their complete independence from external sources of energy and drinking water as key factors for their sustainable survival.

In line with the topic of the sustainability of cities (which are also the biggest polluters), this paper also intends to:

- (1) Point out to the UN that a formal approach to finding a new solution/path (which was publicly pointed out by the Secretary-General by seeking a meaningful plan (BBC News, 22 September 2019) is needed and clearly and directly address obstacles [10] encountered in attempts to address climate change;
- (2) Draw the UN’s attention to the fact that the growing morbidity and excessive deaths of people from climate change [5] could lead to a situation where the question of responsibility for this is raised in the future and that this is the reason for urgent policy change towards climate change;
- (3) Provide assistance to the UN (i.e., UNFCCC and IPCC, which, on their website, implicitly call for assistance: “Engage with the IPCC” [14]). The authors of this paper firmly believe that the solutions described in [6] are, at this historical moment, the only correct way for the salvation of humankind.

## 2. Methodology

In order to achieve the sustainability of a city, which, in the case of this paper, means that it is continuously, throughout the year, provided with energy and drinking water through significant RES systems (solar, wind) that are interminable, it is necessary to provide storage of both energy and drinking water. In the case of using solar energy, energy storage should balance summer surpluses with winter energy shortages (for the northern hemisphere, and for the south, it is of course the other way around), which means that energy storage must be seasonal.

As cities are relatively large consumers of energy, seasonal energy storage, in today's era of technological development, can obviously be economically implemented only with pump-storage hydroelectric (PSH) technology, because it can store even the largest amounts of energy and is a mature technology with very high efficiencies (75–92%) and relatively low prices (USD 0.434/W [15]). The situation is similar with drinking water if it is obtained with the help of solar energy, because the storage must be relatively large in order to supply cities with drinking water during the winter.

Present-day technologies produce energy and drinking water separately from the RES system. Specifically, RES systems provide energy as their output, and if it is to be used for the production of drinking water (e.g., from seawater), then this energy is used to drive desalination systems. Therefore, it is necessary to separately install the capacities of RES systems that produce energy and those of RES systems that drive the desalination system. In the case of solar systems, this means that more collectors are needed than in the case when both resources (energy and water) are produced by the same collector surface.

In the case of PV or wind systems, only electricity is produced as their output, which can then be delivered to cities, or desalination devices can be powered by this electricity; however, in that case, these RES systems cannot also provide heat/cooling energy to cities.

Due to all of the above reasons, it was necessary to develop a completely new technology, Seawater Steam Engine, which can simultaneously produce energy (electricity and heat for heating and cooling) and drinking water from seawater or other unclean water sources. Thus, from the input solar energy, SSE technology can provide as many as four products as its output, which puts it far ahead of other technologies known today.

In addition, this technology is mainly made of currently available raw materials such as iron (steel), which implies a relatively low cost, and due to its simplicity of construction, it could be equally available to developed and less developed countries. From the above, the potential for application is evident: i.e., SSE technology could play a key role in stopping climate change.

For these reasons, this paper shows, for the first time, how SSE technology can make a city sustainable (completely independent of external energy sources and drinking water). The proposed system differs from previous RES technologies, which most often produce electricity (which is the easiest to transmit over long distances) that is delivered to the power system and from there to individual cities. There is no storage of this energy from the RES system, and the power system experiences constant shocks, depending on the ability of the RES system to produce electricity. Moreover, in this way, cities receive only electricity indirectly (through the electricity system), while other forms of energy (heat, i.e., heating and cooling) and drinking water cannot be obtained.

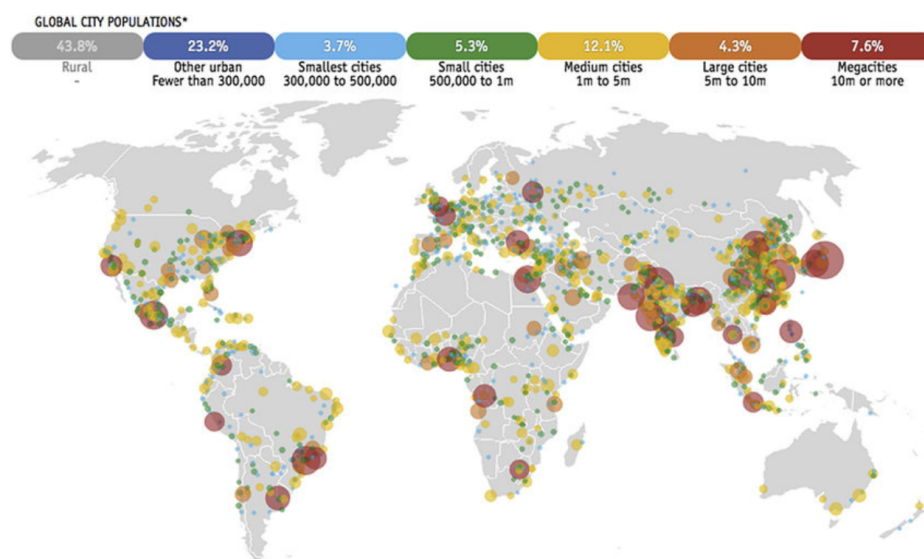
This paper describes a completely different principle of achieving the sustainability of cities than all previous ones, both in the production of energy and drinking water and in its distribution (using loops), which changes the relationship in all three aspects of sustainability.

### 2.1. Distribution of the World Population in Cities

From the estimate of the distribution of the world population in cities (2020) [16], shown in Figure 1, it can be seen that 56.2% of the population lives in cities, of which small cities (5.3%), smallest cities (3.7%) and other urban areas (23.2%) together make up 32.2% of the population and medium cities (12.1%), large cities (4.3%) and megacities (7.6%) together



make up 24% of the world's population; that is, more than 30% of the population lives in cities with less than 1 million inhabitants, and over 20% lives in larger cities. The number of cities with less than 1 million inhabitants, according to [17], starts in 558th place, which means that out of 10,000 cities in the world, 94.4% of cities (in number) have a population below 1 million. Of the total population, 37% live in coastal communities by the sea [18], which is important information in terms of the possibility of using seawater as a resource for the application of new technologies that can supply these cities with drinking water.



**Figure 1.** Population of cities worldwide, distribution estimated for 2020 [16]. Reprint with permission 5217100788999; 2021, Elsevier.

Certain statements made by the UN [11], namely, “In all regions, local governments and their organizations are contributing to the advancement of sustainable urbanization by fostering climate change mitigation actions, urban resilience, alternative economic models and social inclusion policies” and “Nearly 10,000 cities and local governments have set emissions reduction targets with accompanying policies and programs to meet those targets”, are in fact a recognition that “sustainable urbanization” is of a more declarative nature, with minor effects that are far from being able to protect the climate. What is the purpose of “contributing to the advancement of sustainable urbanization” if these “contributions” are far smaller than the “increase of environmental pollution” by CO<sub>2</sub> emissions from these same cities and how long should the climate system “wait” (so that it does not breakdown) until the current minor contributions outgrow the pollution and completely nullify it? Therefore, the same issue arises again, which is that the UN does not have the instruments to make the world's cities sustainable, but everything remains on a voluntary basis, and today, every city “contributes as much as it can”.

Regarding the definition of sustainable communities, the Institute for Sustainable Community states: “Throughout the world, people want the same things: access to clean air and water; economic opportunities; a safe and healthy place to raise their kids; shelter; lifelong learning; a sense of community; and the ability to have a say in the decisions that affect their lives” [19]. However, this definition is extremely vague because it is not about assessing the quality of people's lives but about the factors that would make a city sustainable, and as such, it would no longer emit CO<sub>2</sub> because it is the key category of sustainability.

## 2.2. Organization of the Transformation Process of Cities towards Sustainability

The transformation of today's cities towards achieving sustainability is an extremely complex task with many variables and limitations, and therefore, a systems engineering

approach is of special importance for solving it from the very beginning, i.e., from setting a policy whose task is to set objectives.

The objective is defined as the direction in which changes are to be made. In this case, it means to make a city completely sustainable, i.e., independent of external energy sources and drinking water (for which the terms “self-supply”, “stand-alone” and “grid-off” systems are used in energetics). The task of systems engineering is to achieve this objective, which, in this case, is the most demanding engineering task in general, because it needs to align natural resources (which are stochastic) with the needs of citizens of a city, which are also stochastic. Thus, engineers will be faced with limited resources in solving this problem, which, in addition to natural resources, comprise money, labor, construction time, the existing construction of a city, possibility of construction in certain locations, etc. Furthermore, engineers will also be faced with various perturbations. For this reason, the notion of systems engineering includes the art and science of choosing from a large number of possible alternatives, a set of actions (alternative or alternatives) that best meet the set objectives of decision makers. The terms art and science indicate that it is necessary to include engineering experience and engineering sciences (calculation and analyses) in an appropriately organized manner in order to best or optimally determine the required solution.

This means that it is especially important to follow the steps of systems analysis (as a segment of systems engineering, consisting of the following steps: setting objectives, determining key performance indexes for evaluating the achievement of goals, formulating alternatives, formulating a solution selection model, selecting the “best” solution and performing feedback analysis). This procedure is very complex in this case and requires the engagement of a large number of associates of different professions, which may lead to a loss of perceiving the integrity of the problem.

Therefore, objectives should be set by mayors (or their administrations) as politicians, with evaluation criteria set by the main engineer, who develops alternatives with a group of planners; designers and management engineers, as systems engineers, should develop models and make calculations, while the feedback analysis of the results should achieve proper communication between all experts and ensure the integrity of problem solving.

However, with all of the complexities and difficulties in solving the problem of the sustainability of cities, this objective offers great local benefits, because these cities would significantly improve their economies. The construction of such large infrastructure facilities and works in cities with many new technologies would strongly encourage the development of industry in these cities, with a multitude of innovations, and such strong development would change the attitudes of citizens towards sustainability; therefore, all of this would be reflected in the overall economic, social and cultural development of these cities.

The social aspect primarily refers to the fact that sustainable cities should not live life with the same rhythm as before, which is independent of nature, but should live in harmony with nature or subordinate their rhythm of life to nature, all in order to enable the consumption of energy in the summer when the most solar energy is available, and in the winter, excessive energy consumption should be avoided (e.g., various events—sports, cultural and other events—should be held mainly in the summer, while during the winter, these events should be reduced and/or have lower energy consumption).

The environmental aspect primarily refers to the placement of the fields of solar collectors, which should minimize damage to the environment. In this sense, the construction of relatively large PSH reservoirs could have very positive effects on social life, as they could be multifunctional lakes that could be used for both recreation and sports.

### *2.3. Seawater Steam Engine—Technology for the Realization of Sustainable Cities*

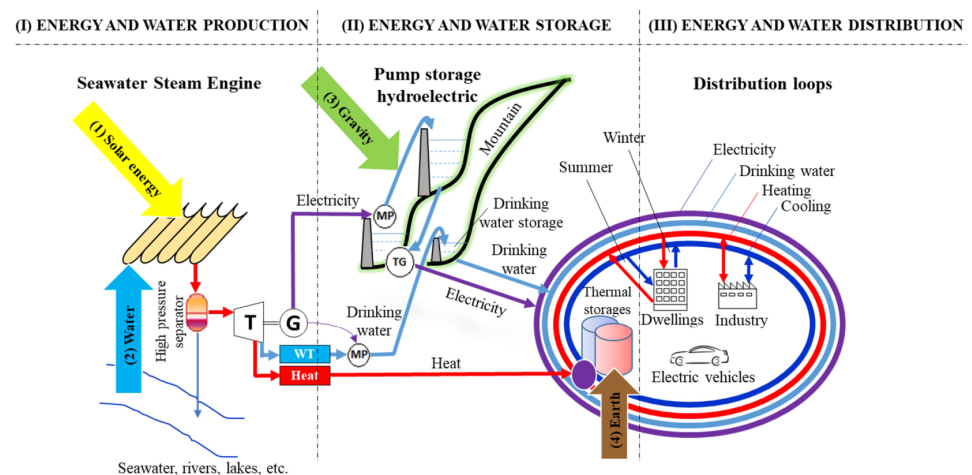
As stated in [6,20–22], Seawater Steam Engine (SSE) technology uses three natural sources—RES energy, seawater or water from other unclean water sources (rivers, lakes, etc.) and gravity (thus, three natural resources)—in order to produce electricity and heat

(for heating and cooling) and drinking water (which could also be referred to as “quadri-generation”), which would be provided continuously throughout the year. Seasonally stored thermal energy would also be supplied by geothermal heat pumps, which means that the fourth natural resource, i.e., Earth, would be used.

Therefore, with this production potential, this technology would achieve continuity of supply to consumers throughout the year, which is the key to sustainability.

The overall sustainability of Earth can be achieved only by nullifying anthropogenic CO<sub>2</sub> emissions, which is possible if we primarily nullify anthropogenic CO<sub>2</sub> emissions in cities (that make up 78% of the world’s energy), which is the subject of this paper. Therefore, in this paper, the sustainability of cities is observed through the lens of the complete independence of cities from external sources of energy and drinking water; i.e., this energy and drinking water must be provided by the RES system. Other aspects of sustainability (listed in, e.g., [13,19]) are not of interest for this paper, because the primary issue is to stop anthropogenic CO<sub>2</sub> emissions and thus prevent climate breakdown. Simply put, overall sustainability on Earth will be achieved if all cities in the world are made sustainable as soon as possible.

Therefore, this paper, unlike all previous approaches to urban sustainability (where relatively small and insufficient steps towards sustainability have been made and have so far yielded no results globally, because global temperatures continue to rise), describes a completely original concept of a sustainable city as a basic unit (“brick”), which would achieve overall sustainability on Earth, as shown in Figure 2.



**Figure 2.** An original concept of a sustainable city: (I) energy and drinking water production by SSE technology; (II) storage of electricity (by pump-storage hydroelectric), thermal energy (for heating and cooling) and drinking water; (III) distribution of electricity, thermal energy (heating and cooling) and drinking water by distribution loops.

This concept consists of three parts: (I) energy and water production by SSE technology, (II) energy and water storage (pump-storage hydroelectric for electricity storage, thermal energy storage for heating and cooling and water reservoir for drinking water storage) and (III) energy and water distribution by distribution loops.

Solar energy can be used as input energy into the SSE system, as well as other renewable sources (wind, biomass, hydro, etc.), which significantly expands the scope of application of this technology (integrated SSE system) in locations with relatively little solar energy.

Seawater and water from rivers, lakes and other sources of unclean water can be used as input water. This water is heated and evaporates in the pipes of parabolic trough collectors (concentrated solar power), after which it enters a high-pressure separator, where steam is separated from the concentrated water, which is then returned to the impure water source [6].



Steam from the high-pressure separator is discharged to turbines (T), where it is converted into mechanical work and generates electricity in generators (G). This energy drives motors and pumps (MP) of pump-storage hydroelectric (PSH), which pumps water from the lower to the upper water reservoir, which serves as seasonal energy storage that balances summer surpluses and winter shortages of solar energy and thus ensures a continuous supply of electricity throughout the year. It is produced in turbines and generators (TG) and is delivered to the city electricity network.

Condensed steam, i.e., water from the turbine (T), is drained to the water treatment plant (WT), after which it is pumped (using MP) to the drinking water storage that supplies the city with drinking water. This reservoir must also be a seasonal tank to ensure a continuous supply of drinking water to the city.

Thermal energy obtained in the SSE system is discharged into the city thermal network, made in the form of loops for reliability. This network distributes heat and cooling energy (obtained by absorption cooling) to the city in the way that it is radiantly distributed from the main loops to all consumers. Seasonal heat storage would also be used, which would ensure the continuous supply of heat to the city for space heating and hot water and an “ice bank” for storing cooling energy, thus ensuring the continuity of cooling during the summer months.

As an additional heat source in these heat storage systems, geothermal heat pumps (fourth natural resource, i.e., Earth) would be used, whose coefficient of performance (COP) for large systems reaches a value of up to 10. In this way, all areas in the city can be continuously provided with heating and hot water during the winter and continuous cooling during the summer months. Since industrial plants themselves produce heat during the production process, they have the possibility of constant heat exchange with the heating and cooling network.

The distribution of electric and thermal (heating and cooling) energy and drinking water through loops would ensure high security of supply, because if a failure occurs in one part of the loop—high-voltage networks, heating systems, cooling systems and drinking water supply systems—the supply of the city would automatically be ensured on the other side of the loop, whereby all of these systems (complete with transformer and pumping stations) would be automatically monitored and managed. Such cities would basically be “Sustainable smart cities”.

In sustainable cities, it is necessary that all vehicles be CO<sub>2</sub>-free, i.e., electrically powered, for which the SSE system would provide enough electricity.

The first step in designing an SSE system for a city is its sizing, i.e., determining its nominal power, which, on the one hand, depends on the available solar radiation and, on the other hand, on the energy consumption of a city. Considering that these are stochastic quantities (possibilities for energy production from solar radiation and energy consumption of the city, which need to be harmonized) and the energy is stored seasonally using PSH technology, the power (size) of the SSE system must match the energy consumption throughout the year from the available solar energy. This can be realized by optimizing the system, which was carried out in [20]. For this purpose, a simulation–optimization model based on dynamic programming was developed, because it is a multistage decision-making process in terms of time (discretization to “i” time steps), where the selected objective function is to determine the optimal power of the SSE generator  $P_{el(NOM)}$ .

Based on the known nominal power, the area of the SSE generator  $A_{coll}$  is determined, and when that area is known, then the amount of produced thermal  $Q_{(i)}$  and electric  $E_{el}$  energy and the amount of drinking water  $V_{DW}$  can be determined from it.

Formulas for the calculation of key parameters of the SSE system—nominal power of the SSE generator, produced heat and electricity and drinking water [20,23,24]—are as follows:

$$P_{el(NOM)(i)} = \frac{\rho g H_{TE(i)}}{\eta_{OS} \eta_{SE} \eta_{PSI} R_{coll(i)} E_{S(i)}} V_{ART(i)} \quad (1)$$

$$Q_i = A_{\text{coll}} \cdot F \cdot \bar{\eta}_{\text{opt}} \cdot \bar{\Phi} \cdot E_{S(\text{coll})(i)} \quad (2)$$

$$E_{\text{el}(i)} = \eta_{Q-\text{EL}} \cdot f_m \cdot A_{\text{coll}} \cdot F \cdot \bar{\eta}_{\text{opt}} \cdot \bar{\Phi} \cdot E_{S(\text{coll})(i)} \quad (3)$$

$$V_{\text{DW}} = \frac{1}{\rho_{\text{H}_2\text{O}}} \cdot \frac{P_{\text{el}(\text{NOM})}}{\eta_{\text{ME}} \cdot \eta_{\text{TUR}} \cdot \Delta h} \sum_{i=1}^N f_{t-\text{DIR}(i)} \cdot T_{S(i)} \quad (4)$$

where  $P_{\text{el}(\text{NOM})}$  is the nominal electric power of the SSE generator;  $\rho$  is water density ( $\rho = 1000 \text{ kg/m}^3$ );  $g$  is the gravitational constant ( $g = 9.81 \text{ m/s}^2$ );  $H_{\text{TE}(i)}$  is the average total head (m);  $\eta_{\text{OS}}$  is the efficiency of the open thermodynamic system;  $\eta_{\text{SE}}$  is the efficiency of the collector field of SSE power plants;  $\eta_{\text{PSI}}$  is the efficiency of the pumping system and inverter;  $R_{\text{coll}}$  is a conversion factor for converting mean daily radiation on a horizontal plane to mean radiation on the aperture of tracking parabolic collectors;  $E_{S(i)}$  is the mean daily solar radiation on a horizontal plane at Earth's surface;  $V_{\text{ART}(i)}$  is the mean daily value of artificial water inflow that can be pumped by the SSE generator from the sea into the upper reservoir;  $Q_{(i)}$  is the thermal energy production (kWh);  $A_{\text{coll}}$  is the aperture area of parabolic collectors ( $\text{m}^2$ );  $F$  is the heat removal factor;  $\eta_{\text{opt}}$  is long-term average optical collector efficiency;  $\Phi$  is the long-term average utilization factor of solar energy based on the Hottel–Whillier concept;  $E_{S(\text{coll})}$  is the average daily value of the collected solar energy;  $E_{\text{el}}$  is electric energy production (kWh);  $\eta_{Q-\text{EL}}$  is the average value of conversion efficiency of thermal into electric energy;  $f_m$  is the load matching factor to the characteristics of the SSE generator;  $V_{\text{DW}}$  is drinking water production ( $\text{m}^3$ );  $\eta_{\text{ME}}$  is the conversion efficiency of mechanical turbine power into electric generator power;  $\eta_{\text{TUR}}$  is isentropic (inner) turbine efficiency;  $\Delta h$  is the difference between the enthalpy of vapor at the inlet and outlet of the turbine;  $f_{t-\text{DIR}(i)}$  is a factor that describes the proportion of the number of hours of direct radiation exceeding  $250 \text{ W/m}^2$ ;  $T_{S(i)}$  is insolation (duration of sunshine);  $I$  is the time stage (increment) related to the dynamic programming;  $N$  is the number of time stages (for a time stage of 1 day,  $N = 365$ ).

### 3. Results

#### 3.1. Why Was Zagreb Chosen as the Paradigm of Sustainability for All Other Cities in the World?

In terms of selecting a city for the case study, which could be a paradigm for all other cities in the world, the authors used three criteria:

- City size,
- Geographical position and climate,
- Vulnerability to natural disasters.

According to data on the sizes of cities, out of a total of 10,000 cities in the world, the city of Zagreb, according to [17], is in 836th place with a stated population of 684,878. However, it is obvious that these data are not up to date because, according to the aforementioned data, Zagreb actually had 806,341 inhabitants in 2019, which would still place it in the category of “small cities” with populations of 500,000 to 1 million. Thus, the city of Zagreb, due to its size (slightly less than 1 million inhabitants), can be a good model for other cities with a population below 1 million, which make up 90% of the total number of cities in the world (where 32.2% of the world's population lives), offering the significant potential to make them all sustainable.

Since it is stated in [25], cit.: “We found that only less than 1/8 of the human population lives south of the equator while around 50% of the dwell population within the area between  $20^\circ \text{ N}$  and  $40^\circ \text{ N}$ ”, it was logical to choose a city that would be on the northern edge of the belt due to climatic conditions, i.e., irradiated amounts of solar radiation, because it means that the problem of the sustainability of these cities (which have more solar energy) could be solved with SSE technology that uses solar radiation.

Zagreb is located at  $45^\circ$  north latitude (N), with a direct component of solar radiation of  $1081 \text{ kWh/m}^2/\text{a}$  (Table 1) and, in this sense (“of the dwell population within the area between  $20^\circ \text{ N}$  and  $40^\circ \text{ N}$ ”), has a favorable location, despite the fact that the stated values of solar radiation for concentrated solar power (CSP) systems are considered uneconomical

because they require larger collector areas. As the intensity of solar radiation per unit area of the collector is practically the same ( $1000 \text{ W/m}^2$ ) at these locations and only the duration of solar radiation (insolation) changes, CSP systems could be successfully used at locations with smaller amounts of solar radiation, but it is important to put the issue of sustainability above the status of the economy, because sustainability has no price. Therefore, the opinion of the authors of this paper is that the application of CSP, i.e., SSE technology with concentrator collectors, should be extended to locations up to about  $1000 \text{ kWh/m}^2$ , where energy storage, which would bridge the winter energy shortages and enable their continuous supply, should be higher, i.e., with hydropower (as the largest type of energy storage facility today), with the potential that the entire world's electricity system becomes completely sustainable [26].

**Table 1.** Input data for: global  $G_h$ , diffusion  $D_h$  and direct  $B_n$  solar radiation per month in a year for reference location (Ref.) of the island Vis (Croatia) and the city of Zagreb (Croatia).

| Location  | Vis-Ref. (Croatia)    |       |       | Zagreb (Croatia)      |       |       |
|-----------|-----------------------|-------|-------|-----------------------|-------|-------|
|           | $G_h$                 | $D_h$ | $B_n$ | $G_h$                 | $D_h$ | $B_n$ |
| Month     | [kWh/m <sup>2</sup> ] |       |       | [kWh/m <sup>2</sup> ] |       |       |
| January   | 54                    | 25    | 87    | 31                    | 19    | 43    |
| February  | 77                    | 31    | 78    | 56                    | 32    | 59    |
| March     | 125                   | 50    | 117   | 91                    | 47    | 88    |
| April     | 158                   | 71    | 136   | 121                   | 59    | 105   |
| May       | 203                   | 77    | 171   | 171                   | 83    | 144   |
| June      | 222                   | 73    | 167   | 175                   | 88    | 132   |
| July      | 224                   | 74    | 222   | 181                   | 79    | 157   |
| August    | 198                   | 64    | 168   | 156                   | 75    | 134   |
| September | 150                   | 46    | 167   | 98                    | 59    | 74    |
| October   | 111                   | 34    | 111   | 68                    | 34    | 79    |
| November  | 65                    | 24    | 74    | 33                    | 21    | 37    |
| December  | 50                    | 22    | 80    | 24                    | 16    | 28    |
| Total     | 1632                  | 590   | 1578  | 1203                  | 612   | 1081  |

Therefore, in terms of location and climate conditions, or irradiated solar energy, the way to realize the sustainability of Zagreb with SSE technology could be more difficult and demanding than in most other cities in the world, which means that, in this sense, Zagreb could be a good model for considering this problem.

When addressing the problem of sustainability, the vulnerability of a certain city in terms of natural disasters, in which climate change has an increasing impact, carries special weight. It is not enough just to make a city sustainable, but it should also be preserved, which means that it is necessary to make it as resilient and prepared as possible for natural disasters. Zagreb is located in a seismically active zone, with the possibility of an earthquake of 6.5 on the Richter scale. Floods can also occur in Zagreb due to extreme weather events, which are becoming more frequent, and no one can predict the level of such floods, which makes the city vulnerable to natural disasters. Therefore, the measures that Zagreb would take must also account for this adverse environmental impact.

In this sense, the upper water storage of the SSE system could be used to regulate high waters at the entrance of the Sava River into the city and defend the city from floods with an original strategy by building another large reservoir (lake). In this reservoir, water would be pumped during high waters (pumping energy would be obtained by pumping water from the upper water storage of the SSE system at a rate that would optimally control this system so that large waters are later used for energy production, which should not be

a problem to perform for Zagreb as a sustainable smart city), which could be applied to many other cities in the world.

Another reason for choosing the city of Zagreb is the experiences of the authors, who have already worked on the problems of energy efficiency and RES systems [26–30] and achieving the sustainability of Zagreb [31]; therefore, they can perceive all relevant issues of such a complex intervention in a particular case.

### 3.2. Input Data

In order to verify the success of solving the problem of the sustainability of cities with SSE technology, the case of the city of Zagreb was selected, with 806,341 inhabitants (2019), an area of 641 km<sup>2</sup> and a population density of 1258 inhabitants/km<sup>2</sup>, according to public data. In the western part of the city, there is sufficient space for the accommodation of SSE technologies, and the terrain configuration with altitude differences (Medvednica Mountain) is suitable for the accommodation of hydro storage.

Gross domestic product (GDP) for the city of Zagreb in 2018 amounted to EUR 17,544 million [32], which is an important parameter for assessing the economic possibilities that the city be made sustainable “on its own”.

Zagreb is located in a moderately continental climate, with the values of solar radiation shown in Table 1, which were obtained from the Meteorom program 7.3.4. [33], while the data for the island of Vis (Croatia) were calculated in a previous paper [34]. The island of Vis (Croatia) was chosen because an optimization model was developed for it, which calculated all characteristic parameters of the SSE system [20] and can be applied in this case as well.

For parabolic trough collectors (as used by SSE technology), only the component of direct solar radiation  $B_n$  (kWh/m<sup>2</sup>a) on the collector surface accompanying the sun is relevant.

Table 2 shows the data on the structure of energy consumption in the city of Zagreb [35] and individual consumption expressed in (GWh) (far right column).

**Table 2.** Structure of energy consumption of the city of Zagreb in 2015 \* [35].

| Measuring Unit: TJ      | Industry | Transportation | Households | Services | Agriculture | TOTAL (GWh) |
|-------------------------|----------|----------------|------------|----------|-------------|-------------|
| Coal                    | 0.0      | 0.0            | 2.9        | 0.0      | 0.0         | 0.8         |
| Natural gas             | 982.6    | 117.6          | 7314.4     | 2816.4   | 17.3        | 3124.5      |
| Firewood                | 4.5      | 0.0            | 1922.4     | 45.9     | 0.0         | 548.0       |
| Solar energy            | 0.0      | 0.0            | 86.3       | 0.0      | 0.0         | 24.0        |
| Geothermal energy       | 0.0      | 0.0            | 0.0        | 25.3     | 0.0         | 7.0         |
| Biofuel                 | 0.0      | 202.5          | 0.0        | 0.0      | 0.0         | 56.3        |
| Other biomass and waste | 0.0      | 0.0            | 141.6      | 11.9     | 0.0         | 42.6        |
| Liquefied petroleum gas | 37.5     | 393.9          | 136.0      | 225.1    | 0.0         | 220.1       |
| Motor gasoline          | 31.2     | 3585.0         | 0.0        | 0.0      | 4.5         | 1005.8      |
| Petroleum               | 0.0      | 0.0            | 0.0        | 0.0      | 0.0         | 0.0         |
| Diesel fuel             | 670.5    | 8097.8         | 0.0        | 0.0      | 123.9       | 2470.1      |
| Extra light heating oil | 128.1    | 0.0            | 187.9      | 738.9    | 8.5         | 295.4       |
| Heating oil             | 48.2     | 0.0            | 0.0        | 72.3     | 0.0         | 33.5        |
| Electric energy         | 1523.9   | 331.9          | 3856.0     | 5161.7   | 4.0         | 3021.5      |
| Steam and hot water     | 1723.2   | 0.0            | 3565.4     | 861.2    | 0.0         | 1708.3      |
| TOTAL                   | 5149.7   | 12,728.7       | 17,212.9   | 9958.7   | 158.2       | 12,557.8    |

\* According to data from 2015, the population of Zagreb was 799,565, while in 2019, that number was only 1% higher and amounted to 806,341 [36]. Such a small difference could not have significantly affected the structure of energy consumption.

According to [29], the annual water consumption of the city of Zagreb for 2020 amounted to 54,683,000 m<sup>3</sup> of water, which is about 55 hm<sup>3</sup> of water per year.

### 3.3. Output Data

Based on the above input data and reference values of the SSE system for the island of Vis in Croatia (where the optimal nominal power of the SSE generator was determined by a simulation–optimization model based on dynamic programming, because it is a multistage decision-making process in a temporal sense, with a nonlinear objective function and constraints [20]), which are calculated by Equations (1)–(4), the results for the city of Zagreb were obtained by linear correlation (comparison with the results obtained for the island of Vis specifically; due to lower values of solar radiation, Zagreb will need higher unit power and a larger collector area compared to Vis, and due to significantly higher energy consumption in Zagreb, the SSE system will need proportionally higher power in relation to Vis), and the results are shown in Table 3.

**Table 3.** Calculation results of relevant parameters of SSE system for the city of Zagreb.

|     | Characteristic Parameters                               | VIS (Croatia) | ZAGREB (Croatia) |
|-----|---|---------------|------------------|
| 1 * | $B_n$ (kWh/m <sup>2</sup> /a)                           | 1578          | 1081             |
| 2 * | Population  | 3637          | 806,341          |
| 3 * | $E_{el(\text{consumption})}$ (GWh/a)                    | 20            | 3022             |
| 4 * | $V_{(\text{consumption})}$ (hm <sup>3</sup> /a)         | 0.45          | 55               |
| 5   | $P_{el(\text{NOM})}$ (MW)                               | 52            | 11,529           |
| 6   | $A_{\text{coll}}$ (km <sup>2</sup> )                    | 0.37          | 39               |
| 7   | $Q_{(\text{production})}$ (GWh/a)                       | 179           | 18,509           |
| 8   | $E_{el(\text{production})}$ (GWh/a)                     | 63            | 6478             |
| 9   | $V_{(\text{DW})(\text{production})}$ (hm <sup>3</sup> ) | 0.48          | 73               |
| 10  | $V_{PSH}$ (hm <sup>3</sup> )                            | 7             | 1057             |
| 11  | $W_{DW}$ (hm <sup>3</sup> )                             | 0.08          | 13               |

\* Input data from Tables 1 and 2.

In the first row of Table 3, the values of direct solar radiation  $B_n$  (kWh/m<sup>2</sup>/a) for the island of Vis [34] and the city of Zagreb [25] are given, which shows that in Zagreb, these values of direct solar radiation  $B_n$  are about 30% lower, which results in about 30% of the required higher unit values. The second row shows the number of inhabitants, and the third row shows total electricity consumption  $E_{el(\text{consumption})}$  (GWh/a) (data for Zagreb are for 2015—taken from Table 2), while the fourth row shows total water consumption  $V_{(\text{consumption})}$  (hm<sup>3</sup>/a) for Zagreb in 2020, which changed very little compared to 2015.

The fifth row of Table 3 contains the values of the nominal power of the SSE generator  $P_{el(\text{NOM})}$  (MW) (Equation (1)), which for Zagreb, should amount to 11,529 MW, while the required area of the collector field  $A_{\text{coll}}$  (km<sup>2</sup>) for this power is given in row 6 and would amount to 39 km<sup>2</sup>. Rows 7, 8 and 9 show the values of produced thermal energy  $Q_{(\text{production})}$  (GWh/a) = 18,509 GWh/a (Equation (2)) and electricity  $E_{el(\text{production})}$  (GWh/a) = 6478 GWh/a (Equation (3)) and drinking water  $V_{(\text{DW})(\text{production})}$  (hm<sup>3</sup>) = 73 hm<sup>3</sup> (Equation (4)), respectively. The 10th row of Table 3 shows the volume of hydro storage  $V_{PSH}$  (hm<sup>3</sup>) (1057 hm<sup>3</sup>, which can be situated in several lakes about 100 m deep, located on the mountain “Medvednica”, along which the construction of the SSE system is planned, which would ensure continuous energy supply throughout the year. The 11th row shows the required volume of drinking water storage  $W_{DW}$  (hm<sup>3</sup>) (13 hm<sup>3</sup>—also located on the mountain “Medvednica”) that is necessary to supply the city with drinking water in periods when there is not enough solar radiation.



The calculation results for relevant parameters of the SSE system for the city of Zagreb (Table 3) show that the SSE system could fully meet the needs of Zagreb for electricity because they amount to 3021.5 GWh/a (Table 2), as well as the needs for drinking water (it can produce 73 hm<sup>3</sup>/a, and needs are 55 hm<sup>3</sup>/a). In addition, the system produces a large amount of heat (18,509 GWh/a), of which 1/3 is converted into electricity, while the other 2/3 of energy could meet the needs of the city for heating and cooling (about 6000 GWh/a), which are now satisfied using: coal, natural gas, firewood, solar energy, geothermal energy, biofuels, other biomass and waste, liquefied petroleum gas, extra light fuel oil, fuel oil, steam and hot water (6060 GWh/a in total), as can be seen in Table 2.

The energy currently used for transportation in Zagreb for motor gasoline and diesel fuel is 3476 GWh/a. Considering that the SSE system could produce 6478 GWh/a of electricity, of which Zagreb needs 3021 GWh, there is still 3457 GWh/a of electricity left, which coincides with the energy required for the transportation sector. Therefore, if Zagreb switched to electric cars, its energy needs in the transportation sector could be fully met, and the city of Zagreb could become the first sustainable city in the world to fully meet all of its needs for electricity and heat, including its transportation sector (with implications for preserving clean air), and meet its needs for drinking water, thus becoming the first city in the world to be completely independent of external sources of electricity and heat (heating/cooling) energy and drinking water.

Figure 3 shows the situation of SSE and the distribution energy system (heating and cooling). The collector field of parabolic trough collectors is positioned in the western part of the city (where there is enough space for its accommodation) along the Sava River, from which water can be pumped. With the height difference that exists on Medvednica Mountain, where the upper water reservoir can be located, summer surpluses and winter shortages of solar energy could be balanced, thus ensuring a continuous supply of electricity to the city throughout the year. The existing “Zaprešić Lake” or the Sava River could be used as the lower reservoir.



**Figure 3.** Layout of the collector fields of SSE technology (which uses Sava River as input water) and distribution loops of heating and cooling for the city of Zagreb.

For the purpose of continuously supplying the city with drinking water, the appropriate “drinking water storage” would be located on Medvednica Mountain.

The distribution network of heating and cooling energy, as well as the supply of electricity and drinking water, would operate in a novel way, with a loop within the city (Figure 3). This would achieve high reliability of supply (from which other parts

of the city would be radiantly supplied). In the eastern part of the city, it would reach the location “Borongaj”, which could accommodate: the control center and management center “Sustainable Smart City of Zagreb”, “Institute of Sustainable Technologies” and the associated “Study of Sustainable Technologies”, the first of their kind in the world, so that they can further develop this innovative technology and its application and, in this sense, as well as in terms of philosophy of sustainability, educate future generations that could disseminate knowledge and technology to other cities around the world, all in order to make them sustainable as soon as possible.

Since the Borongaj location has sufficient usable area, it could be used for the possible addition of solar photovoltaic collectors to increase the reliability of electricity supply to consumers, thus increasing the reliability of the city’s supply with heat and cooling energy and drinking water, because supply reliability of sustainable cities is crucial.

### 3.4. Investment

Considering that this is a completely new SSE technology, as well as an original method of distributing heat (heating and cooling), electricity and drinking water (loop), only a rough estimate can be made for the necessary investments on the basis of similar systems that have been developed and on the basis of the authors’ design experiences.

The investment consists of SSE collector fields (through which seawater or water from other unclean water sources passes), power block, water treatment technology, PSH technology, thermal energy storages, ice banks, distribution loops (35 km long) and adaptations to existing systems.

The total investment in the SSE system can be estimated on the basis of the costs for solar parabolic trough collectors, reported in [37], which states the price of 177 USD/m<sup>2</sup> for solar parabolic collectors for 2025. The price includes: site preparation, collector structure (incl. assembly), pylons and foundations, drives, mirrors, receivers, cabling, HTF system (fluid) and HTF system (excl. fluid).

Thus, for a collector area of 39 km<sup>2</sup> (Table 2, row 6):

$$177 \text{ USD/m}^2 \times 39,000,000 \text{ m}^2 = 6,903,000,000 \text{ USD}$$

Investment costs for the power block and water treatment technology should be added to this value, so the total investment could amount to about USD 7 billion.

The investment in the accumulation system can be estimated from the data from [15], which states the amount of 0.434 USD/W for PSH systems. The capacity of hydro storage is also evaluated linearly by correlation and is 703 MW, which amounts to an investment of:

$$703,000,000 \text{ W} \times 0.434 \text{ USD/W} = \text{USD } 305,000,000$$

Since another large reservoir is required for high water regulation and a drinking water reservoir needs to be built, the entire reservoir system, complete with engines, pumps, hydro turbines and generators, could be estimated at about USD 1 billion.

The investment in the distribution network system is difficult to estimate because it is an original concept of the distribution of heat (heating and cooling), electricity and drinking water, which would be in the form of a loop (ring) in the city, with a total length of 35 km. In addition, the heat distribution system would consist of seasonal thermal energy storage (TES) and ice banks, which, according to the experience from the sustainable city Borongaj (Zagreb, Croatia) [38], can be estimated at about 300 TES of 80,000 m<sup>3</sup> of water and about 6000 probes (sonde) of geothermal heat pumps, 100 m long. The whole system of distribution and storage of thermal energy (heating and cooling) with geothermal heat pumps to ensure the continuity and reliability of supply to consumers throughout the year, complete with pumping stations and substations, could be assessed to about USD 100 million per kilometer of the loop from which energy and drinking water would

continue to be radiantly supplied to all parts of the city. This means that this investment could be assessed as follows:

$$35 \text{ km} \times \text{USD } 100 \text{ million} = \text{USD } 3.5 \text{ billion}$$

Assuming that the adaptation and construction of new lines in the old network and its connection to the new “loop system” are estimated to amount to USD 1 billion, the total investment could be estimated with a value of:

$$7 + 1 + 3.5 + 1 = \text{USD } 12.5 \text{ billion}$$

Assuming that this investment will be realized by 2025, after 30 years (2055), the average annual investment would be around USD 0.4 billion/year.

The GDP for the city of Zagreb in 2018 was EUR 17,544 million [32], with the exchange rate of EUR 1 = USD 1.18 (on 13 September 2021), which amounts to USD 20,702 million, i.e., USD 20.7 billion.

Thus, the value of USD 0.4 billion/year accounts for 1.93% of GDP, or an investment of about:

$$2\% \text{ of GDP per year}$$

which clearly shows that the city of Zagreb has the economic strength to implement this system.

This rough economic analysis of only investment costs does not include benefits, meaning that from the construction of the energy and drinking water supply system (from 2025), Zagreb would not have any costs related to fossil fuels. Furthermore, with parallel investment in the energy efficiency of buildings in Zagreb, energy consumption would be significantly reduced, so the entire SSE system and distribution system could be smaller, which means a smaller investment. This is why it is very important to plan properly and strictly adhere to the systems engineering approach and find the optimal solution and dynamics for the construction of all systems that would make the city of Zagreb sustainable, which means independence of external energy sources and drinking water.

## 4. Discussion

### 4.1. Various Approaches to Combating Climate Change

The conclusions of COP26 [39] once again show the failure of UN policy because they list the same methods of combating climate change (II. Adaptation and IV. Mitigation) as listed in the Paris Agreement, which, to date, have yielded no results. This is best illustrated in citations 20 and 21, item IV. Mitigation, Glasgow Climate Pact, which reads:

*“20. Reaffirms the Paris Agreement temperature goal of holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels;*

*21. Recognizes that the impacts of climate change will be much lower at the temperature increase of 1.5 °C compared with 2 °C and resolves to pursue efforts to limit the temperature increase to 1.5 °C”.*

Therefore, despite the fact that after 6 full years since the adoption of this agreement, no results have been achieved in the direction of reducing climate change (on the contrary, it is increasing, with more extreme events and with increasing global temperature), COP26 “reaffirms the Paris Agreement temperature goal”.

This can only indicate that the UN either does not really notice the weaknesses of the Paris Agreement or is simply not ready to recognize them. Given that the former is unlikely (because the climate situation is getting worse and worse), it is clear that the UN is not yet ready to acknowledge the mistakes of the Paris Agreement, regardless of the reason.

In 2021, the UN came to an extremely absurd conclusion, i.e., to stick to an agreement that has not yielded results for 6 years and that is obviously unenforceable, while still

insisting on its maintenance (COP26) and thus preventing any other policy from being established. Thus, the Paris Agreement (which was supposed to bring a solution) has actually become the main obstacle to solving the problem of climate change.

For this reason, it is necessary to completely change the global policy on combating climate change to an approach that is not reduced to “as much as any party can” and “carbon pricing”. Instead, the strategy should be to reorient the high-carbon economy into a green economy by adopting a new technology that would be a powerful weapon in the fight against climate change, that could produce both energy and drinking water and that would be equally accessible to both developed and underdeveloped countries. Such a policy was developed and called the Climate New Deal by the first three authors of this paper, and it is explained in more detail in [6].

However, this completely new policy also requires completely new strategies in the fight against climate change, which would not be economically based (such as the Kyoto Protocol and the Paris Agreement with “carbon pricing”) but driven by engineering-based strategy (Section 2.3), and which would be based on making all cities (as well as the largest energy consumers) completely sustainable, which means being completely independent of external sources of energy and drinking water. Thus, overall sustainability could be achieved by making all cities in the world sustainable so that each city, out of a total of 10,000 cities, would become a “brick” in building a fully sustainable civilization.

This also means that all cities would have to change their previous policies and strategies to achieve sustainability, which have been based on showing certain percentages indicating how much sustainability they have achieved in a particular area.

This paper shows how the new Climate New Deal policy can be implemented in cities with up to 1 million inhabitants with new SSE technology, but also in cities with more than 1 million inhabitants (using new strategies for mixing collectors—canopies), and solutions for megacities have also been proposed. Thus, this work can become a guide for mayors of all cities in the world on how to make their cities sustainable.

Therefore, this paper shifts the burden of combating climate change to cities, and if all of them would strictly implement the strategy of achieving sustainability, overall sustainability could be achieved.

The essential difference in policies to combat climate change is that they would no longer set percentages for reducing CO<sub>2</sub> emissions by a certain year (2030 or 2050) or seek to reduce the use of a fossil fuel (e.g., coal) or aim for climate neutrality, because past experiences in the fulfillment of agreements have shown that such tasks are unlikely to be carried out; rather, according to the authors of this paper, a new, much more ambitious policy (“Climate New Deal”) should be sought, with the strategy aimed at achieving the sustainability of all cities in the world by 2050.

#### *4.2. Solving Sustainability Problems for Cities with a Population of over 1 Million*

Regarding the problem of sustainability, cities with a population of over 1 million (medium, large and megacities) in locations with over 1000 kWh/m<sup>2</sup>/a of direct solar radiation generally do not have space for the collector systems of SSE technology, and distances from the city to the SSE system could be too large, in which case the collector layout strategies must obviously be altered. The roofs of buildings, currently used for photovoltaic and thermal collectors, are insufficient surfaces to achieve more serious energy production. Therefore, with such limitations, radical new solutions clearly need to be resorted to. The authors of this paper propose to place so-called “canopies” over low buildings, i.e., constructions with SSE collectors, which could achieve the required production of all types of energy and drinking water and would be in the vicinity of consumers. It is clear that the construction of structures with collector systems within the city would change the image of the city, but these structures could be made so as not to obscure the sun above a certain percentage in winter, and in summer, due to the shade they would produce, less cooling energy for the city would be required. Simply put, there would be entire neighborhoods covered by SSE collectors, so cities would have “canopies” with



multiple functions (futuristic trends in solar architecture). In this way (by covering SSE collectors and placing them over low parts of the city), the SSE system would be in the city itself and would supply it with the necessary energy and drinking water in the same way (or according to the same concept) as proposed for the city of Zagreb. These cities could achieve sustainability, as the SSE system could continuously supply them with energy and drinking water throughout the year.

On the other hand, if cities with more than 1 million inhabitants are located in areas with relatively little solar energy (below 1000 kWh/m<sup>2</sup>/a of direct solar radiation), then, clearly, different strategies must be applied. In this case (in this transitional period, e.g., in the next 30 years), there is no sustainable solution other than to use the energy of the RES system produced outside these cities (hydro, wind, biomass, etc.) and then transmit it to them in the form of electricity, which should become the main energy supply of such cities. As the transmission of electricity is far more efficient relative to heat transfer, electricity would be converted into thermal energy in the city itself in the SSE system (heating and cooling), after which all other processes would be the same as in SSE systems that directly use solar energy or would be reduced to them. However, this also raises the question of whether it will be possible to produce enough RES energy for these cities to be sustainable and whether this transition to RES systems will be possible in a certain period of time (the next 30 years) in order to prevent further climate change. Given that cities can only be sustainable or not sustainable, i.e., they cannot be “unsustainable-sustainable cities” because that would be an oxymoron, such cities would have to change and undergo a radical transformation in terms of depopulation policy whereby their populations are reduced to the limits required to achieve sustainability in parallel with the process of increasing energy participation from RES systems.

The authors are aware of the criticisms that such strategies for solving the problem of sustainability of large cities could provoke. However, the following truth is hard to deny:

*If fossil fuels are responsible for the big cities of today, seriously threatening the climate system, then it is obvious that the transition to RES systems would lead in the other direction (reversal of trends), i.e., in the direction of the depopulation of such large cities and stopping climate change.*

Therefore, these processes should be reversed so that the situation with the climate system (global warming) is also reversed in the direction of its mitigation and global temperature drop.

If we do not want to give up such unsustainable cities and still want to prevent climate breakdown, there is only one solution left: in the upcoming period (30 years), these large cities must more intensively use nuclear energy, which does not emit CO<sub>2</sub>. However, there are major ethical dilemmas because nuclear energy is not acceptable to people due to fears of accidents and the production and disposal of radioactive waste, and it is not a renewable energy source. However, stuck between the threat of climate breakdown, strong (actually the greatest) resistance of big cities to be sustainable and fears of nuclear power, humanity will have to choose, and the authors of this paper propose the transformation of big cities towards sustainability, which is the underlying focus of this paper.

#### 4.3. The Issue of Energy Efficiency in Cities

Since buildings in the world consume about 35% of energy and are responsible for 38% of CO<sub>2</sub> emissions [40] and given that older buildings predominate in many cities, consuming more energy, in order to achieve sustainability, it is logical to take measures to significantly reduce their consumption.

In this sense, a good example is the city of Zagreb, which has a relatively large number of old buildings whose consumption exceeds 250 kWh/m<sup>2</sup>/a, so the total energy consumption of the city buildings (both old and new) makes up almost half of the overall energy consumption. This also means that there is a very high potential to primarily reduce energy consumption in buildings by applying energy efficiency measures to the level of passive standard (15 kWh/m<sup>2</sup>a), which would significantly reduce the total energy



consumption in buildings [41,42] and significantly affect the size of the SSE system. Thus, by a parallel reduction in energy consumption in buildings and the construction of the SSE system, the SSE system could be significantly smaller.

#### *4.4. Natural Resources for Implementation of the SSE Technology and Planning of Sustainable Cities*

The advantage of SSE technology is that it is relatively simple and mainly uses available sources of raw materials (iron), so it is equally available to developed and underdeveloped countries. This is of particular importance because countries/companies that have invested heavily in the development of RES technologies will certainly not be willing to donate them to less developed countries.

The question that could also be asked is why water for some cities would be obtained from SSE technology when it can be obtained by purifying water from rivers flowing through them. The answer is that rivers currently are polluted by different pollutants, i.e., wastewater from settlements (sewers) and industry, and microbiologically (viruses, bacteria, fungi and parasites) and chemically contaminated (heavy metals, nitrates, nitrites, detergents, pesticides, ammonia, etc.). Furthermore, their contamination with antibiotics is a growing problem, as well as the possible problem of radioactive waste (if the river operates to cool a nuclear power plant). These all result in the fact that fewer and fewer cities can safely use drinking water from their rivers or other natural water sources, because not all pollutants can be safely addressed and removed by using available water treatment methods. Therefore, obtaining drinking water with SSE technology (evaporation and subsequent condensation and additional treatment) could be the safest way to purify it.

Planning for sustainable cities is the most important and meaningful job because the overall success of climate protection depends on it. Partial solutions, such as those used in cities today (bicycle paths, electric cars, increasing green areas, placing photovoltaic collectors on roofs, painting facades and streets white, “greening buildings”, etc.) might have a positive impact from a sociological point of view. However, they will not make these cities sustainable, nor make them resistant to increasing climatic extremes (floods, fires, droughts, etc.); rather, success in the direction of sustainability requires serious interventions and responsible management structures in cities that will be able to recognize the strategies for achieving sustainability, such as the system proposed in this paper.

#### *4.5. Climate Change and Maintaining Sustainability*

In the dynamics of the transformation of cities towards sustainability, it is necessary to emphasize another problem that relates to the fact that, with climate change, the input energy parameters of certain renewable energy sources also change (in addition to possible changes in water resources in terms of its absence if, for example, it is a lake or a small river). These primarily refer to the sun and wind, but also to hydropower and ocean energy (waves, tides, salinity gradient energy, and ocean temperature differences), so care should be taken to keep the city sustainable, not only in the present but also in the upcoming variable climatic conditions as society gradually changes/adapts to them.

When selecting a particular renewable energy source, the long-term data series provided by hydrometeorological institutes for a particular location in the city to be made sustainable will not be good enough but should be limited to shorter periods of time (e.g., 5 years). Special attention should be paid to trends (increases or decreases in solar radiation, wind energy, etc.). With greater climate change, it is logical that deviations from the budget for energy production from the SSE (RES) system at a particular location will be greater. In this sense, it is best to rely on the expertise of design engineers (who can perceive all relevant aspects of the problem and make decisions within given constraints), who will determine the reserves in the capacity of the SSE (RES) system in order to keep cities permanently sustainable (it is generally much more difficult to plan SSE/RES systems than fossil fuel energy systems, which are easily manageable—coal, oil and gas are added to power plants according to consumer needs), which also means that SSE (RES) systems can

permanently and reliably supply energy and drinking water. The installed equipment of the RES system has its own lifespan, but it will be periodically maintained and changed, and the old equipment will be disposed of sustainably (which is extremely important, especially if PV collectors are used), as well as equipment for water reservoirs (e.g., geo foils), all in order to permanently maintain the sustainability of cities [43].

#### *4.6. New Philosophy: Philosophy of Sustainability*

Given the experience with the COVID-19 pandemic, where people, despite the dangers to their health and lives, offered great resistance to lifestyle changes, it is logical to expect that people will offer even greater resistance to more serious lifestyle changes aimed at sustainability. People do not want to change their current way of life or their worldview, and despite so much informatization, they do not have convincing answers from authorities to new questions, so they resort to skepticism. Therefore, it is necessary to change people's consciousness, which is one of the most difficult processes where a new philosophy could play a decisive role. All other disciplines originate from philosophy, and today, they are so extensive that it is difficult to perceive them, so they need to be comprehended from the philosophical aspect. All relevant aspects of achieving sustainability should be critically observed, and in that sense, a new way of thinking (a different consciousness of people) will be articulated.

Although the engineering profession should play a key role in achieving sustainability, because the whole process is very limited in time, the authors believe that this will not be possible without introducing a new philosophy as a parallel process of changing consciousness, which should provide answers to all questions surrounding the harmonization of civilization with nature and set new paradigms for achieving sustainability (e.g., related to cities, so they can continue to maintain and/or grow in the future only if the environment allows it). For this reason, the authors encourage the development of a new philosophical direction, "Philosophy of Sustainability".

## **5. Conclusions**

This paper answers the question of how to systematically solve the problem of sustainability in 10,000 cities, as many as there are in the world today, whose number has increased significantly in the 5000-year-long period since the first industrial revolution and expanded in the second (because the energy of fossil fuels could be transmitted through electricity over long distances and brought into cities, where factories and workforces were situated), with an increasing number of inhabitants, all the way to megalopolises. Such cities have become the largest consumers of energy (78% of total energy consumption) and thus the largest polluters and the main cause of climate change.

To this end, this paper primarily criticizes the achievements related to climate agreements to date, because goals evidently will not be achieved in the future, as evidenced by rising global temperatures (which, in 2020, increased to as much as 1.2 ( $\pm 0.1$ ) °C compared to the pre-industrial period [3]). Even the latest appeal by over 230 editors of scientific journals in the field of medicine, i.e., the "call for emergency action to limit global temperature increases, restore biodiversity, and protect health" [4], clearly warns that a further rise in global temperature will disrupt biodiversity, human health and lives (described in Section 1).

In contrast to these approaches, which obviously do not yield results, the authors of this paper offer a completely different solution to achieve sustainability, emphasizing the need for a new ("top-down") climate policy, as already presented by the first three authors [6], which is based on the reorientation of the high-carbon economy into a green economy and the need for a radically new technology that should produce both energy (heat for heating and cooling and electricity) and drinking water. Of particular importance, the solution should be equally accessible to both developed and less developed countries because climate change is a common problem facing all of humanity.

In addition, the authors had to look critically at the ways in which cities today are trying to be made sustainable, which boil down to achieving certain percentages of sustainability in certain areas of sustainability. This shows that, at present, no city is completely sustainable: i.e., no city is completely independent of external sources of energy and drinking water, and this cannot be achieved using the previous approaches, so overall sustainability will not be achievable with the previous strategies. This leads to the conclusion that it is necessary to change strategies in order to achieve overall sustainability, which comes down to making all cities in the world sustainable, applying a systematic engineering approach to each of these cities, so in this way, they would be “bricks” that would build the overall sustainability of the Earth (“bottom-up”).

Therefore, stopping climate change would be implemented by a new “top-down” global policy (“Climate New Deal” [6]) and a “bottom-up” strategy to make all cities in the world sustainable.

This paper pays special attention to this new strategy for achieving sustainability, which envisages the application of new Seawater Steam Engine technology in cities. The proposed SSE system could continuously supply cities throughout the year with electricity and heat (heating and cooling) and drinking water using four natural resources—solar energy (or some other renewable energy source), seawater (or other unclean water sources), gravitational potential energy and the Earth’s thermal energy (Section 2.3).

This paper also presents an original concept of a sustainable city (using Zagreb, which has slightly less than 1 million inhabitants, as a case study), which can guide decision makers (mayors) of cities in the transition of today’s cities towards sustainability. Thus, it is an original concept of energy and drinking water production with SSE technology, an original application of energy storage and an original concept of energy distribution through loops, which significantly increases the reliability of the supply of these resources (Section 2.3). The results for the example of the city of Zagreb show that the proposed system of production, storage and distribution of energy and drinking water can fully meet all needs of the city for energy and drinking water throughout the year, which is key to achieving sustainability. Furthermore, the paper presents an estimate of investment, which, for the example of the city of Zagreb (whose GDP was 22,695 EUR/inhabitant in 2018 [32]), shows that to achieve sustainability requires investments of about 2% of GDP in the next 30 years, which shows that Zagreb also has the economic strength to finance such a system (Section 3.4).

The paper also proposes a radically new strategy for solving the problem of collector accommodation in smaller cities (less than 1 million inhabitants), but also in larger cities, by installing SSE collector systems as new “canopies over cities” (Section 4.2). For cities with over 1000 kWh/m<sup>2</sup> of solar energy, despite the fact that such systems are considered uneconomical for this level of solar radiation, this paper emphasizes that in achieving sustainability, the question of the price should not be raised because sustainability has no price.

For cities that do not have enough solar energy, it is suggested that they continue to be supplied with energy outside of the city, which would of course be from the RES system.

The paper also addresses the problem of nuclear energy (Section 4.2), highlighting that humanity is stuck between a possible climate breakdown, the resistance of cities to achieving sustainability and the fear of nuclear energy (which of course does not emit CO<sub>2</sub>), and in these conditions, decisions on how to solve the problem of big cities need to be made. The authors’ suggestion is, of course, that energy be brought to cities without sufficient solar energy through other RES systems.

In addition to the aforesaid issues, the authors address another very sensitive topic: if cities cannot be made sustainable, their depopulation should be addressed; i.e., the number of inhabitants should be reduced to the limits required for their sustainability (Section 4.2).

Aware of the problem that without a change in consciousness, people will not be able to achieve the sustainability of cities and thus global sustainability (because the success of

the whole action depends on all of humanity), the authors encourage the development of a new philosophical direction: “Philosophy of Sustainability” (Section 4.6).

This paper is therefore also an open appeal to the UN to revise the Paris Agreement after a public debate at the UN climate conference (COP28) in 2023 (when the first verification of the achievement of the goals of the Paris Agreement should be made) and adopt a different policy that could reverse the negative flows of global temperature increase, i.e., reduce global temperature.

Contemporary civilization puts the importance of living in cities ahead of sustainability and therefore continues to use fossil fuels (even subsidizing them) that have enabled the emergence of these cities and this way of life. However, it is not possible to achieve sustainability while cities continue to survive on the consumption of fossil fuels. Thus, humanity is facing a serious dilemma: i.e., either it will make all present-day cities in the world (as the largest consumers of energy) completely sustainable, or it will face the breakdown of the climate system and disappear.

The choice is very difficult because people generally do not want to give up this contemporary way of life. Nevertheless, the authors of this paper hope that the international community, i.e., those who make decisions on its behalf, will understand the seriousness of the situation and have enough empathy, both towards current generations (given that climate breakdown could happen relatively quickly because climate change does not occur linearly; rather, it is accelerating) and towards those yet to come and make the right decision.

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## References

1. IPCC. 2021: Summary for Policymakers. In *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*; Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., et al., Eds.; Cambridge University Press: Cambridge, UK, 2021; in press. Available online: [https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC\\_AR6\\_WGI\\_SPM.pdf](https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf) (accessed on 5 September 2021).
2. World Meteorological Organization (WMO). Mediterranean Gripped by Extreme Heat, with New Reported Temperature Record. 2021. Available online: <https://public.wmo.int/en/media/news/mediterranean-gripped-extreme-heat-new-reported-temperature-record> (accessed on 27 August 2021).
3. World Meteorological Organization (WMO). 2020 Was One of Three Warmest Years on Record. 2021. Available online: <https://public.wmo.int/en/media/press-release/2020-was-one-of-three-warmest-years-record> (accessed on 27 August 2021).
4. Mora, C.; Dousset, B.; Caldwell, I.R.; Powell, F.E.; Geronimo, R.C.; Bielecki, C.R.; Counsell, C.W.W.; Dietrich, B.S.; Johnston, E.T.; Louis, L.V.; et al. Global risk of deadly heat. *Nat. Clim. Chang.* **2017**, *7*, 501–506. Available online: <https://www.nature.com/articles/nclimate3322#citeas> (accessed on 27 August 2021). [CrossRef]
5. BMJ. “Over 200 Health Journals Call on World Leaders to Address ‘Catastrophic Harm to Health’ from Climate Change: Wealthy Nations Must Do Much More, Much Faster.” *ScienceDaily*, 6 September 2021. Available online: [www.sciencedaily.com/releases/2021/09/210906091017.htm](http://www.sciencedaily.com/releases/2021/09/210906091017.htm) (accessed on 27 August 2021).
6. Glasnovic, Z.; Margeta, K.; Logar, N.Z. Humanity Can Still Stop Climate Change by Implementing a New International Climate Agreement and Applying Radical New Technology. *Energies* **2020**, *13*, 6703. [CrossRef]
7. United Nations. *Kyoto Protocol*; United Nations: Tokyo, Japan, 1997. Available online: <https://unfccc.int/kyoto-protocol-html-version> (accessed on 5 September 2021).



8. Stern, N. *Stern Review on the Economics of Climate Change*; Government of the United Kingdom: London, UK, 2006. Available online: [http://mudancasclimaticas.cptec.inpe.br/~{\}\rmclima/pdfs/destaques/sternreview\\_report\\_complete.pdf](http://mudancasclimaticas.cptec.inpe.br/~{\}\rmclima/pdfs/destaques/sternreview_report_complete.pdf) (accessed on 5 September 2021).
9. United Nations. *Paris Agreement*; United Nations: Paris, France, 2015. Available online: [https://unfccc.int/files/essential\\_background/convention/application/pdf/english\\_paris\\_agreement.pdf](https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf) (accessed on 5 September 2021).
10. BloombergNEF. *Climate Policy Factbook, Three Priority Areas for Climate Action*. 2021. Available online: [https://assets.bbhub.io/professional/sites/24/BNEF-Climate-Policy-Factbook\\_FINAL.pdf](https://assets.bbhub.io/professional/sites/24/BNEF-Climate-Policy-Factbook_FINAL.pdf) (accessed on 15 September 2021).
11. UN-Habitat. *World Cities Report 2020, The Value of Sustainable Urbanization*. 2020. Available online: [https://unhabitat.org/sites/default/files/2020/10/wcr\\_2020\\_report.pdf](https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf) (accessed on 15 September 2021).
12. United Nations. *Climate Action, Cities and Pollution*. 2021. Available online: <https://www.un.org/en/climatechange/climate-solutions/cities-pollution> (accessed on 15 September 2021).
13. Cassells, K. *The World's Most Sustainable Cities*. Uswitch, 14 May 2021. Available online: <https://www.uswitch.com/gas-electricity/most-sustainable-cities/> (accessed on 15 September 2021).
14. IPCC. *Engage with the IPCC*. 2017. Available online: [https://www.ipcc.ch/about/engage\\_with\\_the\\_ipcc/](https://www.ipcc.ch/about/engage_with_the_ipcc/) (accessed on 5 September 2021).
15. Deane, J.P.; Ó Gallachóir, B.P.; McKeogh, E.J. Techno-economic review of existing and new pumped hydro energy storage plant. *Renew Sustain. Energy Rev.* **2010**, *14*, 1293–1302. [[CrossRef](#)]
16. García-Ayllon, S. Rapid development as a factor of imbalance in urban growth of cities in Latin America: A perspective based on territorial indicators. *Habitat Int.* **2016**, *58*, 127–142. [[CrossRef](#)]
17. *World Population Review, World City Populations 2021*. Available online: <https://worldpopulationreview.com/world-cities> (accessed on 15 September 2021).
18. United Nations. *Ocean Conference, Factsheet: People and Oceans*, New York, 5–9 June 2017. Available online: <https://oceanconference.un.org/documents> (accessed on 15 September 2021).
19. Institute for Sustainable Community. *What Is Sustainable Community*. Available online: <https://sustain.org/about/what-is-a-sustainable-community/> (accessed on 15 September 2021).
20. Glasnovic, Z.; Margeta, K.; Premec, K. Could Key Engine, as a new open-source for RES technology development, start the third industrial revolution? *Renew. Sust. Energ. Rev.* **2016**, *57*, 1194–1209. [[CrossRef](#)]
21. Margeta, K.; Glasnovic, Z. Seawater Steam Engine-The most powerful technology for building sustainable communities and stopping the climate change. In *Proceedings of the II International Energy & Environmental Summit—2017, Dubai, United Arab Emirates, 18–20 November 2017*. [[CrossRef](#)]
22. Glasnovic, Z.; Margeta, K. *Seawater Steam Engine as a Prime Mover for Third Industrial Revolution*; LAP LAMBERT Academic Publishing: Saarbrücken, Germany, 2017.
23. Glasnovic, Z.; Margeta, K.; Omerbegovic, V. Artificial water inflow created by solar energy for continuous green energy production. *Water Resour Manag.* **2013**, *27*, 2303–2323. [[CrossRef](#)]
24. Glasnovic, Z.; Rogosic, M.; Margeta, J. A model for optimal sizing of solar thermal hydroelectric power plant. *Sol. Energy* **2011**, *85*, 794–807. [[CrossRef](#)]
25. Kumm, M.; Varis, O. The world by latitudes: A global analysis of human population, development level and environment across the north–south axis over the past half century. *Appl. Geogr.* **2011**, *31*, 495–507. [[CrossRef](#)]
26. Glasnovic, Z.; Margeta, J. Vision of Total Renewable Electricity Scenario. *Renew. Sust. Energy Rev.* **2011**, *15*, 1873–1884. [[CrossRef](#)]
27. Glasnovic, Z.; Urli, N.; Desnica, U.; Sesartic, M.; Miscovic, L.; Peric, N.; Firak, M.; Krmar, S.; Etlinger, B.; Metikos, M.; et al. *Croatian Solar House: A Feasibility Study*; Rudjer Boskovic Institute: Zagreb, Croatia, 2002; ISBN 953-6690-24-1. (In Croatian)
28. Sesartic, M.; Glasnovic, Z.; Matijasevic, L.; Filipan, V.; Doerig, T.; Dejanovic, I.; Jukic, A. *Feasibility Study of the Application of Energy Efficiency Technologies in the Residential-Commercial Building Agria Osijek*; University of Zagreb: Zagreb, Croatia, 2007; ISBN 978-953-6470-29-7. (In Croatian)
29. Sesartic, M.; Glasnovic, Z.; Glasnovic, A.; Doerig, T.; Matijašević, L.; Filipan, V.; Jukić, A.; Margeta, K.; Dejanović, I.; Sesartić, A. *A New Standard for Energy Efficient Buildings in Croatia, Energy and the Environment 2008*; Croatian Solar Energy Association: Rijeka, Croatia, 2008.
30. Glasnovic, Z.; Sesartic, M.; Margeta, K. Straw as a building material. *Gradevinar* **2010**, *62*, 267–271.
31. Margeta, K.; Farkas, A.; Glasnovic, Z. Construction Materials Future. *Gradevinar* **2011**, *63*, 1009–1012.
32. City of Zagreb. *GDP for the City of Zagreb and the Republic of Croatia, 2018*, City Office for the Strategic Planning and Development of the City, Press Release, 4 March 2021. Available online: [https://www.zagreb.hr/userdocsimages/arhiva/statistika/2020/bdp%202018/bdp%202018\\_web.pdf](https://www.zagreb.hr/userdocsimages/arhiva/statistika/2020/bdp%202018/bdp%202018_web.pdf) (accessed on 23 September 2021). (In Croatian).
33. *Meteonorm 7.3.4. Worldwide Irradiation Data*. Available online: <https://www.meteonorm.com/> (accessed on 15 September 2021).
34. Premec, K. Climate data for Island Vis and Split in Croatia. *Meteorol. Hydrol. Serv.* **2014**, *57*, 1194–1209.
35. City of Zagreb. *Statistical Yearbook of the City of Zagreb 2020*, City Office for the Strategic Planning and Development of the City. 2020. Available online: [https://www.zagreb.hr/UserDocsImages/1/SYCZ%202020\\_web.pdf](https://www.zagreb.hr/UserDocsImages/1/SYCZ%202020_web.pdf) (accessed on 23 September 2021).
36. City of Zagreb. *Annual Energy Efficiency Plan of the City of Zagreb for 2017*. Available online: <https://knowledge-hub.circle-lab.com/article/4199?n=Annual-Energy-Efficiency-Plan-of-the-City-of-Zagreb> (accessed on 23 September 2021). (In Croatian).



37. Dieckmann, S.; Dersch, J.; Giuliano, S.; Puppe, P.; Lüpfer, E.; Hennecke, K.; Pitz-Paal, R.; Taylor, M.; Ralon, P. LCOE reduction potential of parabolic trough and solar tower CSP technology until 2025. In *AIP Conference Proceedings*; American Institute of Physics: College Park, MD, USA, 2017; Volume 1850, p. 160004. [[CrossRef](#)]
38. Glasnovic, Z.; Sesartic, M. *Sustainable City Borongaj, Zagreb—Preliminary Design*; University of Zagreb: Zagreb, Croatia, 2008. (In Croatian)
39. COP26, Glasgow Climate Pact, Advance Version. Available online: [https://unfccc.int/sites/default/files/resource/cma2021\\_L16\\_adv.pdf](https://unfccc.int/sites/default/files/resource/cma2021_L16_adv.pdf) (accessed on 29 November 2021).
40. IEA. World Energy Statistics and Balances, Energy Technology Perspectives. Available online: <https://globalabc.org/resources/publications/2020-global-status-report-buildings-and-construction> (accessed on 5 October 2021).
41. Glasnovic, Z. Energy Efficient Building of the Faculty (FCET) as a Paradigm of Old Buildings of the City of Zagreb, Zagreb Energy Week, Faculty of Chemical Engineering and Technology, University of Zagreb, 10–16 May 2010. Available online: [https://eko.zagreb.hr/UserDocsImages/zg\\_energetski\\_tjedan/2010/FKIT.pdf](https://eko.zagreb.hr/UserDocsImages/zg_energetski_tjedan/2010/FKIT.pdf) (accessed on 10 January 2022). (In Croatian).
42. Passive House Institute. “What Is a Passive House?”, Passivhaus Institute. Available online: [https://passipedia.org/basics/what\\_is\\_a\\_passive\\_house](https://passipedia.org/basics/what_is_a_passive_house) (accessed on 5 October 2021).
43. Glasnovic, Z.; Margeta, K. *Revitalization of Hydro Energy: A New Approach for Storing Solar Energy, Solar Energy Storage*; Sørensen, B., Ed.; Elsevier: London, UK, 2015; Chapter 8; pp. 189–206, ISBN 978-0-12-409540-3.