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Sinan Küfeoğlu

# The Home of the Future

## Digitalization and Resource Management

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# Preface

What awaits us in future is a tempting question for many. Climate change and its possible impacts and depletion and contamination of the world's limited resources are alarming headlines that keep academics, authorities, and industry occupied. Tackling climate change, mitigating the adverse effects, reducing $CO_2$ emissions in all sectors, primarily in power, transport, buildings, and agriculture, and most importantly, building a sustainable future for future generations are some of the challenges.

To build a safer and more sustainable future, as humankind, we would like to use more renewable energy, increase energy efficiency, and reduce our carbon and water footprints in all economic sectors. The increasing population and humans' ever-increasing demand for consumption pose another question whether the world's resources are sufficient for all now and future generations. Fair access to water, energy, and food is the objective for all. In line with the United Nations Sustainable Development Goals, scientists, researchers, engineers, and policymakers worldwide are working hard to achieve these objectives. Rising sea levels will be another menace for us. A significant portion of the human population resides seaside. The growing urban population is another factor that planners should consider. These lead us to think of the possibility of sustaining life on the sea. In that case, energy and water supply seem straightforward, but what about the food?

Digital technologies and increasing digitalisation in daily life, society, and business bring hope and convenience to optimise resource production and consumption. Expanding digitalisation will be a vital tool to achieve Sustainable Development Goals. On the other hand, income generation and economic activities are needed for a sustainable life as well. COVID-19 pandemic has shown us that home offices or working from home is a prominent alternative from traditional working arrangements. Designing an environment that will be both a living space and a proper and comfortable working space is another tempting subject.

To answer all these challenges, we would like to introduce the core of smart cities of the future, the building block of the future's urban life: Open Digital Innovation Hub (ODIH). ODIH will serve as the 'Home of the Future', a fully digitalised and smart, self-sustaining building that answers all the motivation we highlight here. In ODIH, we introduce a living space that produces its water, energy, and food by minimising carbon and water footprints thanks to the Internet of things, artificial intelligence, and blockchain technologies. It will also serve as an open innovation environment for start-ups and entrepreneurs who wish to integrate their solutions into the infrastructure of ODIH and test those in real time. We believe this will be a true open innovation test bed for new business models.

Cambridge, UK
December 2020

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# Contents

# 1 Sustainable Living Spaces and Open Digital Innovation Hub

**Abstract**

We dream of a self-sustaining 'Home of the Future' that will be a home and a workplace for two persons. This home should be utilising digital technologies to optimise its resource consumption as well as vital resource production. We envisage of a home capable of producing energy, water and food and an open office that will be a hosting bed for start-ups and entrepreneurs to test and monitor their daring ideas and solutions in real-life. The objective of this book is to investigate the self-sustaining concept under the water-energy-food nexus perspective. To apply the theory into practice, we will design a self-sustaining house that will serve as an Open Digital Innovation Hub (ODIH) for entrepreneurs, start-ups and researchers. ODIH, as a platform, will serve like a catalyst for exploring the boundaries of Internet of Things, Artificial Intelligence, Smart Charging and Blockchain that can be used in resource management.

The author would like to acknowledge the help and contributions of Zehra Çonguroğlu, Sefa Güngör Özkan, Umut Gergin and Hasan Ecehan Bayır in completing of this chapter.

## 1.1 Introduction

We dream of a 'Home of the Future' that will be a dwelling and a workplace for two persons. This home should be utilising digital technologies to optimise its resource consumption as well as vital resource production. We dream of a home capable of producing energy, water and food and an open office that will be a hosting bed for start-ups and entrepreneurs to test and monitor their daring ideas and solutions in real-life. The objective of this book is to investigate the self-sustaining concept under the water-energy-food nexus perspective. To apply the theory into practice, we will design a self-sustaining house that will serve as an Open Digital Innovation Hub (ODIH) for entrepreneurs, start-ups and researchers. ODIH will be a floating platform providing residence for two persons and can produce its own water, energy and food. The concept Self-Sustaining is defined by the Merriam-Webster Dictionary and by the Cambridge Dictionary as:

> maintaining or able to maintain oneself or itself by independent effort (Merriam-Webster 2020).
> used to describe an activity that can continue without more investment (Cambridge Dictionary 2020).

Water is a finite and essential resource for life. The growing population and inefficient use of freshwater can cause a water crisis. Over 80% of the wastewater generated in developing countries is discharged without treatment into surface water bodies, and globally, two million tons of



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sewage, industrial and agricultural waste is discharged into the world's waterways (UN-Habitat 2010). Therefore, it is essential to use water in a controlled manner and manage it properly after use. In ODIH, clean water will be supplied through reverse osmosis (seawater) and humidity to water systems. It will also harvest rainwater and purify greywater to be used in cleaning and soilless agriculture.

The energy need is increasing day by day, and it becomes prevalent which resources we prefer to meet this need. In 2017, it was measured that only 17% of total energy consumption came from renewable energy sources (United Nations 2017). The three most used energy sources are oil, coal and natural gas (IEA 2020). Replacing them with renewable energy sources such as solar and wind energy has become a critical requirement to reduce carbon emissions. ODIH will essentially be a prosumer that produces its own energy and sell the excess power over Blockchain. It will have a rooftop Photo-Voltaic (PV), auxiliary Wind Turbine and a small Biogas plant. To store energy, we will employ batteries and heat pumps.

Food production is a complex process that requires many steps and natural resources such as water and land. Also, harmful chemicals used in industrial production methods for both herbal and animal food and the transportation of food after production to urban regions of the world by vehicles using non-renewable energy affect climate change. Moreover, a doubling of global food demand is expected in the next fifty years (Moll et al. 2003). Therefore, people should move towards a safe and sustainable food production that will reduce the food supply chain and harmful chemicals. The smart agriculture phase aims to provide a certain amount of food products annually. Each household will have its own food supply. The compound will also harness rainwater through smart agriculture.

In addition to these facts about water, energy and food ODIH's all household appliances will be the Internet of Things (IoT) compatible and smart. We will also have a smart charging infrastructure for Electric Vehicle use. We aim to design a Home Management System (HMS) to run and oversee the operations in the compound. HMS will make use of Artificial Intelligence, Machine Learning, Big Data, and it will be an evolved version of traditional smart meters. Also, ODIH aims to host all innovators and entrepreneurs who have ideas on digitalisation in smart homes and self-sustaining buildings. HMS will be open source, and innovators will integrate their solutions and test those in real life.

As defined by the World Commission on Environment and Development, sustainable development is "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987). When 17 sustainable development goals of the United Nations' are examined, it is seen that 11 of them are related to the ODIH project. These goals and their relationship with ODIH are:

Goal 1 No Poverty: we introduce the self-sustaining concept to produce enough water, energy and food for two grown-ups over a year. We anticipate that the self-sustaining idea will reduce poverty for households.

Goal 2 Zero Hunger: Smart agriculture phase aims to provide a certain amount of food products annually. Each household will have its own food supply.

Goal 3 Good Health and Well-being: Home Management System will incorporate health applications thanks to its open-source software and suitable hardware (sensors and IoT devices) of ODIH. This way the residents' health condition will be monitored regularly.

Goal 6 Clean Water and Sanitation: Clean water will be supplied through reverse osmosis (seawater) and humidity to water systems. We will also harvest rainwater and purify greywater to be used in cleaning and soilless agriculture.

Goal 7 Affordable and Clean Energy: ODIH generates its own energy primarily from rooftop solar power (PV) systems. Auxiliary renewable energy supply will come from wind and biomass.

Goal 9 Industry, Innovation and Infrastructure: by harnessing digital technologies and building an open-source HMS, our aim is to foster innovation in smart cities. New digital solutions will be easily integrated and tested in ODIH.

Goal 11 Sustainable Cities and Communities: ODIH is designed to be the very core of smart cities of the future. By being genuinely self-sustaining and employing digital connection to the outer world, similar units will be easily connected to each other to form new sustainable communities.

Goal 12 Responsible Consumption and Production: HMS will monitor and reduce resource consumption within ODIH. Furthermore, liquid waste (black and grey water) will be completely recycled, whereas solid waste will be recycled to a certain extent.
Goal 13 Climate Action: By consuming 100% renewable energy over a year, ODIH will prevent 10 tons of $CO_2$ emissions per year, saving roughly 425 trees from cutting annually.
Goal 14 Life Below Water: ODIH is designed to be a floating platform. Similar floating objects such as ships and boats dump their liquid waste into the sea, thus contaminating the ecosystem and harming the life below water. ODIH recycles its liquid waste and therefore protects life below the water by not polluting the ocean.
Goal 15 Life on Land: Increasing human population on earth will bring an increased demand for food and, therefore, farmlands. Deforestation for farming is a significant concern for life on land. ODIH promotes soilless agriculture by using the Nutrient Film Technique. We aim to reduce land use for agriculture, thus protect life on land.

In the literature, there are numerous indices to assess the overall concept of sustainability in the built environment. To better understand the characteristics of ODIH, some prevalent concepts, which are self-sustaining, sustainability, net-zero, green building, zero waste, self-sufficient, passive house and smart home, are defined in Table 1.1. After definitions, the relationship of these concepts with ODIH will be evaluated.

Sustainability is quite a generic concept, so that there are sub-concepts like sustainable housing, sustainable design and sustainable construction. These concepts generally aim to use resources as efficiently as possible from production to consumption in the houses or systems. ODIH, on the other hand, uses digital technologies for the efficient use of water, food and energy but also produces its own resources. Nevertheless, we should make one primary remark that we do not aim to use sustainable materials in construction. We deliberately omitted material science and building technologies and solely concentrated on the integration of digitalisation with resource management.

Net-zero is generally associated with energy and includes concepts such as net-zero energy and net-zero energy building. Over a year time, ODIH produces its total energy need in net terms so that it can be evaluated under the definition of net-zero energy building.

The concept of Green Buildings has been defined by standards set by many institutions in the literature. Although each institution uses different criteria and definitions, five common issues emerged together. These five titles are listed as follows: Water, Energy, Pollution, Innovation, and Resources and Materials. Although ODIH might be included in the scope for Water and Energy, it is not fully covered by the definitions of Green Buildings. However, the metrics of Green Buildings are hazy, and there are no certain numerical standards. For instance, speaking of ‘saving water in buildings’, we are not sure how much water should be saved or recycled. Nevertheless, in ODIH we aim to produce all water demand over a year within the compound. If we briefly touch on Resources and Materials, Green Buildings are expected to be made of recyclable or sustainable materials. However, such a situation is not expected within the scope of the ODIH project.

Zero-waste is a very difficult concept to achieve. It aims not to generate any waste that will disturb the ecosystem from the production to the use of any commodity or product. Although ODIH has similar aspirations in terms of waste treatment, it does not promise to be ‘zero-waste’. On the other hand, the concept of self-sufficiency seems to be fitting the very nature of ODIH. However, we believe the concept of self-sustaining is a better match since ODIH also aims to be engaging in economic activities via selling energy within the Smart Charging scheme. Our scope also covers harnessing digital technologies for resource optimisation. Thus, income generation and digitalisation make our perspective larger than self-sufficiency.

Passive houses use the sun effectively to heat themselves and store and reuse heat together with a highly efficient heat recovery unit. However, ODIH directly stores the energy it generates in its batteries. Unlike ODIH, passive houses use resources such as oil and gas, albeit sparingly.

In addition to ODIH’s self-sustaining character, the smart home concept should also be explained.

**Table 1.1** Sustainable built environment definitions

| Terminology | Citation | Definition |
|---|---|---|
| Net zero | Hernandez and Kenny (2010a) | "The term 'net-zero energy' being applied when the balance is zero" |
| | U.S Department of Commerce (2019) | "A net-zero energy house produces as much energy as it consumes over the course of a year" |
| | The U.S Green Building Council (2020) | "Net-Zero Energy recognizes buildings or spaces that achieve a source energy use balance of zero over a period of 12 months" |
| | Tucker (2012) | "Net Zero Energy Building is one which generates as much power and energy as it consumes" |
| | Hernandez and Kenny (2010b) | "The overall annual primary energy consumption is equal to or less than the energy production from renewable energy sources on site" |
| Self-sufficient | Moench (2000) | "Self-sufficient homes make their own energy, produce their own food and do their part to save the world's environment" |
| | Open Access Government (2019) | "Self-sufficient homes supply all their own energy, water, sewer needs, and food" |
| Green buildings | Real Estate Investment Blog (2020) | "A high performing home that is energy and water efficient has good indoor air quality, uses environmentally sustainable materials and also uses the building site in a sustainable manner" |
| | Desjardins (2020) | "Green homes are healthy, energy-saving, affordable, accessible and sustainable homes" |
| | Heindenry (2016) | "A green home is with environmentally friendly materials and sustainably built, with a focus on the efficient use of water and energy" |
| Smart homes | Aldrich (2003) | "A residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond" |
| | Spigel (2005) | "The smart home is a sentient space where human subjects and domestic objects speak to one another via intelligent agents and internet connections" |
| | Ricquebourg et al. (2007) | "Houses that have user interfaces such as white goods, sensors, motors, control devices or graphics in the door environment, have a residential gateway that makes it possible to connect to the outside world and have a network that enables the communication between service providers and residents in the external environment" |
| Zero waste | Lehmann and Crocker (2012) | "It is shorthand for the better management of resources in an increasing number of corporations and governments around the world. Zero waste is a way of thinking and doing that will become even more commonplace and important as we attempt to deal with environmental, social and economic issues facing all of us" |
| | Kahn and Islam (2017) | "In an ideal, zero-waste scheme, the products and by-products of one process are used for another process. The overall goal of this approach is to generate new solutions that convergent over long periods of time, so the natural ecosystem is not disturbed" |

(continued)

**Table 1.1** (continued)

| Terminology | Citation | Definition |
|---|---|---|
| Sustainable housing | Edwards and Turrent (2000) | "Housing that meets the perceived and real needs of the present in a resource-efficient fashion whilst providing attractive, safe and ecologically rich neighbourhoods" |
| | Saidu and Yeom (2020) | "Sustainable and affordable housing is housing that manages and coexists within the limitations of available scarce resources, at the same time preserving and conserving these resources for future needs" |
| Sustainable construction | Edwards and Turrent (2000) | "Sustainable construction "The creation and management of healthy buildings based upon resource-efficient and ecological principles" |
| Sustainable design | Edwards and Turrent (2000) | "Sustainable design Creating buildings which are energy-efficient, healthy, comfortable, flexible in use and designed for long life" |
| Passive houses | Passive House Institute (2015) | The Passive House is a building standard that at the same time, is genuinely energy-efficient, convenient and inexpensive |
| Self-sustaining | Oxford Learner's Dictionaries (2020) | "Able to continue in a healthy or successful state without help from anyone or anything else" |

**Table 1.2** Certificates

| Certifying body | LEED | BREEAM | Green globes | Green Buildings Council Australia | Green Buildings Council Australia |
|---|---|---|---|---|---|
| Criteria Of Certification | Water efficiency | Energy | Indoor environment | Energy | Ecological quality |
| | Energy and atmosphere | Water | Emissions, effluents and other impacts | Transport | Economic quality |
| | Materials and resources | Waste | Integrated design | Land use and ecology | Sociocultural and functional quality |
| | Indoor environmental equality | Transport | Site | Health and well-being | Technical quality |
| | Innovation in design | Land use and ecology | Energy | Water | Process quality |
| | Regional priority | Health and well-being | Water | Materials | Site quality |
| | Sustainable sites | Management | Resources-systems options, analysis and materials selection | Pollution | |
| | | Innovation | | Management | |
| | | Materials | | Innovation | |
| | | Pollution | | | |

Smart homes can fulfil many functions such as comfort and security, and residents can communicate with interior objects. Nevertheless, the level of intelligent communication is hazy, and the whole concept lacks standardisation.

There are various organisations that issue numerous certificates for the buildings. These certificates and the assessment criteria are summarised in Table 1.2.

As can be seen in Table 1.2, in terms of sustainability, the common criteria that organisations emphasise are:

- Water
- Energy
- The Pollution
- Innovation
- Resources and Materials

ODIH will introduce its own criteria. ODIH will be a testbed for a novel sustainability index that we name 'self-sustaining' criteria. The assessment is done in three dimensions, namely: water, energy and food.

### 1.1.1 The Self-sustaining Concept

In addition to covering resource optimisation through digitalisation, ODIH defines the concept of self-sustaining as supplying its water-energy-food resources and sustaining it over a year without the need for external investment. We focus on creating a self-sustaining system in terms of food, water and energy. While being self-sustaining in these three fields, the main objective is to utilise digital technologies to minimise resource consumption and optimise resource production with the aid of our HMS. We propose a new standard, self-sustaining, with three dimensions: water, energy and food. The assessment is done in terms of necessary resource generation over a year. We will have 5-levels: A: 100–80% B: 80–60% C: 60–40% D: 40–20% E: < 20%. Let us clarify the self-sustaining concept over an example. If a building generates 65% of its yearly energy consumption, its self-sustaining credit will be B (energy). Similarly, water and food will have credit notes as well.

In ODIH, we managed to produce 100% of yearly water and energy demand and only 20% of annual food demand. This means it will have the self-sustaining credit of AAE. Figure 1.1 illustrates the self-sustaining grading system.

We would like to extend the metric of self-sustaining to large public buildings, schools, and university campuses or even to cities or countries. Self-sustaining implies the amount of external investment or expenditure a closed system needs over a year. Through this study, we aim to demonstrate the significance of digitalisation in achieving true sustainability, especially in the built environment.

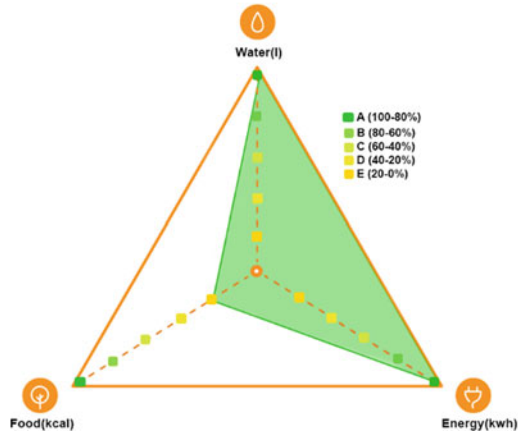


**Fig. 1.1** ODIH self-sustaining assessme

### 1.1.2 The Design of ODIH

To provide both a building block for the smart cities of the future and to show that life above the water is possible, we designed ODIH as a floating platform. A fully digital living space with communication capabilities with the outer world at the same time producing vital resources for the residents' survival in the long run. Figure 1.2 illustrates the fundamental relationship between ODIH and the smart cities of the future, and Fig. 1.3 shows the exterior design of ODIH.

ODIH will be a two-story floating platform. Downstairs is designed as an open office for researchers and entrepreneurs. There will be water storage tanks here. In the upstairs, there will be a one-bedroom flat, and two persons will be living here. Upstairs will also have four soilless farming rooms. The main purpose will be to observe and collect resource consumption data of these residents. All resource production data of ODIH, water, energy, and food and consumption data will be shared online with open access for research purposes. Figure 1.4 illustrates the components of ODIH and their locations.

Figures 1.5, 1.6, 1.7, 1.8, 1.9 present renders from interior spaces of ODIH (Fig. 1.10).


**Fig. 1.2** Smart charging and data flow between the smart city and self-sustainable compound

**Fig. 1.3** External design of ODIH

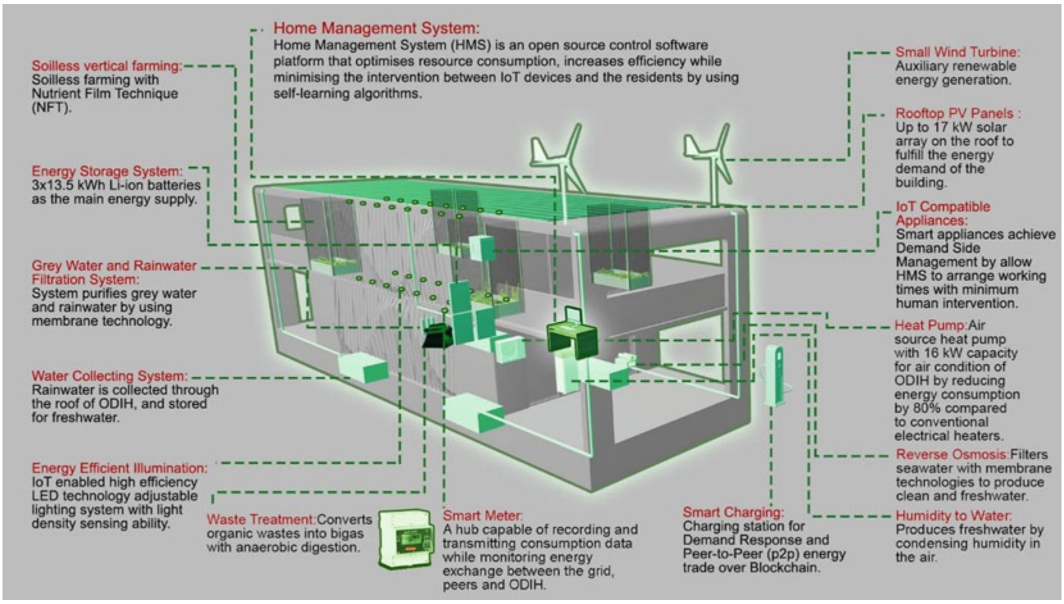


**Fig. 1.4** Components of ODIH

**Fig. 1.5** The effect of shades in the interior

**Fig. 1.6** The effect of shades in the interior

**Fig. 1.7** Smart farming lanterns

### 1.1.3 A Breakdown of the Detailed Content

There will be eight chapters in this book. The names and contents of the following chapters are as follow:

Chapter 2: Water

- Clean water supply
- Wastewater treatment and waste management
- Rainwater management
- Heat pumps

Chapter 3: Energy

- Energy generation
- Photo-Voltaic (PV) installation
- Small wind turbine installation
- Storage (Batteries)

Chapter 4: Food

- Smart Agriculture
- Soilless farming

Chapter 5: Enabling Technology: Internet of Things (IoT)

- Smart household appliances
- Other smart appliances and equipment
- Hardware research to build up the Home Management System (HMS)

Chapter 6: Home Management System: Artificial Intelligence

- Artificial Intelligence (AI) & Machine Learning (ML)
- Software research work to build up the Home Management System (HMS)

Chapter 7: Demand Response and Smart Charging

- Demand Response

**Fig. 1.8** Working area for the researchers

**Fig. 1.9** Landscape of ODIH and working area

- Smart charging
- E-mobility integration

Chapter 8: Blockchain and Peer-to-Peer Trading

- Blockchain applications
- Peer-to-Peer energy trade and smart contracts
- Establishing ODIH as a financial entity

**Fig. 1.10** Living room

ODIH will be a test-bed for open innovation and novel business models. All electric devices will be IoT compatible, and the HMS will be open source. That means the start-ups and entrepreneurs will be able to integrate their products to ODIH and use its infrastructure. Following a Living-Lab concept, new business models will flourish here. Nevertheless, we deliberately omitted the business model development dimension of ODIH to keep the focus of this book on digitalisation and resource management. Therefore, the book covers science (water-energy-food nexus) and digitalisation in detail. We leave the business development dimension for a follow-up study.

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# 2 Water

**Abstract**

The world's freshwater sources are already limited and existed human activities constantly pollute sources. This chapter aims to present a comprehensive technology selection for freshwater generation, waste treatment, heating, ventilation, and air conditioning (HVAC) systems. Smart cities, which we believe should be built upon the concept of self-sustaining, cannot be considered independently of activities such as water, waste, and air conditioning management. We selected specific technologies in the Open Digital Innovation Hub (ODIH) to provide air conditioning, water generation and consumption, and waste disposal needs with optimum resource consumption. Greywater and rainwater will be purified by membrane technology to reproduce usable water. The salty seawater located beloved ODIH will be desalinated by the Sea Water Reverse Osmosis (SWRO) system, and lastly, the system which produces high-quality water from moisture is the main water production systems. Toilet and organic wastes are treated by a small-scale bioreactor that works with the anaerobic digestion principle. Exhausted gas will be used in a particular stove. For the HVAC, we will use an air source heat pump with a 16-kW capacity. According to the results of our calculations, ODIH can produce its required water without a water supply network connection.

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## 2.1 Introduction

Water occupies a prominent place in every aspect of our life. Continuity of life is directly connected to water. Water also takes part in enabling transportation, stabilizing temperature, cushioning, which provides protection during an earthquake, cleaning and breaking down wastes, enabling production, providing home, and being a key point for agriculture (Horspool 2019). Also, according to the research carried out, the human body can endure for a few weeks without food, while only a few days without water (European Federation of Bottled Waters 2020). Despite all these benefits, freshwater sources, lakes, and even the atmosphere are being polluted every minute. Water in the world, as a source, is limited. Rainfall regimes differ according to the location (Mullen 2020). Around 97% of the hydrosphere is saltwater, whilst only 3% is freshwater which is critical for terrestrial and freshwater species (Advancing Global Change Science and Solutions 2020). The water distribution in the world is shown in Fig. 2.1.



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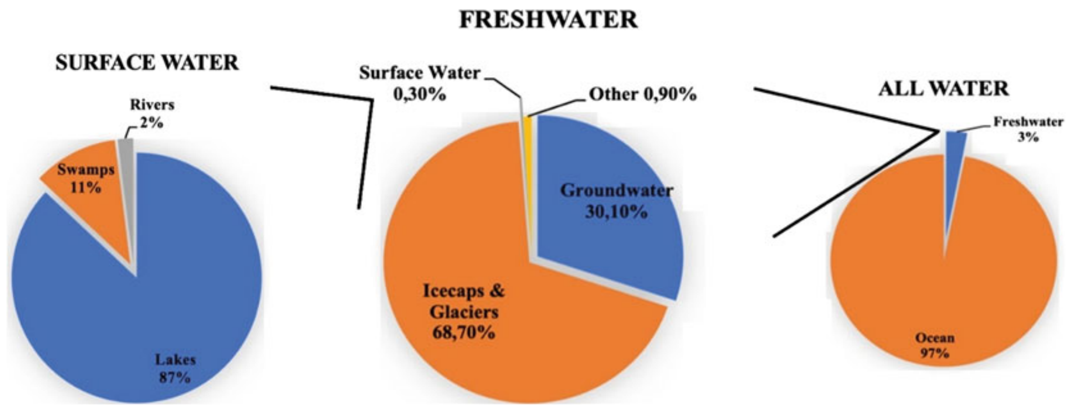


**Fig. 2.1** Water distribution on earth (Solutions 2020)

**Table 2.1** Water consumption per capita in the world, 2017 (Statista 2017)

| Countries | Water consumption per capita ($m^3$) |
|---|---|
| USA | 1206.8 |
| Canada | 883.3 |
| Belgium | 883.9 |
| Turkey | 746.8 |
| Mexico | 704 |

### 2.1.1 Current State of Water

3% of the water in the world is freshwater, and it might sound a fair amount for fair use. However, the increasing population limits access to this limited water supply. According to access to freshwater, countries might be classified as "water-rich" or "water-poor" based on the amount of water per capita in the country. Countries with an annual water amount of more than 8000 per capita are among the water-rich countries, countries with less than 2000 $m^3$ per capita fall in water scarcity group and countries with less than 1000 $m^3$ per capita are defined as water poverty group (Uyar 2018) However, given the population estimate of 100 million for the year 2030, the freshwater consumption will be 1120 $m^3$/year per capita when the current amount and consumption of water remains constant (Uyar 2018). Table 2.1 gives the top 5 countries water consumption per capita in the world in 2017.

Looking at the distribution of water in the continents of the world, North America comes first. The top 5 countries rich in water are Brazil, Russia, Canada, Indonesia, and China. Besides, the top 5 countries that are poor in terms of water are Israel, Jordan, Libya, Mauritania, Cape Verde (Shiklomanov and Rodda 2003).

As explained above, population and water consumption are increasing in parallel. Unfortunately, this consumption is not distributed equally to everyone in the world. 844 million people cannot reach potable water (WHO 2019), and almost 2 billion people are obliged to use contaminated water (Unicef Data 2019). As a result of low-quality drinking water services, food production, gender equality, education, health subjects crucially affected (Abundant Water 2020).

The world's atmosphere contains 37.5 billion gallons of water (Watergen 2020). When the atmospheric humidity increases to a limit, it falls as rain. By replicating this process, humidity can play as a secondary water source for ODIH (Open Digital Innovation Hub).

#### 2.1.1.1 The Future of Water in the World

Scarce water resources are a risk for everyone and every generation. The number of countries affected by the water crisis will increase due to the growing population and economies. At this point, the risk perception regarding water becomes important. Water scarcity causes problems such as health problems (inadequate hygiene conditions even with access to water), climate change, and loss of biodiversity (Aksoy and Öktem 2014).

The gap between worldwide water supply and demand is projected to arrive at 40% by 2030. Local people, farmers, industries, and governments