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1.Jasmina PEKEZ, 1.Eleonora DESNICA, 1.Ljiljana RADOVANOVIĆ, 1.Dalibor DOBRILOVIĆ, 1.Dragica RADOSAV

# THE IMPORTANCE OF THE USE OF SOLAR RESOURCES IN THE INTERNET OF THINGS (IoT)

1.University of Novi Sad, Technical Faculty "Mihajlo Pupin", Zrenjanin, SERBIA

**Abstract:** The need to encourage the use of renewable resources exists in all developed countries. This enables the saving of non–renewable resources, security and independence in energy supply, preservation of the environment, increasing the competitiveness of the economy, and socially responsible business. Modern living conditions imply the increasing application of ICT technologies in all spheres of life. The application of sensor stations within smart technologies such as smart cities, smart agriculture, etc. implies the installation of sensor stations in places without infrastructure, which is why batteries with limited capacity are mainly used to power them. This problem can be overcome by using photovoltaic cells to transform solar energy into electricity, which would ensure their energy independence, which would allow their even greater application. In this paper, a study of the possibility of supplying sensor stations with electricity using PV cells was conducted.
**Keywords:** solar energy, IKT technologies, sensor stations

## 1. INTRODUCTION

Nowadays, the mass use of sensor stations is implied in the walks of life, such as the Internet of Things (IoT), in conjunction with smart technology environments such as smart cities, smart agriculture, and smart measurement. All of these systems imply the utilization of a large number of sensors. The position of these sensors is often located in an open space, which is frequently without any infrastructure and therefore without access to the electricity grid. How the operation of such sensors is continuous, constant and how such stations are used in increasing numbers in modern systems, they have a battery power supply that solves the problem of electricity supply, and at the same time represents a problem due to the limited capacity of batteries.


Figure 1. Smart City Components

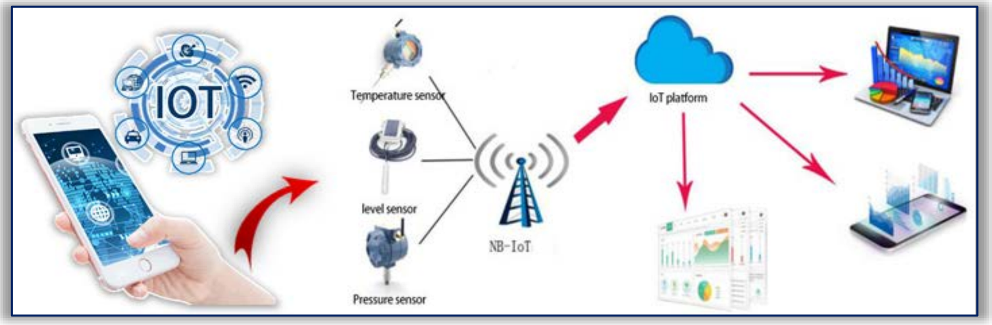


Figure 2. Sensor stations – Internet of Things (IoT)

Smart environments are becoming quite popular in the home setting consisting of a broad range of connected devices. While offering a novel set of possibilities, this also contributes to the complexity of the environment, posing new challenges to allowing the full potential of a sensorized home to be made available to users [11].

Smart environments have the potential to allow users to engage and interact seamlessly with their immediate surroundings. This has been made possible by the introduction of intelligent technologies, coupled with software–based services. It is evident that technological advances have provided a new era for both sensing technology and computational processing to facilitate the vision of smart environments. Although a number of challenges exist in their deployment, a number of large–scale programs are endeavoring to progress their uptake further [12].

Smart environment monitoring system monitors the key ecological index and gives quick response to the abnormal fluctuations by sending reminder to nearby citizens, municipal government, and the responsible party. Such systems can also provide the most economical plan for sewerage treatment and garbage collection [13]. The environment and resource management is not necessary to be limited within a city since the smart network between cities can cooperate and formulate a joint monitoring scheme that may greatly improve the overall utility of the environmental protection facilities [13].

Green city, based on the smart network and macro urban planning, minimizes the overall carbon and harmful gases emission and maximizes the resource utilization efficiency in order to create the virtuous cycle between urban development and ecological protection. Feasible approaches include green space and green building construction, energy–related policies and regulations, and management of trash recycling and sewerage [13].


Figure 3. Sensors types

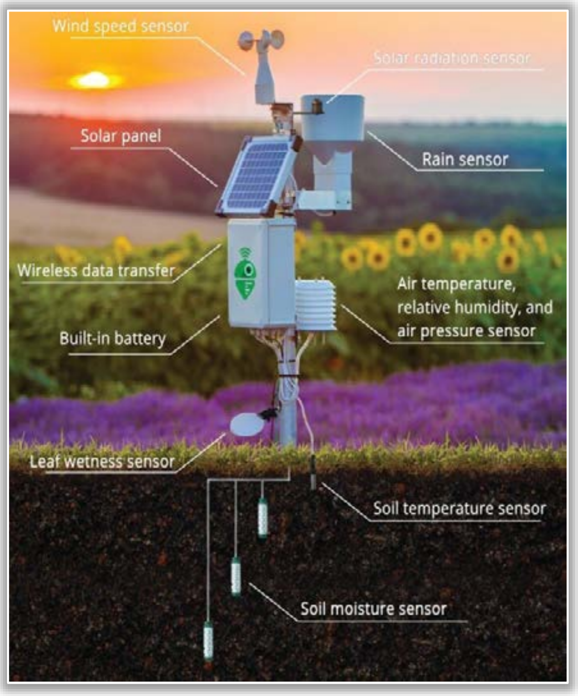


Figure 4. Weather stations are equipped with different sensors

## 2. METHODOLOGY

### — Internet of Things

Any facility that is equipped with sensors and software and can connect to the Internet with the help of which it could be managed and controlled can be defined as an IoT device. In this way, these devices enable the so–called "Digital intelligence", that is, they are allowed to use the necessary data at the appropriate time without human participation.

Internet of Things (IoT) is a system that integrates different devices and technologies, removing the necessity of human intervention. This enables the capacity of having smart (or smarter) cities around the world. IoT is a technology that already has a very wide application and which is getting bigger and bigger every day. It is applied in smart homes, smart cities, smart agriculture, smart industry and traffic. It is estimated that there are already more IoT devices today than people in the world. Internet of intelligent devices is a technology that provides an efficient connection between the digital and physical world that is, connecting real–world sensors and actuators to the Internet. In other words, it is a set of interconnected devices, apropos a system of mechanical and digital machines and objects, which enables data to transmit over the Internet without requiring interaction between people or between people and computers.


Figure 5. IoT devices

— Power supply of sensor stations

The power supply of sensor stations is done by using batteries that impose the need for their frequent change and charging. Given the increasing use of sensor stations, it is necessary to find better, independent and more reliable solutions to provide the necessary energy. There are two approaches to solving this problem in the available literature that deals with the mentioned problem. One is the maximum reduction of energy consumption, which in addition to the optimization of microcontrollers and sensor stations is reduced to the use of less energy–intensive technologies such as LP–WAN (Low Power – Wireless Area Networks). Another approach is to use solar energy sources to power the sensor stations and recharge the batteries they use.

≡ Low Power Wide Area Networks

Low Power Wide Area Networks (LPWAN) technologies are created to enable wireless communication between devices in a WAN environment while having low power consumption but also low data rates. As such, they are suitable for connection at a distance of up to several kilometres in urban or several tens of kilometres in rural areas. Generally, these devices contain a highly sensitive receiver with a sensitivity of up to −130 dBm, which is significantly higher in comparison to −90 and −110 dBm in traditional wireless technologies. The desired battery life cycle is achievable by reducing the frequency of data transfer daily, although this largely depends on the type of application, that is, a system that uses LPWAN sensor stations.

≡ Use of solar energy sources to power sensor stations

The energy source of sensor stations decreases very quickly during their continuous operation, which has to be replaced or supplemented. Sometimes that is complex, due to unavailability. The solution to this problem is reflected in the usage of renewable energy sources [7]. For using renewable energy effectively are numerous factors to be considered. Some examples are energy source characteristics, storage device type, wireless nodes' power management functionality, wireless communication protocol, and detailed application requirements [8]. Solar energy is available everywhere in nature and therefore has great potential for use by powering sensor nodes. The amount of electricity that is obtainable depends on the surface of the photovoltaic solar panel and its efficiency, the amount of solar radiation falling on the panel, the location where the same is (geographical position, angle about the earth's surface and the side of the world facing it), ambient temperature and solar panel temperature. The energy efficiency of a photovoltaic panel ranges from 15–25% and depends on several factors [9]. There is no solar radiation during the night, so it is necessary to ensure that energy is stored during sunny hours thereby being used overnight [10].

A comparative view of the generated current for the power supply of the sensor station measured at the output of the solar panel and the input to the battery is shown in Figure 6. The blue line in Figure 1 presents the current charging Li–Po battery. The conducted research is part of the research project Creating laboratory conditions for research, development and education in the field of the use of solar resources in the Internet of Things, which aims to create a platform for testing the impact of solar radiation and photovoltaic panel temperature on current and voltage solar panel when powering sensor networks for different surfaces of solar panels, light sources and types of photovoltaic cells.

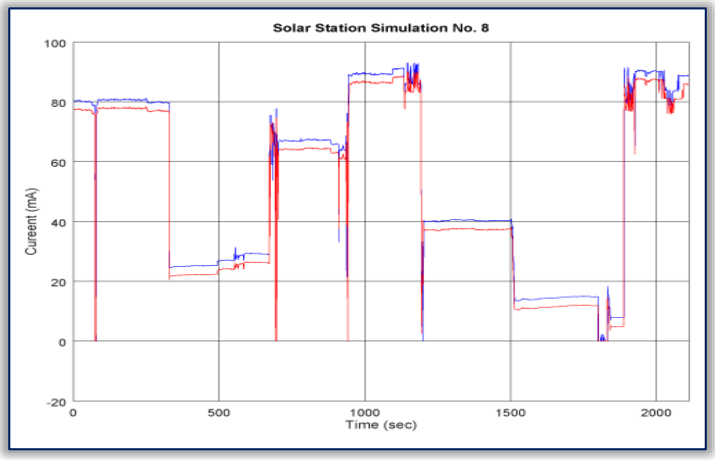

Figure 6. The current output from the solar panel and current charging Li–Po battery

## 3. CONCLUSION

Experimental research in this area can significantly contribute to the creation of new technical solutions in the field of solar power supply of sensor stations, the creation of more qualified experts for the development of sensor stations and hardware–software systems, significant improvement of domestic educational institutions and their study programs in the field of ICT and the development of sensor systems for both domestic and foreign markets. The outcomes of the research will make a significant contribution to environmental protection as well, as they encourage the use of solar energy to power sensor stations in the IoT and thus reduce greenhouse gas emissions and eliminate waste batteries.

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