START UP FOR DEVELOPMENT

MODULE 3

SMART ENVIRONMENT

SMART STREET LIGHTS · SMART METERS · SMART PARKING · WEATHER SENSORS · SOLAR INVERTERS · DIGITAL SIGNAGE · WATER & GAS METERING · ITS SYSTEMS · EV CHARGING · IP CAMERAS · WASTE MANAGEMENT · ACOUSTIC SENSORS
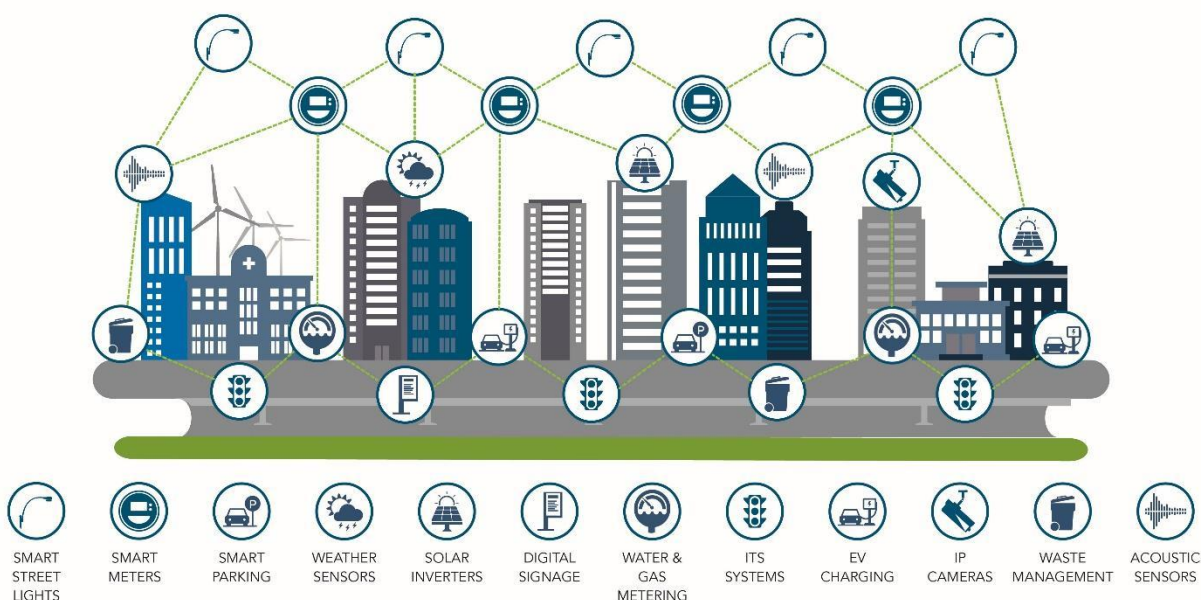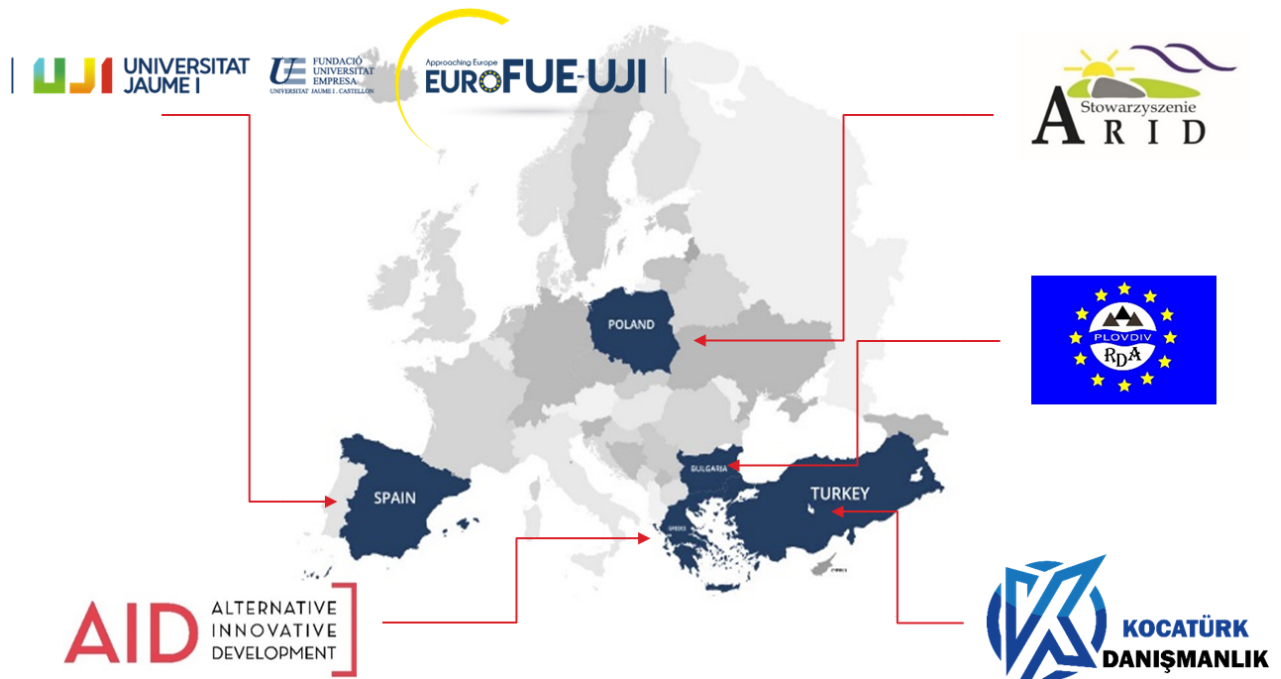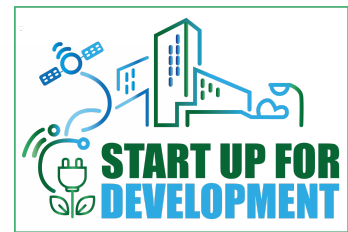
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APPLICANT COORDINATOR: FUNDACIÓN UNIVERSITAT JAUME I-EMPRESA (ES)

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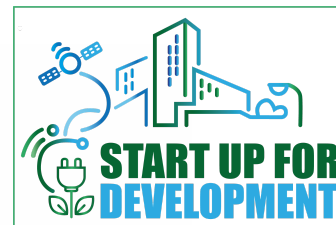ENALLAKTIKI KAINOTOMA ANAPTYXI ASTIKI MI KERDOSKOPIKI ETAIREIA (GR)

CONTENT MAP:

ANNOTATION AND LEARNING GOALS:

The module is focusing on smart systems for managing environmental quality to improve energy efficiency and the quality of the environment in cities.

The goal of this module is to be aware of the problems and challenges of the changing world which is directed more and more to climate change caused by solutions that have been used for many years. The aim of the following chapters is to explain the challenges and how to solve those problems and implement new, innovative and environmentally friendly technologies like Smart Bins, emission-free electric buses, smart street lighting, WSN for controlling air pollution and IoT-based smart water quality control systems. Those are just a couple of new technologies. The goal is to understand the importance of making a better change in the world and implement those technologies as a small step to a better future.

The main goal of the module is to improve knowledge, skills and professional competencies in the field of smart environment.

EXPECTED LEARNING OUTCOMES:

After studying the module, the trainees are expected to acquire theoretical knowledge, cognitive and practical skills in the field of smart environment, as follows:

Knowledge:

- Of the concept of smart environment
- Of basic definitions of examples of smart environment solutions
- Of benefits of smart environment

Skills:

- To recognise the biggest environmental challenges
- To find innovative ways to deal with the challenges
- To implement given examples in their own environment

Competences:

- Sense of responsibility for the environment of the city and the surrounding villages
- Professional competences to use the acquired knowledge in their own municipality/city/village
- Ability to transfer the given examples to the needs of their own environment

By the end of this course the learner should be able to...

- Identify the environmental needs of the changing world.

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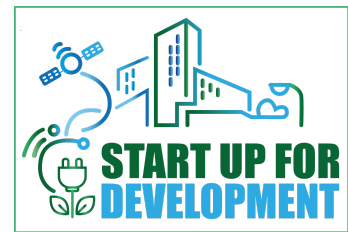*cannot be held responsible for any use which may be made of the information contained therein.* **4** | Page
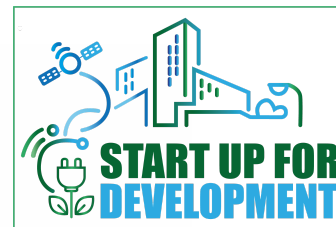
- Recognise environmental challenges.
- Know which technologies to use and how to use them to make the better change.
- Assess the possibilities and needs of his own country in order to decide which technology is a possible step.
- Implement the following five technologies in his environment.

FORMS AND METHODS OF WORK

This module requires self-learning with the materials and activities or/and training seminars. Both can be held on-site or on-line. The aim is for the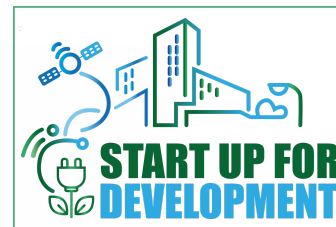 trainee to learn by reading, exercising, applying, evaluating his/her knowledge through the self-evaluation test and through gamification. If needed, the trainee can check for further information in the given resources.

Workshop:

- Team working
- Working with a text
- Identifying the problem
- Finding solutions to the problem
- Mind mapping
- Brainstorming
- Review of results
- Evaluation

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GENERAL MODULE OVERVIEW

The idea is to build an environment with embedded sensors, displays, and computing devices so that users can better understand and control the environment.

1. UNIT 1: Smart bins
    1.1. Introduction and definition
    1.2. Implementation
2. UNIT 2: Electric emission-free buses
    2.1. Introduction and definition
    2.2. Implementation
3. UNIT 3: Smart lighting
    3.1. Introduction and definition
    3.2. Implementation
4. UNIT 4: Wireless sensor networks for controlling air pollution
    4.1. Introduction and definition
    4.2. Implementation
5. UNIT 5: IoT-based smart water quality monitoring system
    5.1. Introduction and definition
    5.2. Implementation

Each unit of the module Smart Environment is about a different technology which is aiming to implement innovative solutions in cities and villages. Starting with Smart Bins which are a big step in introducing efficient recycling in daily life. The second unit is one of the solutions to the air pollution problem, which is a big challenge in many European cities. The electric emission-free buses are a way to avoid a big-scale smog in the cities. Following the buses, the next module speaks about Smart Lighting in order to provide a safe, sustainable and economic environment. After that another way to control air pollution in cities – The WSN system of sensors around the city which helps the government and the anti-smog alert to act faster and more efficiently. Finally, it consists of introductions to all technologies which present the challenge, the problem, the technology and the implementation of it. After every unit there is a short explanatory video on YouTube so the learner is able to imagine how the technology is being used. For better understanding of how and where the technology is being implemented there are examples at the end of every unit.

UNIT 1. SMART BINS

This unit shows the problem of waste segregation in the world and explains how smart bins can be a solution to the problem. The smart bin is an Internet-of-Things based technology that helps to compensate for the lack of knowledge and the ignorance regarding waste segregation. On occasion it also solves various other problems which appear due to wrong segregation.

1.1. Introduction and definition

The idea of smart bins is an innovative solution to reducing waste in the world. It is a chance to improve the recycling processes and the system of waste management in places where people still don't see segregation of waste as something very important.

Many countries already got the hang of how to segregate waste effectively in order to recycle and this way to take care of the environment since the European Union started to encourage efficient waste management policies in 1994. Others still have a long way to go for the people to understand the importance of engaging in the process of segregation. Many people still throw trash away in an illegal and unauthorised way or get rid of trash by burning it. This results in enormous air pollution. Thousands don't understand how to segregate. An intense long-term education has to be implemented in order to make the citizens aware of the extent of the problem.

Until that time there is a smart solution to the problem which helps to segregate the waste outdoors and indoors without further difficulty in a fully automated way – Smart bins. These bins are the first and most innovative solution of intelligent waste
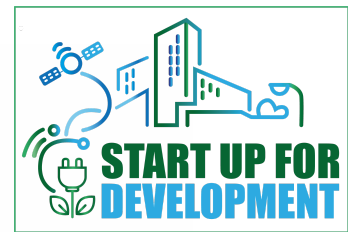
segregation in the world. Based on the Internet of Things, this advanced technology helps to go a big step forward in terms of a smart environment.

It is most effective in public places where you will find thousands of people passing every day – airports, stations, city centres, malls or even larger work places.

1.2. Implementation

There are many different models of smart bins. Firstly, introduced in the Republic of Korea over 20 years ago was the Intelligent Trash Bin which had various functions such as flame alerts, live maps and trash levels using several kinds of sensors. Other model designs used Radio-Frequency Identification providing rewards and profits from advertisements. With the time newer and more developed models came into use with more sophisticated functions like compression of trash inside the bin. To eliminate the problem of people refusing to segregate or the lack of knowledge how to segregate, smart bins have been equipped with a trash image classification system that recognises the type of waste and segregates based on a programmed algorithm. It recognises at the same time, if given trash is recyclable. This also reduces costs for segregation work after collecting waste from bins all over the city where people usually care less about segregation than in their private homes.

The waste is placed into the container and the sensor measures its capacity. The compactor then compresses the waste and measures the compacted trash resistance. Finally, notifications are sent via e-mail or SMS when the bin is full and ready to be emptied. The sensors inside the bins and the monitoring system enables dustmen to control the capacity of the bins and selectively empty the bins that are to 80% full. Thanks to the compression system the bins have to be emptied less often. That provides reduced air pollution since dustmen have to drive to fewer bins and therefore covering less distances.

This is a short explanatory video on how the smart bin works:
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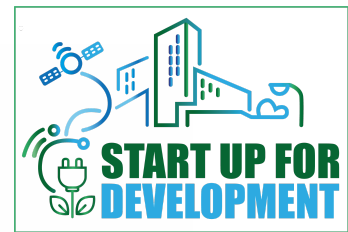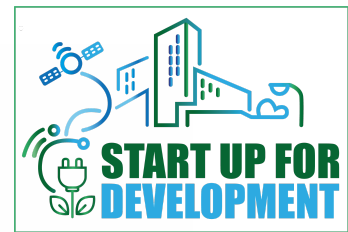
UNIT 2. ELECTRIC EMISSION-FREE BUSES

The second unit shows a big influence on the air quality by introducing electric emission-free buses in cities and villages. Showing all its benefits, the unit explains how this kind of green public transport can decrease air pollution and traffic.

2.1. Introduction and definition

One of the main challenges of our time regarding a smart environment is air pollution. There are already various methods to prevent this health-endangering result of the growing number of cars, increasing traffic, gases from factories and power plants. 25% of the emitted black carbon is caused by urban buses. This percentage is rising with every year. This is a problem that needs to be addressed directly.

In the past few years one particular way of reducing air pollution has been electric emission-free buses. Among many countries where this technology has been already implemented, Poland is the leading exporter regarding electric buses and therefore increasing the implementation of those environmentally-friendly vehicles in many European countries and providing sustainable mobility. Those buses are completely electric and therefore emission-free which is quite sensational regarding the battle with the increasing air pollution problem.

2.2. Implementation

In order to develop a completely emission-free vehicle the old diesel buses need to be replaced by electric ones. Based on the concept of renewable sources the buses are equipped with innovative solutions such as energy-converting brakes that provide electricity and a strong traction battery with a capacity of 550 kWh. That way the buses can be driven longer without having to charge them for a distance of even 200km. Replacing the bus fleets by vehicles fuelled with green energy reduces to a large extent of greenhouse gas emissions. The aim is to replace in the near future the complete bus fleet with electric emission-free buses to change the diesel fuelled public transport into an environmentally-friendly one. One additional advantage of this advanced and innovative technology is also the fact that the buses are very comfortable for passengers and drive silently which reduces the troublesome traffic noise. The temperature inside the buses is easily controllable and the heating system is mainly electric which ensures a comfortable ride.

A good example of implementation of this technology is the City of Cracow in Poland. The project in the year 2018 was aimed to increase the number of electric emission-free buses in order to develop a green public transportation. The aim was to have a bigger bus fleet which encouraged citizens to use public transport instead of driving their own cars and therefore to reduce traffic. First it started in 2015 with the delivery of the first electric buses to Poland. Today there are more than one hundred new buses of the Solaris brand including emission-free, hybrid and electric vehicles. For the future the number is supposed to grow to almost 500 vehicles in 33 Polish cities. There are several charging stations for the buses to charge after finishing their route located in all parts of the city. The project is supposed to be implemented also in 17 other surrounding areas which has an impact not only on the environment of the city but also on the areas around the city.

The next step in the development of green public transport would be vehicles running on hydrogen. The Solaris Company is already improving their vehicles in that direction and trying out models of hydrogen emission-free buses.
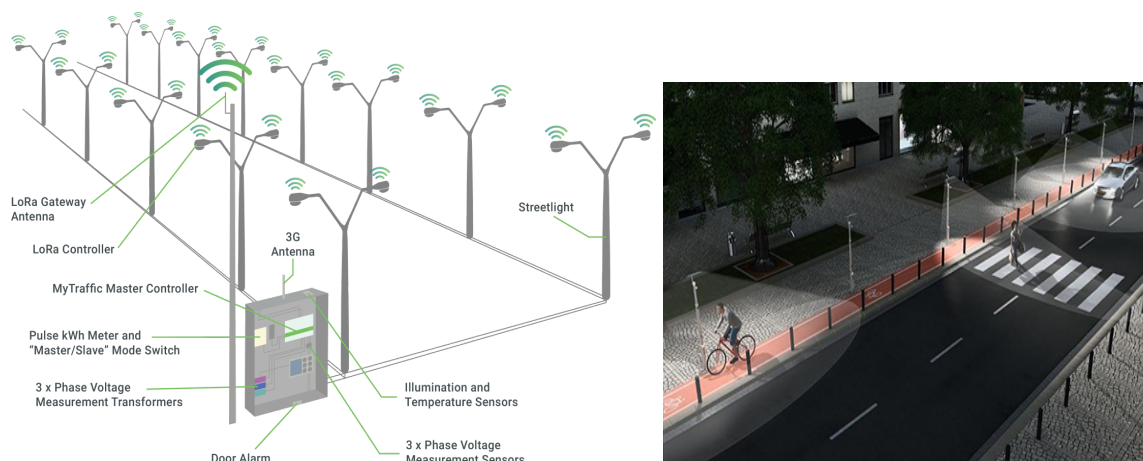
This is a short explanatory video on how the electric busses work:

https://www.youtube.com/watch?v=Rp5u6vOkiyg

UNIT 3. SMART LIGHTING

The next unit clarifies a smart lighting system which can improve the economic as well as the environmental situation of cities and villages, at the same time showing many more benefits of having smart lanterns on the streets.


3.1. Introduction and definition

Everyone knows how important it is for traffic safety and for the safety of pedestrians to have functioning street lighting by night. It gives us the feeling of security and self-confidence for both driver and pedestrian. Unfortunately maintaining the street lighting system is not cheap for the government. At least 10-20% of the municipality's expenses are spent on energy costs and also 10-20% on operation and maintenance costs caused by uneconomic street lighting which is unfortunately also contributing to the growing problem of CO_2 emission and with that – to air pollution. The problem is not only local but seeing the bigger picture it is developing to be a global challenge since urbanisation is increasing with every year. The cities are growing bigger and bigger, so the need of sustainable energy resources to cover the electricity necessities is crucial.

The challenge is to switch to a sustainable lighting system that prevents intelligent lighting that is efficient and economic at the same time. The solution is the further explained smart lighting system. Systems based on Internet-of-Things, that are using Low-Power and Low Range Wide Area Networks (LP/LoRa-WANs) are proven to be the most efficient and low-cost solution. A smart street of a smart lighting system is
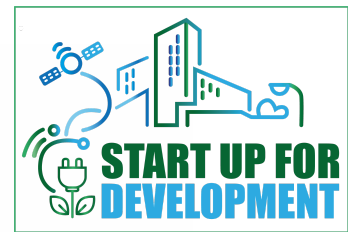
a network of Wi-Fi connected street lamps which are equipped with many other helpful devices available for pedestrians.

3.2. Implementation

In order to improve the economic situation of municipalities and to change the cities into smart cities, it is crucial to change the municipalities' management of electricity and energy resources by introducing a smart lighting system. How does this intelligent and Wi-Fi connected system work?

First of all, there is a strong need to change the old light bulbs to LED lights. This type of lighting is the most popular solution thanks to its efficiency, long lifespan, lack of warm-up period, price and quality. The second step is to adapt power cabinets which are very important in the whole system in order to be able to pass light switching impulses from modern control centres to the individual lighting poles. Control is the key word in this technology. Usually, the lighting systems were based on a timer which set off the lights at an arranged time. With smart lighting you can easily adjust the light according to the necessity of the day. With functions like the grid monitoring, dimming, real time alerts and therefore real time control you can influence the intensity of the lighting without wasting energy unnecessarily. The individual light poles are communicating the information through a synchronisation mechanism to smart lighting applications and errors are reported immediately.

The light poles have to be powered all day, which can be a benefit if you add other devices to the light pole and use the fact of constant powering for the pedestrians to have several advantages. Besides the obvious lighting functions, smart lighting poles are equipped for example with motion radars, a communication hotspot, a Wi-Fi hotspot, a monitoring camera, an RGB Status light, a public address loudspeaker, possibly an air quality sensor (which will be explained in the next unit), a touch panel, a wireless phone-charger, an SOS button, a USB charge socket, an electric vehicle charge socket or many other possible solutions.

▶ YouTube

This is a short explanatory video on how the smart lighting system works:

https://www.youtube.com/watch?v=2mwVC08looc

UNIT 4. WIRELESS SENSOR NETWORKS FOR CONTROLLING AIR POLLUTION

The fourth unit emphasises one of the biggest environmental challenges of our time – Air pollution. With the increasing number of vehicles on the streets which is therefore causing bigger traffic and at the same time having big factories which produce a huge amount of black carbon in the air, the smog seems unstoppable. This is how we can regain control over it using Wireless Sensor Networks (WSN).
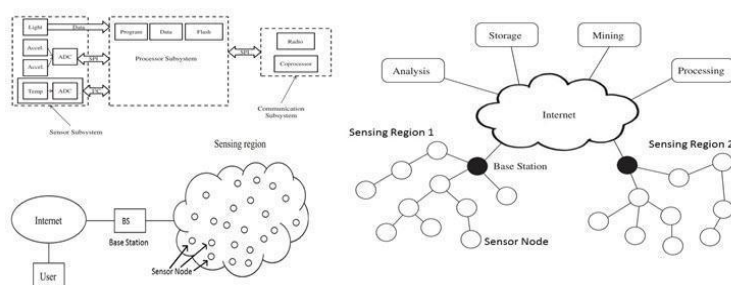

4.1. Introduction and definition

A big number of cars and buses, factories, power plants and many other factors cause one enormous danger for the environment and a direct effect on the citizen's health – Air pollution. In order to find a solution for this serious problem there must be a solid data collecting technology to have real-time results and therefore to know to what extent the problem is existent in given cities. There is a strong need of implementing technologies that enable the governments of the cities to have the state of air pollution under control and to decide according to this real-time collected data.

One brilliant solution for this situation are wireless sensor networks for monitoring environmental pollution. Thanks to the sensor nodes or tags equipped with chemical pollution detectors that are connected to each other and to a communication system it is easier to make plans and decisions having accurate information. Especially for factories and businesses it is a way of knowing how to prevent emission of gases and therefore to prevent air pollution. They are able to see exactly and immediately which actions work and which don't.
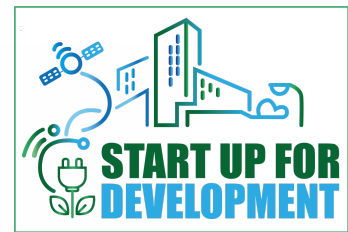
Usual monitoring systems are unfortunately very expensive so many cities can't afford to install such a system. Therefore, the WSN-based monitoring system is a great solution for smart cities which is easy to install and most importantly affordable for cities.

4.2. Implementation

Compared to previous measuring devices this Internet-of-Things-based technology of pollution monitoring is easy to handle. It consists of accurate sensor nodes and tags, a digital processor and communicational possibilities operated at remote control stations in order to receive the information about the pollutant concentration at this location at an Internet-connected gateway. Machine Learning algorithms are used to provide alerts in critical moments of high air pollution as well as immediate and automatic information through wireless connections from various locations simultaneously and enables further analysis of the data. According to the needs you can connect a series of different sensors measuring thermal, chemical or biological data. It can be connected to an application for easier access to the data.

How makes this system your city smart? It intensifies the density of monitoring stations a lot. Usual air quality monitoring systems had just a few measuring stations across the city. All the more, the WSNs are easy and affordable to install in many more places of the city which allows the smog alert organisations to have a wider real-time awareness of the actual quality of the air collecting a bigger amount of data at the same time. In order to increase the monitored area, it is very easy to add new sensor nodes in new places which was very expensive in former monitoring systems.

One of the economic aspects is the renewable energy unit. The motes in all measuring stations are being powered by a solar panel so the lifetime of the sensor is almost self-sustaining.

This is a short explanatory video on how the WSN work:

https://www.youtube.com/watch?v=vznxLHsEeXU

UNIT 5. IoT BASED SMART WATER QUALITY MONITORING SYSTEM

The fifth unit explains the importance of water quality in our daily life and emphasises the ways how to control it and therefore how to improve its quality for maintaining a healthy environment for citizens. Smart water systems reduce water scarcity and allow real-time information on the chemical and biological data of the drinking water we have at home or the water we use to irrigate.
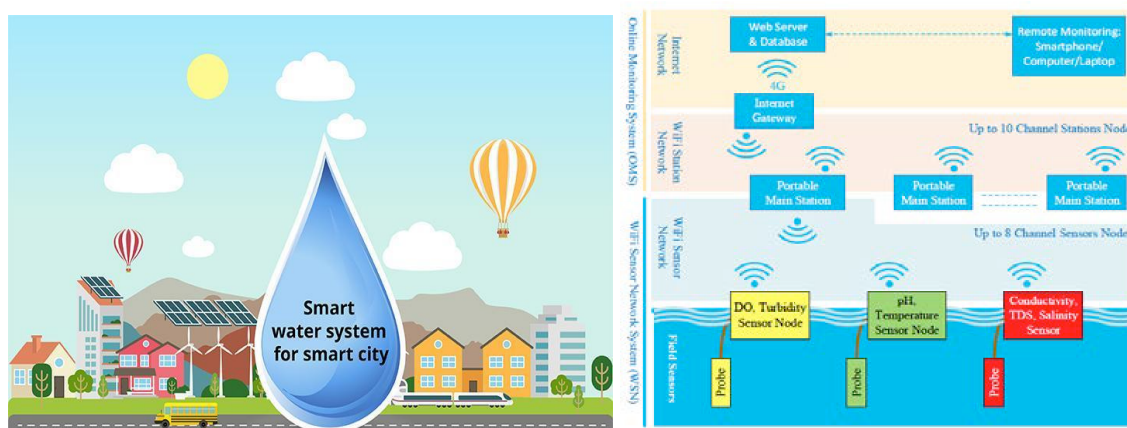

5.1. Introduction and definition

One of our big responsibilities is to protect and control the quality of water. Water being one of the fundamental elements in the world is crucial for all living things to live, function and to be healthy. Maintaining a balance of water quality is most important to prevent people from having health issues and the environment from losing the balance between species. That's why it is so important to be as aware as possible while developing a smart city, especially regarding a smart water quality monitoring system.

Following the famous words of Peter Drucker – "If you can't measure it, you can't manage it." it is most crucial that thanks to the Internet-of-Things-based technology you can actually fight the environmental issues in water quality by constantly monitoring the quality of what we use in our daily life for the most important things like drinking or cooking which has a great effect on our health. At this moment the challenge of scarcity of good quality water is getting bigger and bigger. If the problem won't be addressed soon, approximately by 2025 half of the world population will have to deal with water scarcity. Additionally, the current water monitoring system is
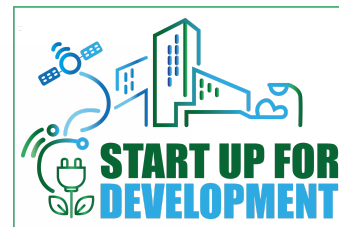
largely a manual system which delays the actions of resolving problems. The worlds' needs require a new system that is fast and efficient.

5.2. Implementation

The solution is similar to the previous unit regarding air pollution. Thanks to IoT-based technologies specialists can deal with problems immediately. IoT-based technologies can also help to implement a better management of water. Using sensors connected to Wi-Fi you can avoid water leakage, chemical leakage, changes in temperature and other problems. The sensors are able to measure the exact and real-time information of bacteria, electrical conductivity, total dissolved solids or chlorine in the water. That way you can address the problems in a much faster time and also meet the needs of the people which will make the life of everyone more convenient.

Through a wireless sensor network (WSN) that is immersed in water at various locations, the collected data including parameters such as pH, turbidity, temperature, dissolved oxygen, or water conductivity are transmitted to a processor, and after processing the collected data, it is sent via a Wi-Fi connection to a server or the cloud where the specialist can easily access it. On this ground the Internet of Things enables you to monitor, control and analyse the quality of drinking water even from far away and whenever you want.

Thanks to a smart water management system you can also easily avoid problems like energy consumption in water pumping, water contamination, unpredictable water demand or poor asset management.

This is a short explanatory video on how the smart water monitoring system works:

https://www.youtube.com/watch?v=l1pjlyPJazg
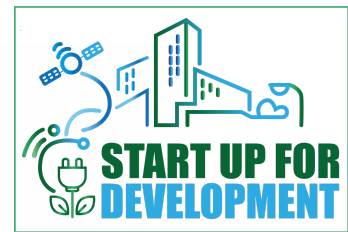
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VIDEOS

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