University of Macedonia
Department of Applied Informatics

Software Protection and Patent Law in the Innovation Technology Industry and Smart Buildings

Doctoral thesis
Of
Metallidou Chrysi

Thessaloniki,2020
Doctoral Thesis Advisory Committee:

Professor Eugenia Alexandropoulou-Egyptiadou
Professor Alexandros Chatzigeorgiou
Associate Professor Emmanouil Stiakakis

University of Macedonia
Department of Applied Informatics

Software Protection and Patent Law in the Innovation Technology Industry and Smart Buildings

Metallidou Chrysi

Scientific Associate in Hellenic Parliament
Msc Informatics & Management, Aristotle University of Thessaloniki
Bsc Electrical & Computer Engineering, School of Engineering, University of Thessaly, Greece

Examination Committee:

1.Professor Eugenia Alexandropoulou-Egyptiadou, *Dep. of Applied Informatics, University of Macedonia*
2.Professor Alexandros Chatzigeorgiou, *Dep. of Applied Informatics, University of Macedonia*
3.Associate Professor Emmanouil Stiakakis, *Dep. of Applied Informatics, University of Macedonia*
4.Associate Professor Psannis Konstantinos, *Dep. of Applied Informatics, University of Macedonia*
5. Professor George Stamoulis, *Dep. of Electrical and Computer Engineering, University of Thessaly*
6. Associate Professor Thomas Hatzigagios, *Dep. of Accounting and Finance, University of Macedonia*
7. Assistant Professor Komnios Komninos, *International Hellenic University*

Abstract

We are moving through the era of technological innovation, artificial intelligence, Industry 4.0, as it is called. The integration of smart technology into all sectors of society is a reality and a mean to facilitate and simplify everyday life.

In this information technology industry, the development of new technology achievements influences and inspires the business world, serves and contributes to the progress of society. This rapidly evolving technological advancement needs a legal framework in order to obtain social and commercial status. Patent Law is the legal science and patent is the legal tool that adds value to intangible assets and therefore technology scientists are motivated to ensure their invention with a patent and also dominant technology enterprises are competing for the development of a strong patent portfolio. This doctoral thesis deals with the legal frame that Patent Law provides for an inventor to grant a European patent or an international one. In addition, for the first time in Greece, combining the fields of Intellectual Property Law and technological innovation, in this thesis, a survey is conducted using a questionnaire that was distributed in 2019, to graduated students of technology institutes in Greece. The purpose of the survey is to clarify the knowhow of students as for the legal aspects of technology. Regarding the results of the survey, it is vital to apply measures in education, for the next generation technical inventors to have the knowhow of utilizing their intellectual asset in their own free will.

Further, this thesis introduces and presents smart technology and its application in society, by directly exploiting the Internet of Energy (IoE) and the Internet of Things technology (IoT) into distributed energy systems, with the aim to achieve energy efficiency, to avoid energy wasting, and improve environmental conditions. In addition, this thesis refers to European's Union legislation for the gradually transformation of the building potential of all European Member States into smart buildings. The thesis presents the development of a smart building template that manages the performance of all technical systems through IoT technology, with the view of achieving energy efficiency. Furthermore, in order to improve the certification of existing buildings, as for energy performance, an automated remote control method is proposed, supported by cloud interface. This method minimizes time consuming procedures and stores, on a cloud platform, the energy performance of each building, for the purpose of drawing conclusions and applying measures.

Eventually, this thesis intends to contribute to the state of the art by informing technological scientists on how to cope with innovation in industry of technology, by introducing a smart building template for the construction of smart buildings according to the Energy Efficient Directive and by developing a smart method for managing and monitoring the technical elements of a building, which will also serve in the inspection of buildings as for energy efficiency. Accordingly, the protection of the environment will strengthen, carbon emissions will reduce and cities will improve sustainability.

Keywords: Software protection, Computer related inventions, Artificial intelligent inventions, Patent Law, Entrepreneurial trend, Management of Technology, Smart technology, Survey on Technical Institute, Smart city, Energy efficiency, Energy

Performance of existing buildings, Internet of Things, Smart building template, Smart Energy Management.

Acknowledgements

I would like to express my deep gratitude to my thesis' supervisor Prof. Eugenia Alexandropoulou - Egyptiadou, for her enthusiastic support and patience.

In addition, i would like to express my gratitude to Prof. Chatzigeorgiou and As. Prof. Stiakakis, who are in my advisory committee, for their useful remarks.

I would like also to deeply thank As. Prof. Kostas E. Psannis for his significant guidance and supportive encouragement.

It has been a great honor working with them.

Last but not least, I would like to thank my family and especially my mother for the invaluable support. I dedicate this doctoral thesis to them.

Contents

Abbreviations

ICT	Information and Communication Technology
IoT	Internet of Things
AI	Artificial Intelligence
ML	Machine Learning
IPR	Intellectual Property Rights
IP	Intellectual Property
WIPO	World Intellectual Property Organization
EPO	European Patent Organization
WTO	World Trade Organization
OBI	Hellenic Industrial Property Organization
EPC	European Patent Convention
UPC	Unified Patent Court
TRIPS	Trade Related Aspects of Intellectual Property Rights
PCT	Patent Cooperation Treaty
ISA	International Searching Authority
SMEs	Small and Medium-sized Enterprises
IOE	Internet of Energy
EED	Energy Efficiency Directive
EPBD	Energy Performance of Buildings Direction
BEMS	Building Energy Management System
BMS	Building Management System
EMS	Energy Management System
HVAC	Heat Ventilation Air conditioning
NZEB	Nearly Zero Energy Buildings

NECP	National Energy and Climate plan
NEEAPs	National Energy Efficiency Action Plans
EEOSs	Energy Efficiency Obligation Schemes
BSO	Building Stock Observatory
OHIM	Office for Harmonization in the Internal Market
Art.	Article
Fig.	Figure

Preface

Every time a global problem arises, the entire technology community, scientists, universities, the industry, concentrate on that problem and make efforts to encounter it and solve it. During this searching process for the optimal solution, many steps are taken in technological progress and many technological advances are achieved, which the global community should recognize, encourage and protect.

In this way smart devices emerged, guided by the need of people to communicate globally, serving the global industry and economy.

In this way the plan for smart cities and smart buildings compiled, guided by the need to protect the environment, prevent energy wasting and create sustainable societies that upgrade the standard of living and add value to the quality of the residents' life.

Simultaneously, every time a problem is solved and new technological advances are emerged, legislation should adapt to the technology perspectives.

Nowadays, the technology industry owns the largest share of the global industry, has many facets, represents and serves many sections of modern life. Therefore, many issues and concerns arise for the social values, regarding the development and application of innovations in our era of Industry 4.0, of information and smart technology. These issues focus on artificial intelligence (AI), machine learning (ML), the Internet of Things (IoT), the use of sensing technologies; sensors which receive environmental stimuli and actions are taken through actuators accordingly. These issues also focus on the development of algorithms and predictive analytics, on automated devices and automated systems that respond with actions to the data that are collected through sensors, on the application of smart methods in smart cities, on the will to provide convenience to citizens, on the protection of the environment, on the energy savings and last but not least, on the legal protection of all those achievements of technology.

Furthermore, the conception of an innovative idea, the research and development of new technologies, the implementation and the commercialization of those technology achievements, the legal and moral protection and justification of the creator for his contribution to the global community, through his technology achievement, are issues that dominate in the current technology society.

In addition, the way laws comply with technology, secure creators, harmonize its application in society, and prevent or even punish fraudulent and unfair applications and even infringement, are also concerns worth mentioning.

At this point it is of primordial importance to state that the common denominator of all these technological advances, whether we refer to artificial intelligence, computers, smart technologies, smart devices, smart communication systems, sensing technologies, smart automated management systems, smart technologies for energy efficiency, or renewable energy exploitation technologies, is the software that when runs brings results on the hardware and achieves the before mentioned optimal solution, which most of the times is innovative regarding the state of the prior art. In the same way, smart buildings are constructed with smart technical elements that base on innovative technologies. In other words, the software which is embedded in hardware and by using IoT technology, manages the whole Building's Management System.

This doctoral thesis takes into consideration that the most essential condition for the development and advancement of technology, is the legal protection of inventors through the legal systems of Intellectual Property provided worldwide, and mainly through Patent Law. On the base of this admission, the current legal framework and the procedure for protecting inventions through patents in Europe is cited, with particular reference to computer implemented inventions and artificial intelligence related inventions. The procedure for granting an international patent, that also validates the paternity of the inventor internationally and ensures the commercial exploitation of the product of his invention worldwide, is also listed. In the context of the ingenuity and mobilization of technology to serve the European Union Regulations, regarding the future generation's smart cities, in this thesis is also cited the Energy Efficiency Direction and the actions of the European Commission for the transformation of existing cities, starting from existing buildings, into Smart Buildings.

Then, in the thesis, a survey is conducted which is implemented with a questionnaire that was distributed in 2019, to 5 Institutes of Technology in Greece, of which only the first Institute of Technology includes in its curriculum a course related to Law and Information Technology, to fourth-year or fifth-year graduated university students. The purpose of the survey is to clarify the knowledge that the students have

acquired the moment of completing the university curriculum of a technology department, as for the management and the legal status of technology. The survey's intention is to find out whether Greece's potential inventors have beyond their technological background, the skills and knowledge; 1.to protect their potential invention, 2.to ensure the paternity of their intellectual property, 3.to benefit from their invention's exclusive commercial exploitation,4.to survive in the global technology innovation industry, in which possibly they may excel, 5.to promote the country's economy by establishing a technology company, and 6.to contribute to the wider society with their technological achievements.

To the best of my knowledge, this is the first time that a survey, which refers to graduate students of Technical Institutes in Greece and examines their knowhow on Entrepreneurship and on Patent Law in the direction of supporting a potential technological invention, is conducted and this survey is published in [1] IEEE Access, a peer-reviewed, open-access scientific journal published by the Institute of Electrical and Electronics Engineers.

Subsequently, since technology industry has already indicated the need for technology professionals who work and take decisions lead by their legal engineering skills, and considering the conclusions of the survey, as future work, a course will be compiled and will be proposed to be included in the curriculum of technical universities. The under preparation course will regard IP and both legal and managerial issues that concern a technology professional and this thesis lays the foundations for its future development. Furthermore, this survey will be soon conducted in other countries, as well, in order to draw general and international conclusions.

Eventually, on the grounds that energy is the driving force of a city and the energy saving is a major issue for the whole world that will ensure the citizens' well-being, the European Union, acting in this direction, is willing to ensure Europe's energy security, competitiveness and sustainability. The use of alternative energy sources, the reduction of gas emissions and the contribution of the Internet of Things (IoT) technology in monitoring energy consumption and controlling energy performance, is of vital importance. According to the Europe's legal frame, a development of a smart technology building template is presented, which is a sensor-based architecture that supports the

operation of energy consuming technical systems, with the aim to achieve energy efficiency in a building and develop an eco-aware behavior to the residents of it. The whole smart building is controlled by a smart management system which is a connection among the building and the residents of it. This management system interacts with a wireless sensor and actuator network, in order to collect data from the surrounding internal and external environment, stores them to the cloud and then uses those data to control actuators and technical systems. It is a user-friendly system and aims to monitor and coordinate all technical systems, provide warnings and notifications, apply adjustments and devise strategies, with a view to evaluate energy consumption, reduce energy costs and offer indoor convenience to the residents of the smart building.

In addition, for existing buildings, a development of an optimally way for monitoring energy consumption in existing buildings is presented. This remote and automated approach can be used for the supervision of a building and can contribute in Building Certification and compliance checking. Through this management system we check the energy consumption of existing buildings and we propose solutions in case of a building's energy inefficient operation. This way the instantaneous presence of an inspector in a building, which reflects instantaneous measurements, can be replaced with remote and continuous measurements, under various conditions. To explain further, the proposed management system for existing buildings is an IoT sensor oriented system. This system is going to use information provided through sensors, connected to cloud for a specific period of time, in order to conclude the energy losses of a building, the energy consumption of all technical systems that operate in this building and the Co2 emissions that derived from them. Then, this information will be used to calculate whether the building is energy efficient. At this point the management system regarding which technical system is energy inefficient, will suggest solutions to minimize the ineffective energy performance of it. This research [2] is also published in IEEE Access, a peer-reviewed open-access scientific journal published by the Institute of Electrical and Electronics Engineers.

Chapter 1:

Legal Framework for Software protection and Patent Law

1.1 Introduction

Nowadays, we are moving into this industrial era that is characterized by the rapid development of technology and especially artificial intelligence, which is a wide field of smart technology and mainly encompasses computer technology, as well as, achievements in Big data, artificial intelligence techniques and machine learning.

The great challenge of this industrial era is that, this smart technology is developing in order to serve global society, which is governed by contracts, Intellectual Property Rights (IPR), privacy, freedom of information, and employment. Therefore, legislation should, simultaneously, evolve so that it enables the protection of those who produce technology, those who apply and adopt it, those who buy or sell it. In this way, technology can be integrated into society, by encouraging law and technology representatives to cooperate and contribute to this direction. Accordingly, the Patent Law is set at the service of technology, in order to ensure its intellectual and moral paternity and to guarantee its application against any kind of commercial and moral infringement.

The legal status of patents for computer related inventions' protection has always been controversial. In the process of this legal framework's establishment, various issues have been addressed and are still emerging, due to the complex nature of the computer programs and the continuous development of information technology[3].

With the dominance of technological innovation in the global industry, lawyers specializing in patents have tried to answer the question of whether computer programs can grant a patent. This research was expanded when computer engineers, who specialize in software, began to separate the production of programs from the hardware, which includes the software and on which, when the software "runs", gives as a result the multiple implementation of a computer's functionality, (hardware and software together). Thus, computer programs were evaluated as works of great value for the global industry and society and today there is a legal framework that secures their spiritual status, with a patent.

Patents do not protect the source code, or the algorithm of computer programs, but the innovative processes and results that they produce as a whole, when the software runs on the hardware. The patents related to computer inventions are a technological

breakthrough in the field of technology, create jobs and contribute to the progress of society. As it is said, the modern war on patents of computer related inventions is not the first and probably not the last in the history of patents. Whenever innovative technologies come to the fore, major market players seek to integrate into the emerging new market and claim control of part of it[4].

The competition among technology companies to deal with the claiming rights on technology patents and the patents' financial exploitation, insists on the protection of computer developers, in order to ensure technological advancement among societies and secure the patents' commercial value. For this reason, it is worth researching the system of Patent protection, as well as, the knowledge of technology scientists, regarding the possibility of securing the paternity of their invention, the commodification of their innovative idea and the exclusive exploitation of its products.

It is of great interest to investigate how familiar are young inventors of technological inventions, in Greece, with the legal framework that protects such inventions. Are Greek inventors ready to deal with the technology industry and reveal their invention to the public? And if so, do they know the benefits and obligations that arise for the inventor? What is their view, on whether it is worth investing in protecting an invention and whether this invention can be considered an incentive to start a business? Considering these questions, we should not forget that the defense of the inventor's rights is the motivation of society for the development of know-how, economic development and improvement quality in the living conditions.

Below we found in literature [5], a research that presents artificial intelligence related patents from 2004 to 2018 on innovations of the Industry of technology and we present the majority of them indicatively:

1. Computer technology (4914) patents ,
2. methods for management of technology (1607)patents,
3. Control (1583), Digital communication (975)patents ,
4. Measurement (830)patents ,
5. Telecommunications (672)patents,
6. Medical technology (485) ,
7. Electrical machinery, apparatus, energy (389)patents,
8. Transport (346)patents ,
9. Audio-visual technology (320)patents,

10. Other special machines (273)patents,
11. Civil engineering (163)patents ,
12. Thermal processes and apparatus (134)patents ,
13. Machine tools (115)patents,
14. Engines, pumps, turbines (79)patents ,
15. Optics (78)patents ,
16. Environmental technology (73)patents,
17. Mechanical elements (61)patents,
18. Materials, metallurgy (60)patents ,
19. Biotechnology (54)patents,
20. Basic communication processes (49)patents,
21. Semiconductors (38)patents

It is significant that the number of patents related to computer-related inventions ranks first.

It is also significant to realize the need for educating technocrats of this technology era on legal aspects and especially Patent Law, considering the management of innovation in the world's Industry of technology.

1.2 Definitions

At this point it is of great importance to quote the definitions of the terms that are used in the dissertation, the explanation of which will help to understand the issues developed in the following sections.

According to the Cambridge dictionary:

- an **algorithm** [6]is
  a set of mathematical instructions or rules that must be followed in a fixed order, and that, especially if given to a computer, will help to calculate an answer to a mathematical problem.
- a **computer program**[7] is
  a set of instructions that makes a computer do a particular thing and
- **computer programming**[8] is
  the activity or job of writing programs for computers
- **software**[9] is
  a set of instructions that control what a computer does; computer programs
- **source code**[10] is
  the set of computer instructions that have been written in order to create a program or piece of software
- **hardware** [11]are
  the physical and electronic parts of a computer, rather than the instructions it follows
- **patent**[12] is
  the official legal right to make or sell an invention for a particular number of years

An algorithm is defined as any well-defined computational process, which is called to solve a specific problem, in finite time. It is a sequence of computational steps that depicts the input of the problem, ie its data, to the output, i.e. the solution of the problem. Any entry that meets the specifications of the problem is called legal and we say that it specifies a specific snapshot of the problem. An algorithm solves a problem when, for each snapshot of the problem in question, it terminates after a finite time, producing the correct output[13].

The definition contained in the standard guidelines of the World Intellectual Property Organization 1977,WIPO [14] is that **Computer Programs** are defined as a set

of commands, capable when integrated into a mean that can be read by a machine to drive a machine with the ability to process information to perform, indicate or achieve a specific mission or result function.

According to[15], the **computer program** is distinguished in a source program or source code and in an objective program or machine code. The source code or computer program refers to the original language in which the program is written. The source code can run on the computer after translation into machine language. Programs are divided into application programs and operating systems. The first, makes the computer capable of performing a specific task. The second running on the computer aims to make the computer work. The concepts of the **algorithm** and **the computer program** are incorrectly identified. The computer program contains the steps of the algorithm applied to the computer and also the result that occurs when these steps of the algorithm are applied.

Software is a broader concept of the computer program. The software includes the computer program and the accompanying material of its design and program description[16].

According to the technical rules ISO 2383-1 and ISO 8402, **software** is a product that belongs to the intellectual property and concerns the processing of data. According to the literature, software is a set of commands or instructions, which when applied to a computer bring about a specific result. **Computer software** is defined as the collection of computer programs, procedures, and instructions that perform certain tasks on a computer system.

The term includes:

a) application software, such as word processors, that perform productive work for users,

b) system software, such as operating systems, that provides the necessary hardware services to the application software,

c) the intermediate software, which controls and coordinates the distributed systems, and

d) the software applied to the computer hardware that is programming the computer hardware at a low level

Software combined with hardware creates the computer entity, as we all know it. Computers as an entity are hardware which has the capacity to store and process data. Hardware is the set of natural components of a computer, such as electrical and electronic components, microchips, etc. However, the separation of hardware and software is not so clear, because every task performed by a computer is hardware that is guided during its operation by software.

According to the Cambridge dictionary:

- **smart**[17](technology/city/building)
  intelligent, or able to think quickly or intelligently in difficult situations
- **renewable energy**[18] is the energy that is produced using the sun, wind, etc., or from crops, rather than using fuels such as oil or coal
- **energy efficient** [19] as a term is used to describe things that use only as much energy as is needed without wasting any.

According to Environmental and Energy Study Institute, the term of **energy efficiency**[20] simply means using less energy to perform the same task that otherwise it was performed by consuming a lot of energy. Energy efficiency means eliminating energy waste. Energy efficiency brings a variety of benefits: reducing greenhouse gas emissions, reducing demand for energy imports, and lowering our costs on a household and economy-wide level. While renewable energy technologies also help accomplish these objectives, improving energy efficiency is the cheapest and often the most immediate way to reduce the use of fossil fuels. There are enormous opportunities for efficiency improvements in every sector of the economy, whether it is buildings, transportation, industry, or energy generation.

According to the Eurostat Statistics Explained site[21], **Renewable energy sources,** also called renewables, are energy sources that replenish (or renew) themselves naturally. Typical examples are solar energy, wind and biomass.

According to the European Commission a **smart city** [22] is a place where traditional networks and services are made more efficient with the use of digital and telecommunication technologies for the benefit of its inhabitants and business.

A **smart city** goes beyond the use of Information and Communication Technologies (ICT) for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population.

Development within the domains of Big Data and Internet of Things (IoT) and consequently the diffusion of sensor networks and the desire to replace batteries and polluting fuels are major force driving advances in energy harvesting technologies[23].

According to Environmental and Energy Study Institute[20], **Building** designers are looking to optimize **building efficiency** and then incorporate **renewable energy** technologies, leading to the creation of zero-energy buildings. Changes in existing buildings can also be made to reduce energy usage and costs. These may include small steps, such as choosing LED light bulbs and energy efficient appliances, or larger efforts such as upgrading insulation and weatherization.

According to the European Commission[24], **Building Energy Management Systems (BEMS)** combine software with smart thermostats and sensors to anticipate behavior, and use weather forecasts and energy prices to predict demand and manage heating and cooling. The aim is to optimise energy consumption and maintenance, enable demand response, and improve comfort and environmental quality. Improvements in sensors and controls, and the use of computers, have made BEMS more sophisticated and less expensive. Systems can be linked, for example by using sensors embedded in lighting to tailor heating and cooling, and managed by algorithms or by users themselves. Artificial intelligence (AI) can greatly enhance their potential by balancing energy saving and user-customised comfort.

Energy systems are essential part of buildings and facilities, which are associated with high costs, and considered key success factor of businesses and services produced from the building or facility. Energy management will protect the underlying business, by allowing accurate and automated management of energy systems and supply. **Energy management systems (BEMS),** are computer-based automated systems that monitor and control all energy-related systems from mechanical and electrical equipment in buildings. **Building Management Systems (BMS)** are commonly used to automate all services and

functions within the building, which include energy management. BMS connects building's components with a central computer to enable the control of different variables and parameters within the building. Through **Energy Management System (EMS)** it is possible to achieve energy monitoring, and savings, in smart homes[25].

1.3 Intellectual Property Rights

Ever since human spirit achieved to develop intellectual creations of great financial interest and industrial application, the terms of “Intellectual Property”, “rights of the creator”, “copyrights”, “patents”, began to evolve and eventually integrate into a legal protection system that protects intangible assets, the so-called Intellectual Property.

According to the World Trade Organization (WTO) [26], governments grant creators the right to prevent others from using their inventions, designs or other creations and encourage them to use that right to negotiate payment by others, using their creation. In this way, governments motivate creators to produce and disclose ideas that will be beneficial for society. These are “Intellectual Property Rights” and they have different forms.

- Software, books, paintings and films are protected under copyright
- eligible inventions can be patented
- brand names and product logos can be registered as trademarks

Among the others spiritual achievements, the protection of intellectual creations that regard technological achievements, such as Computer Implemented Inventions and Artificial Intelligent inventions, is subjected to Intellectual Property. According to[27], Intellectual Property law bases on the right of the creator on his creation, the protection of the enterprise that exploits it financially and the need of the society to benefit from it.

The protection for Intellectual property rights has led to International Conventions such as the TRIPS Agreement of the World Intellectual Property Organization.

According to the author, Alexandropoulou E. [28], in the European Union, among others, instructions have been issued for the regulation of Intellectual Property, regarding intellectual creations that come from the field of Informatics, such as for the protection of computer programs. Greece, like other European Union countries, has passed in its legislation the relevant Directives on the protection of Intellectual property.

According to the author in [28], the object of Intellectual Property is the creation of the creator’s intellectual effort, which is so- called as "work". Original works are protected regardless of any judgment of their value, their destination and of their possible protection by other legal regulations that protect intellectual property, as well. The work

is protected as soon as it acquires a form perceived by the human senses and not as long as it is at the early stage of being just idea. For example, considering computer programs, any form of expression of a computer program is protected, but the ideas and principles, on which any component of the program is based, are not.

According to the author Alexandropoulou E. [29], due to the technological nature that distinguishes intellectual achievements of technology from classical works, the protection of computer programs under Copyright Law has emerged, after several scientific discussions among Copyright Law, Industrial Property Law and Competition Law. In Greece, computer programs and their preparatory design material, by meaning the software, is protected under Art. 2 par. 3, Law No 2121/1993, [30]. Protection is provided in any form of expression of a computer program, regardless of the purpose and utility it serves and the material in which it is integrated. This way the computer program is protected, whether it is functional or application program, or standardized or adapted to specific needs. A prerequisite for the legal protection of a computer program in the field of Intellectual Property is its originality. According to the art. 2 par. 3 of Law No 2121/1993[30], in Greece a computer program is considered original, as long as it is a personal intellectual creation of its author. In other words, any computer program, that is not a copy product, is regarded as original.

According to Alexandropoulou E. [28], as far as what concerns the original Intellectual Property holder of the work, this is the actual creator of the work, who, by creating it, automatically acquires Intellectual Property on it. However, the status of creator and Intellectual Property holder does not always coincide; "It is possible for the creator of the work not to be the Intellectual Property holder, in case the creator transfers his intellectual property to another person, e.g. his employers. The holder of Intellectual Property in collective work, such as computer programs can be the natural or legal person, whose name or surname appears on the work- material and in these cases the creators are usually numerous"[28].

In[28], there are listed all cases, regarding the holder of an Intellectual Property creation:

- In the case of a collaborative work, two or more people work together as a team, with common sense, resulting in holding the Intellectual Property together as co-creators, and in equal parts.
- In the case of the collective work, there are independent contributions of more creators, under the spiritual direction and the coordination of a natural person, who owns the Intellectual Property of the collective work, while the creators of the individual contributions, are the Intellectual Property holders of their contributions, if they can be used separately.
- In the case of the complex work, which consists of sections created separately by more creators, each co-creator owns the Intellectual Property of the section he created, if this can be used separately, otherwise the complex work belongs jointly to the co-creators.
- In the case of work created by employees in execution of an employment contract in the private sector, the original holder of the Intellectual Property is the creator. The transfer of Intellectual Property Rights from the employee-creator to his employer is regulated by the employment contract. If there is no relevant provision in the employment contract, the following applies:
    - The employer, who also bears the burden of the relevant financial investment, is automatically transferred only those rights, which are necessary for the fulfillment of the purpose of the contract. Art. 40 of Law No 2121/1993, [30], specifically applies to computer programs, that the employer is automatically transferred the entire property right of a computer program, provided that the program was created by a paid programmer in execution of an employment contract or according to the instructions of his employer. The employee, therefore, in case he develops a program under the above conditions, is not entitled to additional remuneration for his creation.

1.4 The TRIPS Agreement

The Trade-Related Aspects of Intellectual Property Rights (TRIPS), "Uruguay Round Agreement: TRIPS Trade-Related Aspects of Intellectual Property Rights," 1994, Agreement of the World's Trade Organization (WTO)[31], negotiated, during the 1986-1994 Uruguay Round, and introduced, for the first time, Intellectual Property rules into the multilateral trading system. This Agreement is a legal recognition of the significant connection between Intellectual Property and Trade. The WTO's TRIPS Agreement is an attempt to bring Intellectual Property under common international rules by establishing minimum standards of protection and enforcement for each government which is a fellow member of the WTO. It has been ratified by European member states, including Greece under Law 2290/1995,[32], the United States and Japan.

The bases on which the main international agreements of the World Intellectual Property Organization (WIPO) were established even before the WTO was created are:

1. the Paris Convention for the Protection of Industrial Property[33] (patents, industrial designs, etc)
2. the Berne Convention for the Protection of Literary and Artistic Works [34](copyright).

However these agreements could not cover all issues that stem from Intellectual Property creations. Therefore the TRIPS Agreement added value to existing international standards.

According to the WTO : "The TRIPS Agreement plays a critical role in facilitating trade in knowledge and creativity, in resolving trade disputes over intellectual property, and in assuring WTO members the latitude to achieve their domestic objectives."

The Agreement enables members to achieve long term benefits of innovation and to reduce short term costs of limiting access to creations of the mind through mechanisms supported by TRIPS and in case of trade disputes over the application of the TRIPS Agreement, the WTO's dispute settlement system is in charge.

According to the WTO, The TRIPS Agreement focuses on:

- the way general provisions and basic principles of the multilateral trading system apply to international Intellectual Property
- the minimum standards of protection through Intellectual Property rights that members should provide
- the procedures that members should provide for the enforcement of those rights in their own territories
- the way to settle disputes on Intellectual Property between members of the WTO

Further, the TRIPS Agreement states an important general objective: "Intellectual Property protection should contribute to technical innovation and the transfer of technology. Both producers and users should benefit, and economic and social welfare should be enhanced"

The TRIPS Agreement includes different kinds for protecting Intellectual Property rights:

- Copyrights
- Patents
- Trademarks
- Geographical indications
- Industrial designs
- Layout designs or integrated circuits
- Undisclosed information

The TRIPS Agreement is the only international agreement that introduces for computer programs to be protected through patents (Art. 27). However the grant of patent on a computer program is contrary to the Munich Convention which precludes the granting of patent on computer programs. This contrast led the European Commission to the Proposal for a Council Regulation on the Community patent[35], which adapts the prohibitive provisions of the Munich Convention, so that the issuance of patents for computer programs to be feasible. The Proposal for a Council Regulation on the Community patent aims at the simultaneous application of Copyright Law and Patent Law. Copyrights protect the source code of the program, but do not protect the ideas and principles of the program. The Patent Law protects the ideas and principles of the

program, as defined in the claims of the invention, when the inventor applies for a patent. Therefore, this combination of protection, secures better the interests of the inventor.

To conclude, it is important to state that the reasons that led to the consideration of computer program related to hardware, as inventions and to the possibility of protecting them with patents, were economic and commercial. The target was to strengthen European competitiveness in the global industry, which is guided by information technology.

1.5 Convention on the Grant of European Patents (European Patent Convention)

The European Patent Agreement was signed in Munich in 1973 and entered into force in 1977,[36]. The agreement was originally signed by 16 member states, including Germany, Belgium, Great Britain, France, Luxembourg and the Netherlands (1977), Italy and Sweden (1978), Austria (1979), Greece and Spain (1986), Denmark (1990), Ireland and Portugal (1992), Finland (1996) and up to date all European Member States have joined it, in order to create a unified Patent Law in the various European Member States for the elimination of disputes between national patents.

The agreement stipulates that the European Patent Office (EPO)[37] based in Munich is responsible for issuing the European patents. Greece ratified the Munich Agreement with Law 1607/1986. The inventor according to the European Patent Convention (EPC)[36], is enable to apply for a national patent for protection at a national level. If he is willing to be granted a European patent, he can apply to the European Patent Office within 12 months, in order to secure protection with a single application, in all the States specified in the Convention, or in any of the States he is willing to ensure protection for his invention.

The procedure for granting a European patent is a rather time consuming process that usually takes 3 to 7 years and the cost of issuing and maintaining protection, in all European countries chosen by the inventor for a period of 20 years, is exceptionally high. This is not a unitary patent, but a bundle with national patents to be validated in the states that were designated at grant with one application filed in the EPO. The procedure includes all national routes for granting all those national patents under the European patent. The 44 countries for which European patents provide protection represent a population of around 700 million people.

According to the EPC[36], a patent is a legal title granting its holder the right – in a particular country and for a certain period of time – to prevent third parties from exploiting an invention for commercial purposes, without authorization. The EPC has established a single European procedure for the grant of patents on the basis of a single

application and created a uniform body of substantive Patent Law designed to provide easier, cheaper and stronger protection for inventions in the contracting states.

The contracting states are: Albania, Austria, Belgium, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

"In each contracting state for which it is granted, a European patent gives its proprietor the same rights as would be conferred by a national patent granted in that state. If its subject-matter is a process, protection is extended to products directly obtained by that process. Any infringement of a European patent is dealt with by national law."[36]

According to Art. 67 of the EPC, a European patent lasts for 20 years starting from the date of filing a European patent application with the EPO. Regarding that annual renewal fees are paid, patents remain in force for those 20 years.

1.6 European Patent application

According to Art. 78 of the EPC[36], a potential inventor, in order to apply for a European patent, should prepare the following:

- a **request** for the grant of a European patent where the inventor's personal information are included,
- an **abstract** of the claimed invention where the technical field is mentioned,
- one or more claims through which the required protection for the invention is stated,
- a **description** in detail of the invention,
- **drawings** referred to in the description or the claims which will be helpful for a person skilled in the art to understand the functionality of the invention.

Along with the application for a European patent, the filling fee and the search fee should be paid from the inventor, as well.

According to Rule 41 of the EPC, the **request** for grant of a European patent is filed on a form of the European Patent Office and it should contain the title of the invention, which shall clearly state its technical designation without fancy names.

According to Rule 47 of the EPC, the **abstract** indicates the title of the invention. The abstract is a brief summary (not more than one hundred and fifty words) of the description, the claims and drawings and establishes the technical field to which the invention is part of and gives the direction for searching the prior art in the particular technical field. The abstract does not state the required protection for an invention, it should state clearly the technical problem that the invention solves and should not refer to its advantages or value. Below follows a table according to the European Patent Office, (EPO), which indicates a technical type of an invention and the corresponding abstract that the inventor should include in his application.

Invention	Abstract should include
1. Machine, apparatus, system	its nature, use; construction, organization; operation
2.Process or operation	its nature and characterizing features; material and conditions employed; product, if significant; nature of and relationship between the steps, if more than one
3.If the disclosure involves alternatives	the abstract should deal with the preferred alternative and identify the others if this can be done succinctly; if this cannot be done, it should mention that they exist and whether they differ substantially from the preferred alternative

Table 1.1:Guideliness for Examination [38]

According to Rule 42 of the EPC, in the **description** the inventor specifies the technical field of the invention, he indicates the state of art of this technical field, includes a European search report and cites relevant documents. After setting the technical background of the invention, the inventor should disclose the claimed invention in detail by stating the technical problem it solves, by analyzing its solution and its advantages over the prior art. The most important thing in the description of a European patent application is the description of at least one way of executing the claimed invention, step by step, using examples when needed or referring to the drawings if any, so as to lead a person skilled in the art to reach the claimed invention's result. Eventually, the inventor should indicate the industrial application of the claimed invention in case it is not obvious.

In the **claims** the inventor states the technical features of the invention, see Rule 43(1) of the EPC, according to which protection is sought for the invention. The claims contain a statement which indicates the object of the invention and the technical features

that are necessary for the definition of the object, but are part of the prior art. The claims begin with the expression "characterised in that" or "characterised by" and specify the technical features for which, in combination with the features stated before, protection is sought.

According to Art. 69(1) of the EPC, the protection is determined by the claims and the description and drawings are used to explain the claims.

According to Rule 43(3),(4) of the EPC, a claim that states the essential features of an invention can be followed by one or more independent claims, which concern particular embodiments of that invention. A claim which follows and includes all the features of another claim is a dependent claim. This dependent claim should state a reference to the (other dependent or independent) claim it follows, and then state additional features.

According to Rule 40 of the EPC, the date of filing a European patent application is the date on which the applicant files the documents. According to Art. 89 of the EPC, the right of priority is ensured by the date of filing the European patent application. The inventor should check his right for priority for the invention he applies for a patent, because the filing date of the first application is claimed as priority. The right for priority has, according to Art. 87 of the EPC:

“ a person who has filed, in or for any State party to the Paris Convention for the Protection of Industrial Property or any Member of the World Trade Organization, an application for a patent, a utility model or a utility certificate, or his successor, for the purpose of filing a European patent application in respect of the same invention, a right of priority during a period of twelve months from the date of filing of the first application.

Every filing that is equivalent to a regular national filing under the national law of the State where it was made or under agreements, including this Convention, shall be recognised as giving rise to a right of priority. A regular national filing shall mean any filing that is sufficient to establish the date on which the application was filed, whatever the outcome of the application may be.”

According to Art. 14 of the EPC, a European patent application shall be filed in one of the official **languages** English, French and German or if filed in any other language it should be translated into one of the official languages.

The **fees** schedule shown in [39] comprises all the fees and expenses of the EPO in Euros effective as from1 April 2020. According to art 5, the fees due to the Office shall be paid in euro by payment or transfer to a bank account held by the Office. Fees are charged for:

- filing (including maybe an additional fee for the 36th and each subsequent page)
- search for published related patents and prior art
- designation of contracting states,
- claims (if more than fifteen),
- examination of a patent
- grant of a patent
- print of a patent

According to the EPO the filing and search fees are about EUR 1 610 and are paid with the application for a European patent. The rest amount of fees are payable by completing the whole procedure. It currently costs EUR 6 100 to grant a European patent. After granting the patent the contracting states are called for national validation.

In order to maintain the patent, renewal fees are also payable for the third year and each subsequent year after the date of filing. Renewal fees must be paid in each designated state in which the European patent has been validated and this fee varies.

1.7 National Law and EPC

The European patent office has published a guide in 2019 regarding European patent applications and patents, law and practices of the EPC contracting states. The centralized procedure for the grant of European patents, according to the EPC, is connected with the national Patent Law of the member states of the EPO. In each of the contracting states for which a European patent is granted, it is regarded as a national patent of that state. The patent applicant should follow a specific procedure of each contracting state in order, for the inventor, to ensure protection of his invention to this state. The most important provisions and requirements under the EPC contracting states' national law is presented in the above mentioned guide with responsibility to the society and industrial property.

This thesis refers to the most important provisions and requirements under the EPC for the national law of Greece. The authority responsible for issuing an official title, a patent, in order to protect an invention in Greece, is the Hellenic Industrial Property Organization (OBI)[40], which certifies and provides to the inventor the exclusive right of protection and industrial exploitation of his idea for twenty years. The patent system followed by national Greek Patent Law is the declaration system. According to this system, OBI carries out the essential and standard check of the application for a patent and grants a patent, to every applicant who requests for it by filing a patent application, and a Research Report. The Research Report briefly mentions, after the application is examined, the degree of originality of the invention, accompanied by a degree of scale A-Z, where A is theoretically the maximum degree of originality. In case an infringement related to a patent occurs, the patent can be annulled in a court with a corresponding judicial annulment. The advantage of the declarative system, according to OBI, over the examination system [41] that applies to the European Industrial Property Organization, is that: “everyone receives a granted patent for his innovation, regardless the requirements for patentability.” In addition, an examination system in Greece would be time consuming and with higher costs, because it demands the existence of an organized audit committee, trained at a high level in terms of technique, a fact that was not considered necessary before the technological explosion of the industry that influenced the whole

world and affected Greece, as well. Below follows Table II with the most important provisions and requirements of Greece's national law, under the EPC.

Contracting State: Greece	National Provisions
1	Law No. 1733/1987 on technology transfer, inventions, technological innovation and the establishment of a Nuclear Energy Commission, as amended by Article 18 of Law No. 1739/1987 and Presidential Decree No. 54/1992 and by Article 9 of Law No. 2359/1995 and Articles 1 & 3-8 of Law No. 4605/2019
2	Law No. 4325/1963 on inventions relating to national defense and amending Law No. 2527/1920 on patents
3	Law No. 1607/1986 on the ratification of the Convention on the Grant of European Patents, done at Munich on 5 October 1973
4	Law No. 3396 on the ratification of the Revision Act of the Convention on the Grant of European Patents (European

	Patent Convention of 5 October 1973, as amended on 17 December 1991) of 29 November 2000
5	Law No. 3966, bringing national legislation into line with the Directive 2004/48/EC of the European Parliament and of the Council of 29 April 2004 on the enforcement of intellectual property rights, Article 53
6	Presidential Decree No. 77/1988 on provisions for implementing the Convention on the Grant of European Patents, as last amended by Presidential Decree No. 46/2012
7	Presidential Decree No. 321/2001 adopting Directive 98/44/EC of the European Parliament and of the Council on the legal protection of biotechnological inventions
8	Ministerial Decision No. 15928/EFA/1253 on the filing of applications for patents or utility models with OBI and on keeping registers, as last amended by Ministerial Decision No. 3111/EFA/433

9	Ministerial decision No. 30560/544/1997 on the filing of applications with the OBI for a supplementary protection certificate in respect of plant protection products]
10	Ministerial Decision No. 14905/EFA/3058/1997 on the filing of applications with the OBI for a supplementary protection certificate in respect of medicinal products]
11	Ministerial Decision No. 11475/EFA/2388 on the filing of applications with the OBI for the six-month extension of the supplementary protection certificate in respect of paediatric medicinal products
12	Ministerial decision No. 10374/2009 on the procedure for the drawing up of the search report or the final search report by the OBI
13	Decision of the Administrative Council of the Industrial Property Organisation 03/2012 of 10 February 2012 concerning a change in the method of calculating the fee for searches on behalf of third parties

14	Law 4144/2013 Article 79 "Regulatory issues of the Hellenic Industrial Property Organisation (OBI)
15	Ministerial decision No. 12625/1/2014 "Electronic distribution of documents to and from the Hellenic Industrial Property Organisation (OBI) and electronic filing of industrial design or model registration"
16	Law 2943/2001 (Articles 6-11) Chapter 3 "Community Trade Marks Chambers"
17	Decision of the Administrative Council of the Industrial Property Organisation 13/A01/2016 of 31 August 2016 concerning a change in the fee for the enhanced search report with written opinion, valid from 1.1.2016
18	Law 4512/2018 Articles 123 and 124 "Regulatory issues of the Hellenic Industrial Property Organisation (OBI)"

Table 1.2: The most important provisions and requirements of Greece's national law, under the EPC [42]

In Greece responsible for granting an official protection title, as a patent, to an invention is the Hellenic industrial Property Organisation [40], which according to Greek law is a legal entity under private law that has been entrusted with the exercise of public authority[41] . The patent grant system that is followed from Greek law is the declaration system. Further, in Greece the patents are granted in accordance with Art. 5 of Law 1733/87,[43] on new inventions which contain the inventive activity and are acceptable for industrial application. The invention may relate to a product, method or industrial application. The patent (Art. 11 of Law 1733/87) gives its holder the exclusive right to use and exploit the invention described in it for 20 years. The right to obtain a patent (Art. 6, Law 1733/87) is vested in the inventor or beneficiary and his or her universal or special successors, and the applicant for a patent is considered the inventor. According to Art. 10 of Law 1733/87, the patent entitles its holder, natural or legal person, the right to productively exploit the invention and in particular to produce, supply or merchandise, use and own for the same purpose products protected by a patent. Also, apply, offer or commercially exploit, the patent-protected method. Finally, it is prohibited for any third party to make productive use, in the sense of those previously mentioned, of inventing or importing, without its consent, the products protected by the patent. In contrast with Copyright Law, a patent not only protects the material result of the idea, but also the idea itself. Protection, in other words, is much broader. Under Patent Law, the particular method of resolving a technical problem is protected from any unauthorized commercial use. Since the idea is protected, the right to patent is infringed by any independent invention of the same solution. If someone accidentally invents the same method, regardless of the holder of the patent, it is not allowed to use it without the permission of the holder of the patent. There is a difference between the laws in case the same invention was invented by someone else before the current holder of the patent. In some countries the Patent Law encourages the system first to invent and in others the system first to apply for a patent. The EPO follows the system first to apply and regards as the legal inventor of an invention, the person who first filed an application with the EPO for his claimed invention.

Further, in case that an inventor has submitted an application to a country other than Greece and then he applies for a patent in Greece, Art. 9 of Law 1733/87 on

international priority applies. According to this article, if an application for a foreign patent has been duly submitted, the applicant then deserves the right of priority, provided that within twelve months of the above foreign filing, he submits an application for the same invention in Greece and the condition of reciprocity applies. The new application must state the date and country of the first foreign application. The right of priority refers to the time of the first application abroad. At the same time, it is important to note that, in accordance with Art. 11 of Law 1733/87, the protection of the inventor through a patent starts from the day of the filing of the application for a patent. In the event that a priority is invoked on the basis of a filing abroad, the validity period of the patent is calculated from the day after the application is filed in the home country.

1.8 Computer software-implemented Inventions

For granting European patents for computer-implemented inventions, by the European Patent Office, the inventor should follow the articles and Implementing Regulations of the EPC and their interpretation in the case law of the EPO's boards of appeal. The terms of : computer program, software and algorithm, are defined according to the EPO and follow[38]:

“A computer program is a sequence of computational steps which may be performed by a digital computer. The steps of a computer program are written in a systematic notation known as programming language. Computer programs are often referred to as "codes".”

“Software is often used as a synonym for computer programs. For some computer professionals, it encompasses the media (e.g. diskette, CD or DVD) on which the software is stored as well as all kinds of documentation (books and manuals etc.) that are delivered with the program.”

“An algorithm can be defined as a systematic procedure for accomplishing a task in a finite number of steps. In the context of computers, it is often used to denote a set of ordered steps for solving a problem or providing an output from a specific set of inputs.”

When an algorithm, wholly or partly implemented in a computer program, defines the underlying concept of an invention, that invention is termed a 'computer-implemented invention'. The definitions for a computer-implemented invention according to the European Patent Office follow:

“A computer-implemented invention is one which involves the use of a computer, computer network or other programmable apparatus, where one or more features are

realized wholly or partly by means of a computer program." "A computer program differs from a computer-implemented method."

"A computer program refers to a sequence of computer-executable instructions specifying a method while a computer-implemented method refers to a method being actually performed on a computer."

"Computer-implemented inventions involve computers, computer networks or other programmable apparatus, whereby at least one feature is realized by means of a program."

Some examples of Computer implemented invention are:

- a program-controlled a washing-machine cycle or a car braking system,
- a smart phone or a smart watch, a smart application
- a touch screen gesture recognition component
- a cryptographic algorithm to encrypt communication data

As for the legal basis that Computer implemented inventions are examined in order to grant a patent, this is the EPC and it is explained below. The requirements for patentability that an invention must fulfill are stated in Art. 52(1) of the EPC:

An invention shall be granted a European patent if only it is new, involves an inventive step and is susceptible of industrial application. However, they are not regarded as inventions according to Art. 52(2), discoveries, scientific theories and mathematical methods, aesthetic creations, schemes, rules and methods for performing mental acts, playing games or doing business, and programs for computers, presentations of information. If a European patent application or European patent relates to the subject-matter of Art. 52(2) or activities as such, then the patentability of the subject-matter or activities are excluded. To explain better "new", "inventive step" and "industrial applicable", we consult accordingly Art. 54, Art. 56 and Art. 57 of the EPC;

An invention is considered to be new, Art. 54, and fulfills the requirement of novelty, if it does not belong in the state of the art. State of the art for an invention is every mean written or oral by any form that is known and accessible to the public, before the date of filing a European patent application. Already filed European patent applications before the filing date of the mentioned invention's European patent application, are also regarded as prior art to the mentioned invention, regardless if they are already published or are going to be published after the date of filing the mentioned invention. A substance or composition, that is a part of the state of the art, which is going to be used in a method, can be patentable in case the overall result of the method's use is not a part of the state of the art.

An invention is considered to involve an inventive step regarding to the state of the art, if it is not obvious to a person skilled in the art, Art. 56. An invention is considered industrial applicable when it can be made or used in industry generally, Art 57.

As far as what concerns computer programs as such, they are not patentable under Art. 52(2)(c) and (3). However, computer programs which produce a technical effect, when run on a computer, are patentable under the generally criteria of Art. 52 (2) and 52 (3). This technical effect goes beyond the "normal" physical interactions between the program (software) and the computer (hardware) on which it is run. The fact that a computer program is designed to automatically operate in a computer does not ensure its technical character. Along with the computer program, there must exist a computer algorithm to execute tasks that cause a further technical effect and that are mentioned in the claims of the invention. According to the EPC, Rule 43(1), the claims through the technical features of the invention define the protection which is sought for the applied invention and according to Art. 84 the claims should be clear and cannot contain program listings. Those may be accepted in short excerpts supported by the description. The claims related to a computer program, that have not a technical character, are objected under Art. 52(2)(c) and (3) and only if the invention fulfills the requirement of having technical character, then the examiner may continue with the requirements of novelty and inventive step.

The claims for computer implemented inventions can be formulated in the following categories:

- Method claims, e.g. a method of operating a data-processing system
- Apparatus or system claims, e.g. a system for data-processing
- Computer program [product]
- Storage medium or data carrier with computer program claims

Computer program and storage medium or data carrier with computer program claims are normally allowed when a corresponding method or apparatus claim is also allowable, provided that all the method steps are computer-executable.

When an inventor applies for a European patent regarding a computer implemented invention, he should include a description, as in inventions from other technical fields. The inventor should be aware that program listings in programming languages cannot represent the disclosure of the invention and the description should be written in normal language and a possible use of flow charts that facilitate the understanding of the technical character of the invention is permitted. All in all, according to Art. 83, the European patent application and the description, which is a part of it, is intended to be examined by a person skilled in the art, who follows the instructions of the applicant. This person does not specialize in a specific programming language but have general programming skills.

1.9 Artificial Intelligence Inventions and Inventorship

Applications of Artificial Intelligence (AI) including computer software related inventions are found globally on all areas of society and technology. Patents for both Artificial Intelligence and computer related inventions are in the foreground and connect business, academia, the judiciary, policy making and patent offices. In favor of innovation and society it is preferable to choose the patent option to protect AI inventions rather than trade secrets. Algorithms, source code, mathematical methods as such may be protected with copyright but not patents. However, a protection of both copyright and patent would best protect AI inventions and Computer-implemented inventions. In addition the 20 year lifetime of a patent is questionable due to the rapidly evolution of AI technology and computer science. Similarly, the 18-month period until a patent is disclosed to the public should be shortened because time for a technological invention is money, and time should be exploited in the best way for business, industry, society and the inventor.

AI technology in the last decade became more sophisticated and maybe complicated to be followed by the law. The connection between AI and patent system is “inventorship”. For instance, under the EPC, the right to a European patent belongs to the inventor , see Art. 60(1) EPC. According to Art. 60(1) EPC, Art. 62 EPC, “the inventor has both the substantive right to the invention and moral rights, the right to be acknowledged and mentioned”. The Art. 81 EPC and Rule 19(1) of the EPC states :"obligatory designation of inventor, including indication of the origin of the right to the invention, if the applicant is not the inventor".

According to [44], currently, under the EPC as well as, under the majority of legal systems worldwide, only natural persons are considered to be inventors and on the ground of this fact the writers discusses the possible answers of whether the patent regime should allow AI systems to be considered as inventors.

Firstly, the writer defines AI as: "a branch of computer science that studies the properties of intelligence by synthesising intelligence. What is being referred to as AI relies on performing mathematical methods or algorithms by way of a computer

implementation. These methods or algorithms are typically capable of learning from data and process data in a manner that demonstrates "intelligence". Although advances in AI depend on progress and growth in hardware resources, they are at least as equally dependent on advancement in the field of software. Subfields of artificial intelligence include searching and planning, reasoning and knowledge representation, robotics, natural language processing and machine learning."

Secondly the writer defines Machine learning (ML) by stating:"Rather than explicitly programming a computer to perform a particular task, an ML system uses a learning algorithm through which some internal state of the system is configured in response to input data. The internal state represents what the machine has "learned" from patterns in the input data, without there being any need for the algorithm to include any explicit coding based on what the input data "means", or for the programmer to explicitly define (or even to know) what patterns the machine should look for in the data."

The writer also defines "smart robots", which was referred to by the European Parliament as possessing, the following characteristics:

- “the capacity to acquire autonomy through sensors and/or by exchanging data with their environment (inter-connectivity) and the analysis of this data”
- “the capacity to learn through experience and interaction”
- “the form of the robot's physical support”
- “the capacity to adapt their behavior and actions to the environment.”

The assumptions of the writer regarding the issue of whether the patent regime should allow AI systems to be considered as inventors follow:

1. In case AI systems will be regarded as inventors under the Patent Law, this may require recognising computers as legal persons. The Commission applied by stating that this possibility cannot be warranted by either

technical or legal considerations and that, at present, most jurisdictions identify as an inventor in a patent application only natural persons.

2. It is clear that regarding European patent granting process, the inventor in inventions involving AI activity should be treated the same as in traditional inventions: a person who made an intelligent or creative contribution to the conception phase of an invention.

3. It is also clear that for AI inventions the inventor is "the person who geared up the AI system towards producing the inventive output, including features such as the choice of the algorithm employed, selection of parameters and design and choice of input data."

4. It has been also established that the current legal framework, including the EPC, is suitable for addressing the inventorship and ownership of AI inventions involving AI activity, when an invention is created with the involvement of an AI system," there are two ownership alternatives, excluding the AI system itself: (1) the owner of the AI system; (2) the user/designer of the AI system."

5. As far as what concerns inventorship all jurisdictions apply national laws, regardlesss the citizenship of the inventor, or the invention's origin. According to Art. 61 of the EPC for European patents, national courts are responsible for jurisdiction and in accordance inventorship is resolved by the national courts, too. According to the writer it is clear that there is no reason to reconsider this arrangement for AI inventions.

To continues with AI inventions, the question that is raised for protecting them with patents according to the EPO is that: “Do(es) the AI and ML method contribute to the technical character of the invention?”In reply to this question "it is recommended to include in the specification as much information about the technical effect as possible and that the inventor needs to identify the technical features and the corresponding technical effect frequently." There are also identified three possible types of AI patenting:

– “Core AI”, which often relates to algorithms as such, or mathematical methods and they are not patentable

– Trained models/machine learning, might be an issue for patenting

– AI as a tool in an applied field, defined via technical effects, which enables patenting

Under the EPC, if the claims of an AI invention are directed to a method involving technical means (e.g. a computer) or to a device, its subject matter has a technical character as a whole and for that reason will not be excluded from patentability.

According to the EPO, “Artificial Intelligence and machine learning are based on computational models and algorithms for classification, clustering, regression and dimensionality reduction, such as neural networks, genetic algorithms, support vector machines, k-means, kernel regression and discriminate analysis.” According to Art. 52(1),(2),(3) of the EPC, terms such as "support vector machine", "reasoning engine" or "neural network" most times refer to algorithms or have abstract mathematical nature and therefore they should be examined carefully for their technical character. According to the EPO, even "telecommunication network data records" without any indication of a technical use is not per se a technical purpose and this is not a patentable subject. Only if a technical purpose is served and there exists a contribution to the technical character of the invention by achieving a technical purpose, then patenting is enabled.

1.10 Report on European Patents for 2018

According to the Five Intellectual Property Offices, IP5[45], the number of patent applications filed with the European Patent Office grew by 4.6%, reaching 174,317 patent applications. In 2017 applications grew almost 4 percent. The internal reforms implemented as part of the Quality and Efficiency strategy that prioritized examination work and increased productivity, led to a further reduction of pending applications leading to an increase of the number of granted patents. In 2018, the EPO production increased further by almost 4 percent, in particular the number of final actions in examination increased by more than 18 percent.

According to the EPO's 2018 Annual Report,[46], the geographic origin of the European patent applications filed with the EPO is illustrated in the graph below. In 2014 the European Patent applications increased by 3.2%, in 2015 by 4.8%, in 2017 by 4.7% and in 2018 by 4.6%. The only year that patent application decreased was in 2016 by 0.6%. It is also observed that most European patent applications were filed from the Contracting States of EPO with 47% of the total and United States follow with 25% of the total (174.317) European patent applications.

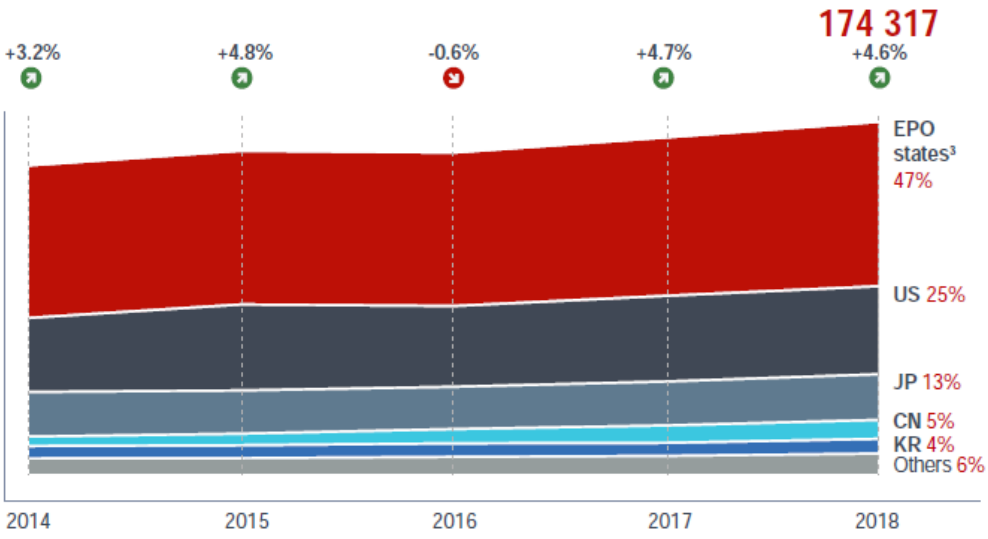
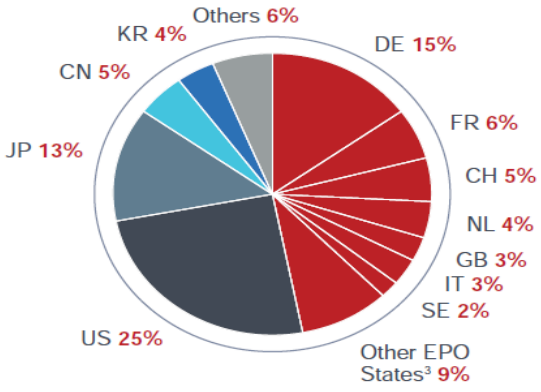


Fig1.1. Total European Patent Applications. Source: EPO. Status: 21.1.2019.

The Origin of the European patent applications is shown in the graph below. The origin is determined by the country of residence of the first applicant listed on the application form. From European Contracting States with the EPO, Germany filed 15% of the total European patent applications which means an increase in the number of patent applications from 2017 to 2018 and France follows with 6% which means a decrease in the number of patent applications from 2017 to 2018 and France is the only country in the graph that reduced that number.



Country	2018	2017	Change
US	43 612	42 463	2.7%
DE	26 734	25 539	4.7%
JP	22 615	21 774	3.9%
Other EPO states³	15 165	14 474	4.8%
FR	10 317	10 619	-2.8%
Others	9 925	8 766	13.2%
CN	9 401	8 641	8.8%
CH	7 927	7 354	7.8%
KR	7 296	6 457	13.0%
NL	7 140	7 043	1.4%
GB	5 736	5 321	7.8%
IT	4 399	4 360	0.9%
SE	4 050	3 783	7.1%

Fig.1.2 Origin of the European Patent application. Source: EPO. Status: 21.1.2019

The table that follows shows the number of European patent applications filed with the EPO for the ten technology fields in 2018, when these ten fields represented 53% of the total number of European applications filed. The technical field of Medical Technology counts 13.795 patent applications with the EPO, Digital Communication follows with 11.940 and with +0.7% increase this year and Computer Technology is the 3rd technical field with 11.718 European patent applications and a +3.3% increase for 2018.

Based on the European patent applications the top technical fields are:

N#	Technical Field	Number of European Patent applications	Rate
1	Medical Technology	13.795	+5.0%
2	Digital Communication	11.940	+0.7%
3	Computer Technology	11.718	+3.3%
4	Electrical machinery, apparatus, energy	10.722	+4.7%
5	Transport	9.039	+5.9%
6	Measurement	8.744	+9.3%
7	Pharmaceuticals	7.441	+13.9%
8	Biotechnology	6.742	+12.1%
9	Other special machines	6.379	+10.9%
10	Organic fine chemistry	6.233	-3.6%

Table 1.3: The top technical fields Source: EPO. Status: 21.1.2019

The top companies' applicants at the EPO with indication of origin are seen in the graph below indicating their country of origin.

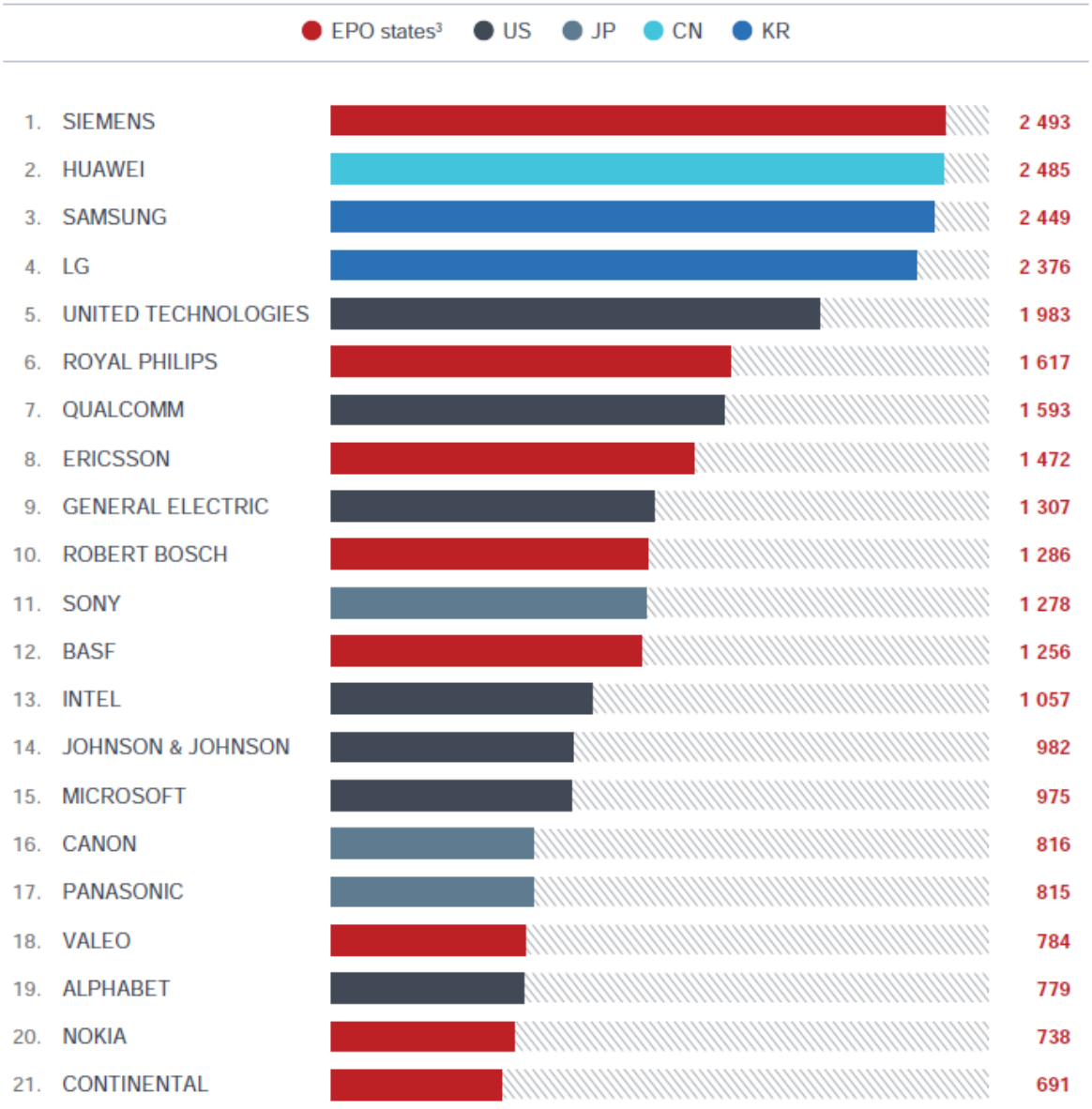


Fig.1.3 Top Companies applicants with the EPO Source: EPO. Status: 21.1.2019

The European Patent applications filed from European countries according to the "size" of companies show that 71% of them were filed by large companies, 20% by Small and Medium Enterprises and individual inventors, and 9% by universities and public research organisations. The results show that most applicants at the EPO are smaller entities in 2018.

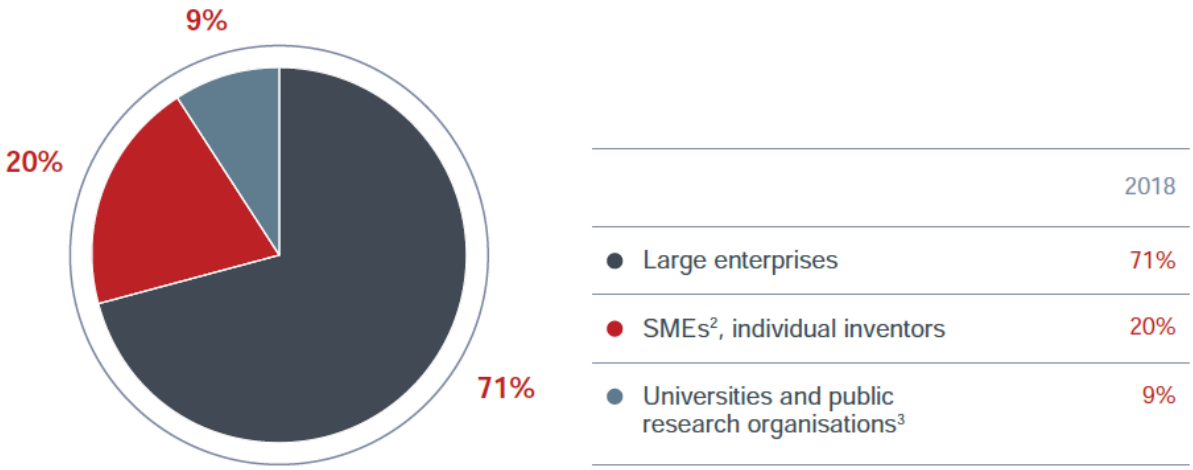


Fig.1.4 Size of Entities filed European patent applications.Source: EPO.Status: 21.1.2019

Eventually the granted European patents at the EPO over the past 5 years follow in the graph below. From the total number of 174.317 European Patent applications in 2018, 127.625 European patents were granted this year, which means that the vast majority of applications were granted with a patent and in fact it is observed that the procedures were shortened from the submission of an application to the issuance of a patent.

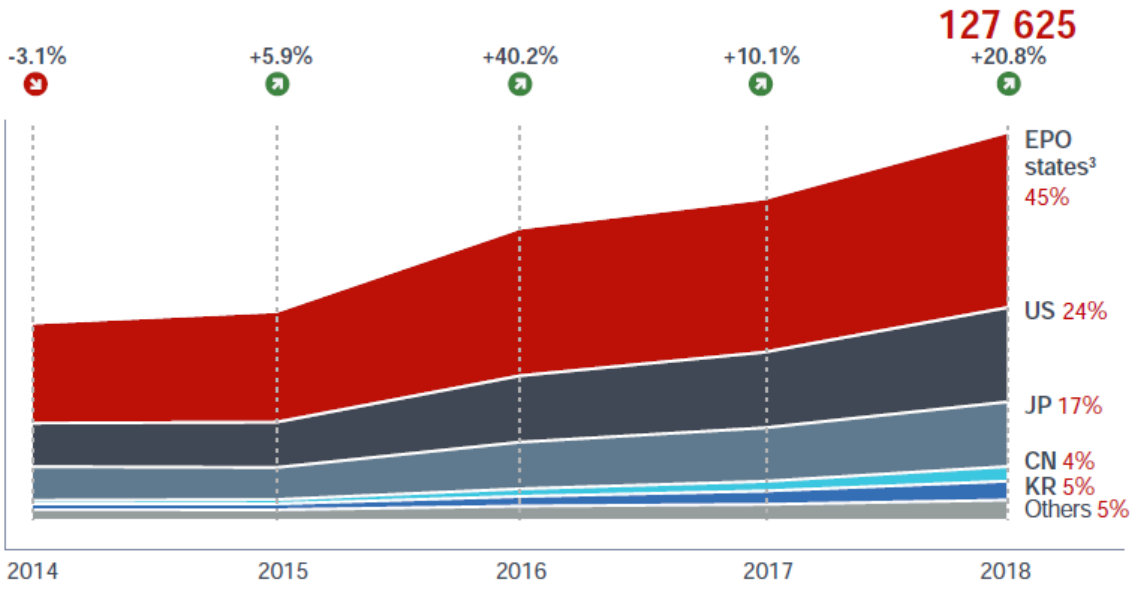


Fig.1.5 Granted European Patents Source: EPO. Status: 21.1.2019

1.11 Unitary Patent

Nowadays, an inventor can ensure protection for an invention in Europe through a national patent or a European patent. The European Commission makes effort in establishing a European patent with unitary effect (the ‘unitary patent’) and a new patent court. The Unitary patent is a legal title that will provide uniform protection across all participating countries, reducing costs and administrative burdens. The Unitary patents will base on European patents and will be granted by filing a request to the EPO under the rules of the European Patent Convention. This means that the procedure for granting a Unitary patent will be the same as in European patents especially regarding quality search and examination.

Besides the Unitary patent ,Regulation (EU) No 1257/2012,[47] , it is also planed the establishment of a Unified Patent Court,(UPC) [48] that will offer a specialized patent jurisdiction.

According to the European patent office the UPC [49]will:

- end the need for litigation in different countries
- enhance legal certainty through harmonised case law in the area of patent infringement and validity
- provide simpler, quicker and more efficient judicial procedures

According to the brochure titled 'An Enhanced European Patent System', [50], the judges of the UPC will be legally qualified judges and technically qualified judges. They must come from one of the Contracting Member States, have proven experience in the field of patent litigation and knowledge of at least one official language of the EPO. Legally qualified judges shall possess the qualification required for appointment to judicial offices in their respective Contracting Member State. Technically qualified judges shall have a university degree and proven expertise in a field of technology, as well as, proven knowledge of civil law and procedure relevant to patent litigation.

Through a Unitary patent it will be possible for inventors (individuals, companies or institutions) to protect their invention in all participating countries. After the patent is granted, there will be no need to validate it in each country, which is the most essential

benefit. Furthermore, the Unitary patent ensures to the inventors a simpler European system and less expensive, because there is no requirement for expensive translations ,Council Regulation (EU) No 1260/2012 [51], in participating countries. Further, the Unitary patent protects inventors from infringement in all participating countries and not only to countries that the inventor chose, due to great costs, through a European patent application. As a result the Unitary patent will strengthen research and development in Europe and encourage investment in innovation.

According to the Unitary Patent Guide[52], in order to register for a Unitary patent, a European patent must have been granted with the same set of claims in respect of all 26 participating Member States (Rule 5(2) UPR; Art. 3(1) in conjunction with Recital 7 Regulation (EU)No 1257/2012). To avoid the case of preventing the EPO from registering a Unitary patent (Rule 5(2) UPR), It is important:

- not to withdraw the designation of any of the 26 participating Member States

- not to contain in a European patent a different set of claims for any of the participating Member States (see Rule 138 EPC)

As to the procedure for obtaining a Unitary patent, a formal "request for unitary effect" must be filed with the EPO in writing, by the European patent proprietor (Rule 5(1) UPR) in one month after publication of the European patent in the European Patent Bulletin (see Rule 6(1) UPR; Art. 9(1)(g) Regulation (EU) No 1257/2012; Art. 97(3) EPC).

The request for unitary effect must include (Rule 6(2) UPR):

(a) details of the proprietor of the European patent Rule 41(2)(c) EPC;

(b)the number of the European patent to which unitary effect is required

The request for unitary effect must also contain a translation of the European patent under Art. 6(1) Regulation (EU) No 1260/2012, as follows:

- where the language of the proceedings is French or German, a full translation of the specification of the European patent into English

- where the language of the proceedings is English, a full translation of the specification of the European patent into any other official language of the European Union.

In 2012, European countries and the European Parliament agreed on the Unitary patent protection in the Europe,[53].

The package consists of:

- a regulation creating a European patent with unitary effect ('Unitary patent')

- a regulation establishing a language regime applicable to the unitary patent

- an agreement between European countries to set up a single and specialized patent jurisdiction (the 'Unified Patent Court')

All European countries will participate in Unitary patent, except for Spain and Croatia. In September 2015, Italy joined the Unitary patent and became the 26th member. In December 2012, the contracting countries, except for Poland, signed the Agreement on a Unified Patent Court. The process for the ratification of the agreement is ongoing. The unified jurisdiction will deal with cases relating to European patents and Unitary patents.

On 24 June 2015, after many negotiations on the Unitary patent, European countries agreed on the renewal fees of the Unitary patent. The renewal fees will be equal to the sum of national renewal fees in four countries:

- Germany,
- France,
- the United Kingdom and
- the Netherlands

This means that an inventor protecting an innovation with the Unitary patent will pay less than €5,000 in renewal fees, over 10 years, for 26 EU countries, instead of €30,000 for a European patent, which is prohibitive for companies to invest and patent in Europe and for the encouragement of innovation and economy in Europe. Further, to maintain a Unitary patent, Unitary patent's proprietors will pay a renewal fee only to the EPO whereas European patent's proprietors will have to pay annual renewal fees to different national patent offices, which operate under different legal requirements. The tables of renewal fees and the comparison between European patents and Unitary patents, follow in Section 1.12. Below follows fig.1.6 with the Renewal fees for maintaining the Unitary patent [52].

Renewal fees for the Unitary Patent

	EUR		EUR
2nd year	35	11th year	1 460
3rd year	105	12th year	1 775
4th year	145	13th year	2 105
5th year	315	14th year	2 455
6th year	475	15th year	2 830
7th year	630	16th year	3 240
8th year	815	17th year	3 640
9th year	990	18th year	4 055
10th year	1 175	19th year	4 455
		20th year	4 855

Fig.1.6 Renewal fees for the Unitary Patent[52]

Eventually, since June 2015, the Commission is working on enacting measures to assist small and medium-sized enterprises (SMEs), as for Unitary patents and other European IP Rights.

The Commission stated that "We will be working in the coming months on affordable European litigation fee insurance a specialised mediation and arbitration service focusing on the needs of innovative SMEs the use of structural funds for rewarding innovative SMEs using IP, and in particular patents connecting SMEs with local IP experts in order to provide them with real and concrete guidance for their IP portfolio developing preventive IP infringing schemes targeted at SMEs (memoranda of understanding between suppliers, intermediaries and rights-holders to prevent or to disincentivise IP infringement behaviours).The Commission will work together with the European Patent Office (EPO) and the Office for Harmonization in the Internal Market (OHIM), European countries and the European Parliament to design those measures and implement them across the European Union."

The new system of patents the Unitary patent System with the Unified Patent Court which will have jurisdiction over Unitary patents and "classic" European patents, is expected for the end of 2020. Then, a Unitary patent may be requested for any European patent granted on or after the date of entry into force of the UPC Agreement. The three routes to ensure patent protection in Europe, in the future, follow in Fig.1.7.

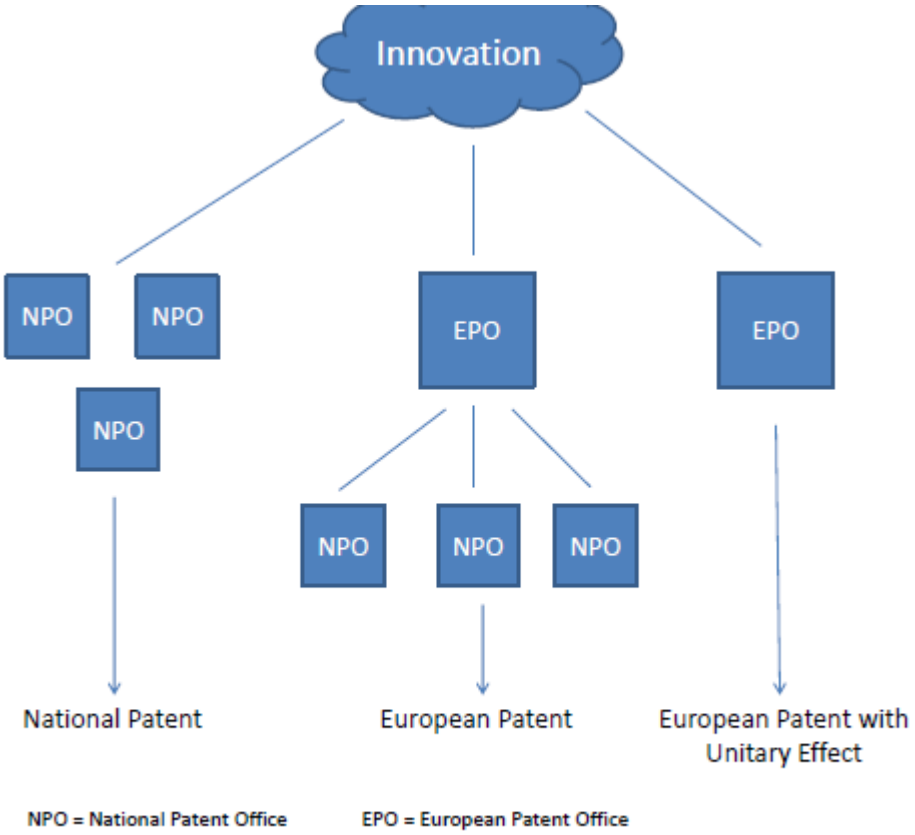


Fig.1.7 Three routes to patent protection in Europe in the future, [50]

1.12 Comparison between European Patent and Unitary Patent.

First of all the Unitary patent and the Unified Patent Court is another route for patenting an invention in Europe. This system does not intend to replace the already existing ones:

- The European patent
- The national patents

The Unitary patents will base on European patents and will be granted by the EPO, as well. Both the Unitary patent and the European patent are granted under the rules of the European Patent Convention. The invention's quality, searching procedure relating to prior art and the examination is of primordial importance in both routes. The Unitary patent provides uniform patent protection in up to 26 EU Member States, whereas in the European Patent the inventor, when filing an application, should choose the Member States he requires protection for his invention.

An inventor, before patenting his invention in Europe, should consider whether he needs for his invention broad geographical coverage or if protection in a few Member States is enough. This is because after a European patent is granted, the patent proprietor will be able to request unitary effect, thereby getting a Unitary patent which provides uniform patent protection in up to 26 Europe Member States. If the inventor needs this geographically protection for his invention, then he should register for a Unitary patent. Otherwise, it is more advantageous to pay for few Member States the costs of renewal fees in each Member State, where protection is sought, or even he could apply only for a national patent.

In addition, since the exclusive jurisdiction is in force for Unitary patents and initially optional for the classical European Patent, the inventor needs to consider whether the patent should be subjected to the exclusive jurisdiction of the Unitary Patent Court or if it

is better to apply for a European patent which is subjected to the national courts of each Member State, that protection for the invention is required. National patents will remain in the jurisdiction of national courts. Further, the patent holder of a classical European patent is able to choose for his patent to be excluded from the jurisdiction of the UPC. However, he should weigh the pros and cons of this decision as mentioned before. The main benefits of the UPC is that it consists of a unified jurisprudence resulting in simpler and easier procedures and the avoidance of parallel litigation, judgments (injunctions, damages) with effect in 25 Member States of the Europe. In comparison, the parallel procedures in the national courts of the individual Member States makes procedures complicated and time consuming.

The costs for a classical European patent includes:

- costs for validation
- costs of renewal fees in each Member State where protection is required

The costs for the Unitary patent will not include validation costs.

They will include:

- cost for one translation during the transitional period
- a single renewal fee to the EPO

The annual fees for maintaining a Unitary Patent and for maintaining a European Patent follows below in the Table 1.4 and Table 1.5.

Year	Unitary Patent (EUR)	26 member
2	35	494
3	105	1 371
4	145	1 746
5	315	2 443
6	475	3 110
7	630	3 801
8	815	4 632
9	990	5 617
10	1 175	6 609
11	1 460	7 789
12	1 775	9 005
13	2 105	10 309
14	2 455	11 586
15	2 830	12 877
16	3 240	14 462
17	3 640	15 972

17	3 640	15 972
18	4 055	17 490
19	4 455	19 302
20	4 855	21 043
Total	**35 555**	**169 667**

[1] Based on national renewal fees as at 1 January 2017.

Table 1.4: The annual fees for Unitary patent in the 26 Member States [54]

Below follows the overall costs of a Unitary Patent and those of a classic European patent considering, not only the fees, but also the costs associated with the validation and maintenance of a classic European patent. These costs include translation costs incurred for validations and the publication fees payable to the various national patent offices, as well as the payment of national renewal fees.

	Unitary Patent (UP)	Classic European patent (EP) validated and maintained in DE, FR, GB and IT
Total official fees for years 5-10	4 400	3 745
Total external costs* for years 5-10	3 000	3 855
Total cost up **to year 10**	**7 400**	7 600
	difference UP vs EP: **EUR -200 = -3%**	
Total official fees for years 5-12	7 635	6 585
Total external costs* years 5-12	3 625	5 265
Total cost **up to year 12**	**11 260**	11 850
	difference UP vs EP: **EUR -590 = -5%**	
Total official fees for years 5-15	15 025	13 345
Total external costs* for years 5-15	5 105	8 645
Total cost **up to year 15**	**20 130**	21 990
	difference UP vs EP: **EUR -1 860 = -8%**	

Total official fees for years 5-20	35 270	30 750
Total external costs* years 5-20	9 150	17 350
Total costs **up to year 20**	**44 420**	48 100
	difference UP vs EP: **EUR -3 680 = -8%**	

* Attorney costs: translation (24 pages), validation and maintenance of a European patent granted during the 4th year after filing of the application.

Table 1.5:The annual fees for Unitary patent and for European patent [54]

1.13 Patent Cooperation Treaty (PCT)

The Patent Cooperation Treaty (PCT) is an international treaty with more than 150 Contracting States [55]. The PCT ensures to an inventor patent protection for his invention simultaneously in many countries worldwide by filing one "international" patent application, instead of filing a large number of national patent applications for every country that protection for the invention is sought, which leads to a large number of costs for all these applications and fees to maintain all these patents after grant. The granting of patents is under the jurisdiction of the national patent Offices (national phase).

The PCT was done at Washington on June 19, 1970, amended on September 28, 1979, modified on February 3, 1984, and on October 3, 2001. According to the PCT the Contracting States, signed this Treaty, [56].

"Desiring to make a contribution to the progress of science and technology, Desiring to perfect the legal protection of inventions, Desiring to simplify and render more economical the obtaining of protection for inventions where protection is sought in several countries, Desiring to facilitate and accelerate access by the public to the technical information contained in documents describing new inventions, Desiring to foster and accelerate the economic development of developing countries through the adoption of measures designed to increase the efficiency of their legal systems, whether national or regional, instituted for the protection of inventions by providing easily accessible information on the availability of technological solutions applicable to their special needs and by facilitating access to the ever expanding volume of modern technology, Convinced that cooperation among nations will greatly facilitate the attainment of these aims."

Most inventors who would wish to apply for an international patent and protect their invention in more than one country, usually first file a national patent application with their national patent Office, and within 12 months from the filing date of that first application, a time period that is defined by the Paris Convention, they file their international application under the PCT and they claim priority of the earlier, national as mentioned before, patent application. The effect of claiming the priority, see Art 8 of the

PCT, of an earlier patent application is that the protection for the invention starts with the very first application of the inventor, regardless it is national or regional and the commercial exploitation of the invention, the publication, or the sale of the invention is valid and protected from infringement or from a competitor's application which was filled after the national filing of the inventor's application and before the international filing of the inventor.

The Art 2 of the PCT defines among others, the priority date. The priority date for an international application may be defined:

a)through one or several priority claims it contain under Art 8, as the filing date of the earliest application whose priority is so claimed or,

b) if the international application does not contain any priority claim under Art 8, as the international filing date of this application.

According to the Art 3 of the PCT, the International Application shall include a request, a description, one or more claims, one or more drawings (where required), and an abstract. The abstract merely serves the purpose of technical information and does not define the protection sought for the invention.

The international application shall:

(i) be in a prescribed language;

(ii) comply with the prescribed physical requirements;

(iii) comply with the prescribed requirement of unity of invention;

(iv) be subject to the payment of the prescribed fees.

The description, see Art 5 of the PCT, shall disclose the invention in detail and lead a person skilled in the art to follow the steps of the described invention and reach the desired result.

The claim or claims, see Art 6 of the PCT, shall define the protection is sought for the invention. Claims shall be clear and supported by the description.

The Drawings, see Art 7 of the PCT, subject to the provisions of paragraph (2)(ii), drawings shall be required when they are necessary for the understanding of the invention.

The PCT **procedure** includes the following stages:

- Filing of an international application with a national patent Office or WIPO, complying in one language with one set of fees.

- Then an "International Searching Authority" (ISA) which is one of the world's major patent Offices does the International Search for an invention in order to define the technical field and the prior art of the invention by finding the published patent documents that are related to this invention. The ISA writes an opinion regarding the invention's potential patentability.

- After the expiration of 18 months from the earliest filing date follows the International Publication according to which the invention is internationally disclosed.

- The stages of Supplementary International Search and the International Preliminary Examination are optional and are executed under the inventor's request. Supplementary International Search: A second ISA may identify further the prior art of the invention which was not have been found by the first ISA due to the great complexity and variety that exists in different languages and technical fields. International Preliminary Examination: one of the ISAs executes an additional patentability analysis, most times after the inventor amends his application.

- Finally at 30 months from the earliest filing date of the initial application with which priority is claimed, follows the National Phase. In this stage the inventor grants the patents from the national patent Offices in which protection is sought for his invention.

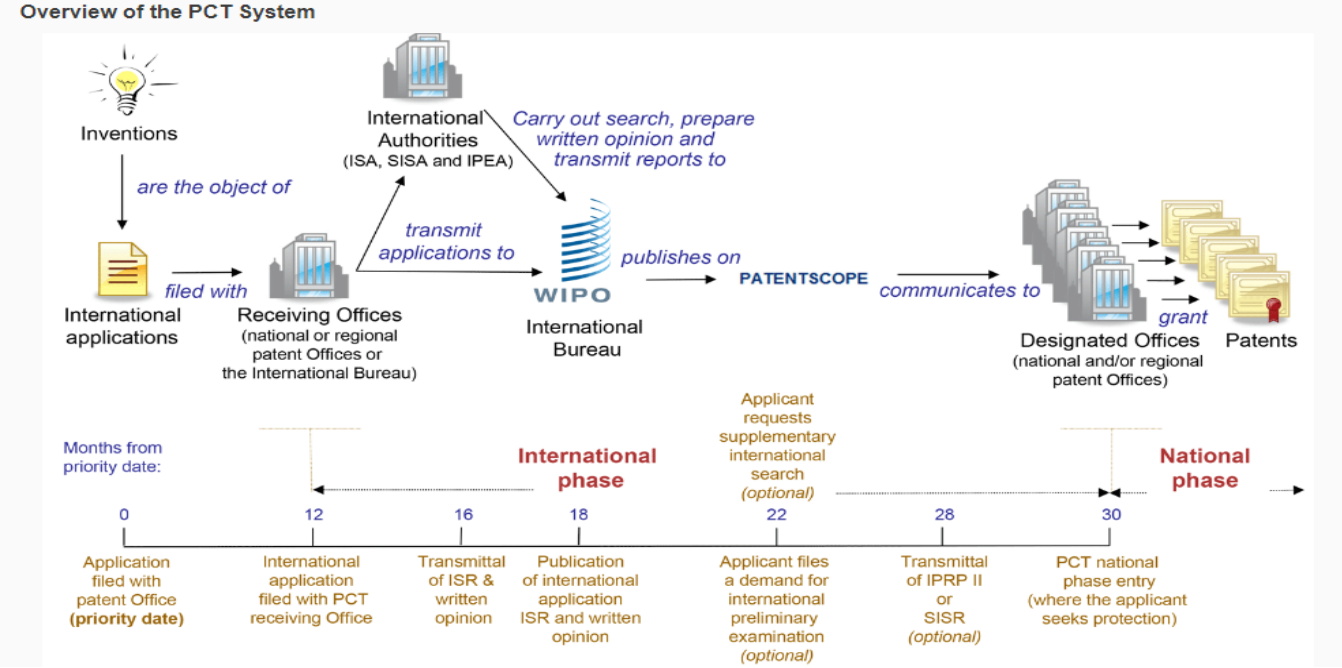


Fig.1.8 The PCT System[57]

For granting an international Patent under the PCT, the inventor should pay fees when applying, fees for granting the patent and fees to maintain it.

- When applying for an international patent the inventor should pay for 3 types of fees, according to the World's International Patent Office:

(a) an international filing fee of 1,330 Swiss francs,

(b) a search fee which can vary from approximately 150 to 2,000 Swiss francs depending on the ISA chosen, and

(c) a small transmittal fee which varies depending on the receiving Office.

✓ The PCT exempts the inventor from costs of preparing and filing separate applications at national Offices due to the PCT that is in force in all Contracting States.

- The most essential fees the inventor needs to pay are those in the national phase. They include, according to the WIPO:

a) fees for translations of the application,

b) national Office filing fees and

c) fees for the services of local patent agents or attorneys.

- ✓ In some Offices, national filing fees are lower for international patent applications than they are for a common national application, " in recognition of the work already done during the international phase."

- Lastly in order to keep an international patent in force, the inventor should pay for maintenance fees in each country that the patent was granted.

- ✓ PCT fee reductions are available to all applicants who file electronically.

- ✓ Some national Offices provide fee reductions for natural persons, universities, not-for-profit research institutes and small and medium-sized enterprises, as for the fees needed to be paid in the national phase with a view to encourage inventors to apply for international applications under the PCT.

Further information about PCT fees regarding the European Patent Office acting on behalf of the WIPO, see Appendix.

From the time the inventor files an international patent application there is an additional period of 18 months before entering the national phase. The inventor can use this additional period of time to exploit commercially his invention in the countries in which he intends to grant a patent. Otherwise, the inventor is not obliged to wait for the expiration of the 30 months from the earliest filing date of the patent application before entering the national phase, because he can request for an early entry into the national phase.

Then, after entering the national phase, the time required for the examination and grant of a patent varies across patent Offices, due to the different national Patent Laws that follows each Country's patent Office.

The publication language of a granted international patent may be: Arabic, Chinese, English, French, German, Japanese, Korean, Portuguese, Russian and Spanish.

Receiving Offices accept international applications for patents in at least one language which is both a language accepted by the ISA that executes the international search and a publication language. An inventor has the option of filing an international patent application in at least one language from which no translation is required. In case he files an international application in a language which is not accepted by the ISA, he will be required to submit a translation of the application for the purposes of international search.

The PCT is used by the world's major corporations, research institutions and universities for ensuring multinational patent protection. The advantages that the PCT route offers to an inventor other than protection in 153 countries worldwide under one patent application, according to the WIPO[58], are:

1) the inventor avoids the major costs of seeking multinational patent protection under complicated procedures to all patent Offices of the countries he needs to secure protection for his invention

2)if the invention is not patentable at the end of the international phase, the PCT procedure may stop and save the costs to the inventor, that in case of a directly seeking protection with separate applications in foreign countries, he should pay, by preparing necessary translations and paying the national fees.

3) the inventor saves money and time through the PCT in document preparation, communication and translations because he does not have to repeat this procedure before each Patent Office. This work is done once during the international processing.

4) in national phase, the inventor may shorten the examination procedures in Contracting States under the PCT and the search and examination work of patent Offices can be reduced due to the international search report

5) The patentability of the claimed invention is internationally respected, accepted and online available.

6) The inventor may show his interest in licensing agreements on PATENTSCOPE, which is also a mean for advertising and potential licensees

1.14 PCT Patent applications in 2018

The total number of international patent applications that were filled under the PCT for the year 2018 is 253.000 with an increase of 3.9% for this year. The top 10 PCT applicants are technology companies and the top 3 technical fields regard inventions of smart technology and energy efficiency that also this thesis concerns.

1. Digital Communication

2. Computer technology

3. Electrical machinery, apparatus, Energy.

The top 10 countries, according to the WIPO, that represent these international applications under the PCT for the year 2018 follow below with a decrease for USA which is in position number 1 and an increase for all other 9 countries. USA filed 56.142 international applications, China 53.345 and Japan 49.702.

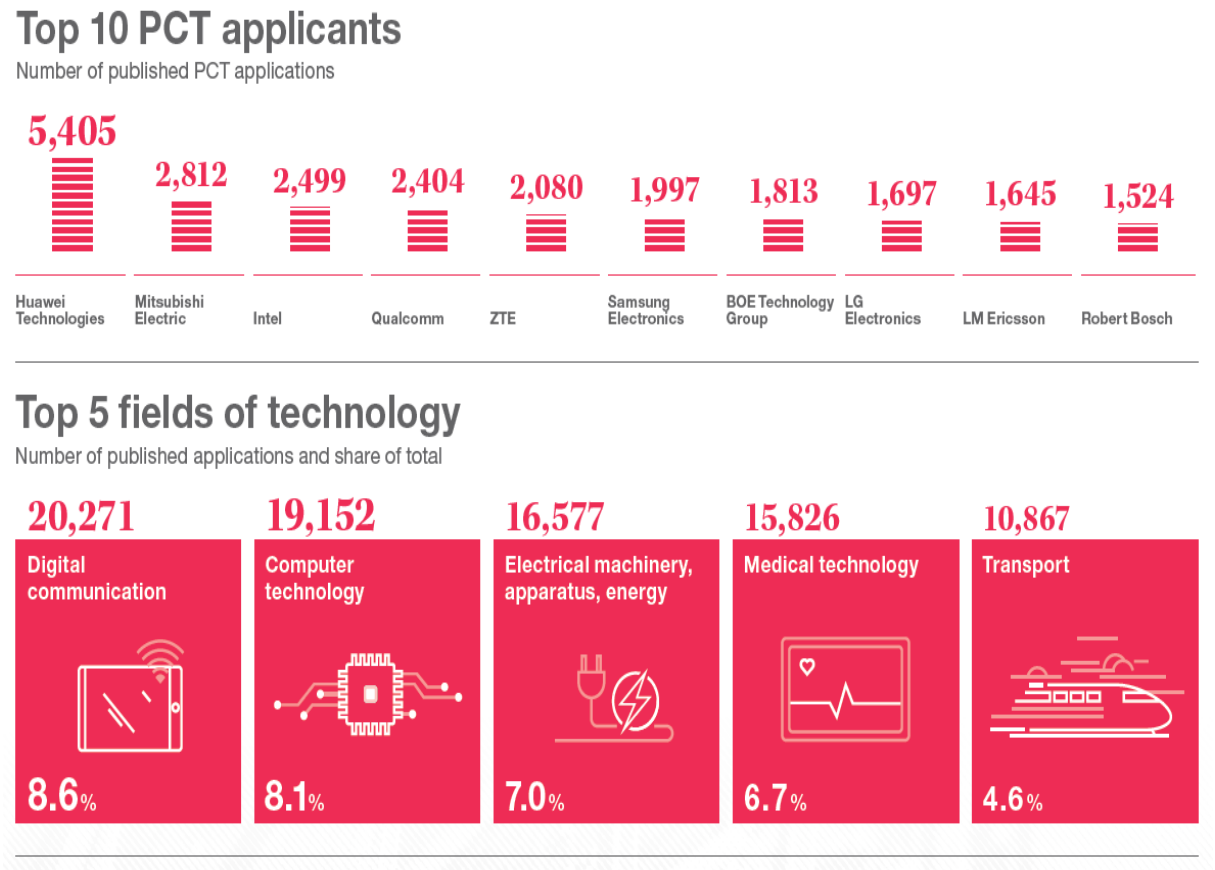


Fig.1.9 PCT patent applications in 2018[59]

1.15 REFERENCES

[1] C. K. Metallidou, K. Psannis E., and E. Alexandropoulou-Egyptiadou, "Survey on the Patent Law awareness and the Entrepreneurial trend of Greece's graduates of Technology Institutes," *IEEE Access*, doi: 10.1109/ACCESS.2020.2994099.

[2] C. K. Metallidou, K. Psannis E., and E. Alexandropoulou-Egyptiadou, "Energy Efficiency in Smart Buildings: IoT Approaches," *IEEE Access*, vol. 8, pp. 63679–63699, Mar. 2020, doi: https://doi.org/10.1109/ACCESS.2020.2984461.

[3] H. Rockman, *Intellectual Property Law for Engineers and Scientists*. New Jersey: J. Wiley and sons, 2004.

[4] D. Kappos, "An Examination of Software Patents." Nov. 20, 2012, [Online]. Available: https://www.uspto.gov/about-us/news-updates/examination-software-patents.

[5] S. Hu and T. Jiang, "Artificial Intelligence Technology Challenges Patent Laws," *2019 Int. Conf. Intell. Transp. Big Data Smart City*, pp. 241–244, 2019, doi: 10.1109/ICITBS.2019.00064.

[6] "algorithm." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/algorithm).

[7] "computer program." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/computer-program).

[8] "computer programming." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/computer-programming.

[9] "software." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/software.

[10] "source code." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/source-code.

[11] "hardware." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/hardware).

[12] "patent." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/patent.

[13] Π. Δ. Μποζάνης, *ΔΟΜΕΣ ΔΕΔΟΜΕΝΩΝ*. ΘΕΣΣΑΛΟΝΙΚΗ: Τζιόλας, 2006.

[14] "The World Intellectual Property Organization (WIPO)." [Online]. Available: https://www.wipo.int/portal/en/index.html.

[15] Μ.-Θ. Δ. ΜΑΡΙΝΟΣ, *ΛΟΓΙΣΜΙΚΟ(SOFTWARE) ΝΟΜΙΚΗ ΠΡΟΣΤΑΣΙΑ ΚΑΙ ΣΥΜΒΑΣΕΙΣ*. Αθήνα: Κριτική, 1989.

[16] D. Bainbridge, *Introduction to Computer Law*, 5th ed. UK: Pearson Education Ltd, 2004.

[17] "smart." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/smart.

[18] "renewable energy." [Online]. Available: https://dictionary.cambridge.org/dictionary/english/renewable-energy.

[19] "energy efficient." [Online]. Available: (https://dictionary.cambridge.org/dictionary/english/energy-efficient).

[20] "Environmental and Energy Study Institute, building efficiency." [Online]. Available: https://www.eesi.org/topics/energy-efficiency/description.

[21] “Eurostat Statistics Explained site, Renewable energy sources.” [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Renewable_energy_sources.
[22] “the European Commission, a smart city.” [Online]. Available: https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en.
[23] “smart building.” [Online]. Available: https://ec.europa.eu/growth/tools-databases/dem/monitor/tags/smart-building.
[24] “the European Commission, Building Energy Management Systems (BEMS).” [Online]. Available: https://setis.ec.europa.eu/publications/setis-magazine/energy-efficiency-buildings/smart-buildings-and-role-of-digitalisation.
[25] S. Khairy and A. G. Hossam, “Building Energy Management Systems (BEMS),” 2018, doi: 10.1002/9781119422099.
[26] “The World Trade Organization.” [Online]. Available: https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm.
[27] Μ.-Θ. Δ. ΜΑΡΙΝΟΣ, *ΛΟΓΙΣΜΙΚΟ(SOFTWARE) ΝΟΜΙΚΗ ΠΡΟΣΤΑΣΙΑ ΚΑΙ ΣΥΜΒΑΣΕΙΣ ΙΙ*. ΑΘΗΝΑ: ΚΡΙΤΙΚΗ, 1992.
[28] Ε. Αλεξανδροπούλου-Αιγυπτιάδου, *Πνευματική ιδιοκτησία και πληροφορική*. Αθήνα: Εκδόσεις Θέμις, 2012.
[29] E. Alexandropoulou-Egyptiadou, *The Hellenic framework for computer program copyright protection following the implementation of the relative European Union Directives, in Investigating Cyber Law and Cyber Ethics*. USA, Pennsylvania: IGI GLOBAL, 2012.
[30] “2121/1993.” [Online]. Available: https://www.opi.gr/vivliothiki/2121-1993.
[31] “Uruguay Round Agreement: TRIPS Trade-Related Aspects of Intellectual Property Rights.” Apr. 15, 1994, [Online]. Available: http://www.wipo.int/treaties/en/text.jsp?file_id=305907.
[32] “2290/1995.” [Online]. Available: http://legislation.di.uoa.gr/eli/law/1995/2290?language=en.
[33] “The Paris Convention.” 1883, [Online]. Available: https://www.wipo.int/treaties/en/ip/paris/.
[34] “Berne Convention for the Protection of Literary and Artistic Works.” Jul. 24, 1971, [Online]. Available: http://www.wipo.int/wipolex/en/treaties/text.jsp?file_id=283693.
[35] “Proposal for a Council Regulation on the Community patent COM/2000/0412.” Jan. 08, 2000, [Online]. Available: http://www.epo.org/service-support/faq/procedure-law/faq.html.
[36] “The European Patent Convention.” 1973, [Online]. Available: http://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ma1.html.
[37] “European Patent Office.” [Online]. Available: https://www.epo.org/index.html.
[38] “European Patent Office , Guidelines for Examination.” [Online]. Available: https://www.epo.org/law-practice/legal-texts/html/guidelines/e/f_iia1.htm.
[39] “Fees schedule.” [Online]. Available: https://my.epoline.org/epoline-portal/classic/epoline.Scheduleoffees.
[40] “Hellenic Industrial Property Organisation.” [Online]. Available: http://www.obi.gr/el/.

[41] Ν. Ρόκας, *Βιομηχανική Ιδιοκτησία*, Αντ. Ν. Σάκκουλα. Αθήνα-Κομοτηνή, 2004.
[42] "The most important provisions and requirements of Greece's national law, under the EPC." [Online]. Available: https://www.epo.org/law-practice/legal-texts/national-law.html.
[43] "1733/87." [Online]. Available: https://www.obi.gr/obi/?tabid=184.
[44] "A study on inventorship in inventions involving AI activity." the European Patent Office, Feb. 2019, [Online]. Available: https://www.epo.org/service-support/updates/2019/20190614.html.
[45] "IP5 Statistics Report,2018 Edition." Oct. 2019, [Online]. Available: www.fiveipoffices.org.
[46] "The EPO's 2018 annual report." [Online]. Available: https://www.epo.org/about-us/annual-reports-statistics/annual-report/2018.html.
[47] "Regulation (EU) No 1257/2012 of the European Parliament and of the Council of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection, OJ L 361, 31.12.2012." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R1257.
[48] "Agreement on a Unified Patent Court OJ C 175,2013/C 175/01." Official Journal of the European Union, Jun. 20, 2013, [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588861962627&uri=CELEX:42013A0620(01).
[49] "Unified Patent Court, UPC." the EPO, [Online]. Available: https://www.epo.org/law-practice/unitary/upc.html.
[50] Select Committee, "An Enhanced European Patent System." [Online]. Available: www.unified-patent-court.org.
[51] "Council Regulation (EU) No 1260/2012 of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection with regard to the applicable translation arrangements, OJ L 361." Official Journal of the European Union, Dec. 31, 2012, [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R1260.
[52] "the Unitary Patent Guide, "Obtaining, maintaining and managing Unitary Patents." European Patent Office, 2017, [Online]. Available: https://www.epo.org/law-practice/unitary/unitary-patent/unitary-patent-guide.html.
[53] "The Unitary Patent." The European Commission, [Online]. Available: https://ec.europa.eu/growth/industry/policy/intellectual-property/patents/unitary-patent_en.
[54] "The annual fees for European patent and for Unitary patent." [Online]. Available: https://www.epo.org/law-practice/unitary/unitary-patent/cost.html.
[55] "Contracting States of the PCT." [Online]. Available: https://www.wipo.int/pct/en/pct_contracting_states.html.
[56] "Patent Cooperation Treaty." [Online]. Available: https://www.wipo.int/pct/en/texts/index.html.
[57] "The PCT system." [Online]. Available: https://www.wipo.int/pct/en/faqs/faqs.html.
[58] "wipo." https://www.wipo.int/pct/en/faqs/faqs.html.
[59] "PCT patent applications in 2018." [Online]. Available: https://www.wipo.int/edocs/infogdocs/en/ipfactsandfigures2019/.

Chapter 2:

Survey on the Patent Law awareness and the Entrepreneurial trend of Greece's graduates of Technology Institutes. Published in *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.2994099 [1]

ABSTRACT

In information technology industry, the development of new technology achievements influences and inspires the business world, serves and contributes to the progress of society. This rapidly evolving technological advancement needs a legal framework in order to obtain social and commercial status. Patent Law is the legal science and patent is the legal tool that adds value to intangible assets and therefore technology scientists are motivated to ensure their invention with a patent and also dominant technology enterprises are competing for the development of a strong patent portfolio. For the first time in Greece, combining the fields of intellectual property law and technological innovation, a survey was created, using a questionnaire that was distributed in 2019, to graduated students of technology institutes in Greece. The purpose of the present survey is to clarify the knowhow of students as for the legal point of view of technology. The intention is to find out, whether Greece's potential inventors have beyond their technological background, the skills and knowledge to support a potential innovative idea. The results of the survey were that students have confidence in the institution of patents; however they lack the knowledge of patenting technological inventions. At the same time they have a positive attitude and motivation for entrepreneurship in the technological industry. Consequently, it is vital to apply measures in education, for the

next generation technical inventors to have the knowhow of utilizing their intellectual asset in their own free will. Then, we can refer to integrated scientist technocrats who can protect their intellectual property and manage a competitive business.

Keywords:

Artificial intelligent inventions, Computer related inventions, Entrepreneurial trend, Management of Technology, Patent Law awareness, Smart technology, Survey on Technology Institutes.

2.1 Introduction

In information technology industry, the development of new technology achievements influences and inspires the business world, serves and contributes to the progress of society. This rapidly evolving technological advancement needs a legal framework in order to obtain social and commercial status. Although for legislation it is difficult to keep up with technology, many efforts are observed in the direction of reforming Intellectual Property Law (IPL) to the nowadays requirements of technology world. Patent Law which is a part of IPL adds value to intangible assets and therefore technology scientists are motivated to ensure their invention with a patent, perhaps to establish a start-up company and also dominant technology enterprises are competing for keeping their technological superiority through the development of a strong patent portfolio.

At this point, it is of importance to specify the nowadays technological world, which is represented by Industry 4.0 and includes smart technology achievements such as Cloud Computing, Big data, the Internet of Things (IoT), Artificial Intelligence (AI) and computer related inventions in general. Initially, brief definitions, are provided,of the above terms mentioned; Industry 4.0 stems from the internet, enables communication between humans and machines in cyber physical systems and aims to acquire and process data and to self-control certain tasks [60], AI is the ability of machines to execute functions that are associated with human intelligence [61], IoT is a technology in the sector of telecommunications [62]. It describes the networking and communication between physical and virtual objects [63]. Big data developed on the ground of the continuous and increasing use of smart devices which connect, collect, exchange and transfer large amounts of data[64], Cloud Computing technology provides storage spaces and mechanisms for data analysis[64], Patent Law is the Regulatory basis and patent is the legal tool that provides protection from infringement to an inventor's intellectual property. Patents motivate scientists to invent by offering them a limited-time monopoly on the technological achievement they invented [65]. Discussions on technical issues like Big data and intellectual property indicate that ethics and computing is a challenge of this era [66].

Further, follows a reference to the European Patent Convention [67]. As far as what concerns computer-implemented inventions, the patentability requirements that they should fulfill according toArt.52(1) are:

-there must be an "invention", belonging to any field of technology

-the invention must be "susceptible of industrial application"

-the invention must be "new" and

-the invention must involve an "inventive step"

It is also important to notice that “claims” for computer-implemented inventions should define all the features which are essential for the technical effect of the process which the computer program is intended to carry out when it runs. According to Art. 84, the claims cannot include program listings. Program listings are accepted only in the description. Moreover, the effective date of the European application is the date of its filing, Art. 54(2),(3) and a European patent lasts for 20 years from the date of filing the application, Art.63. In addition, in order for a patent to stay in force renewal fees must be paid, otherwise the patent will lapse. Eventually, in case of an infringement, according to Art. 64(3), any infringement of a European patent shall be dealt with by national law in each Contracting State in respect of which the patent is granted.

Afterwards, in terms of Patent Law and technology, patents are the primary way to protect and promote innovation in technology applications. The main challenge is to be able to distinguish among technological achievements those that meet the requirements of granting a patent and to have the knowhow to manage an invention for the benefit of the inventor, the economy and society.

This is where the issue arises. Often engineers and scientists of technology have the knowhow to develop an innovative idea, but lack the knowledge to support their invention and protect it from being stolen and used immorally. However, the problem lies deeper, in their academic education at the university; Most of the curriculum in Technical Institutes do not include courses in IPL, nor do they deal with the management and commercialization of a potential invention, even if industry is increasingly pointing out the education of IPL at technical universities.

Regarding all mentioned above, this research is an effort to draw conclusion as for the effect of Patent Law into nowadays technology graduated students of Greece through a survey which is implemented with a questionnaire.

The purpose of the present survey is to clarify the knowledge that the students have acquired the moment of completing the university curriculum of a technology department, as for the management and the legal status of technology. The intention is to find out, through this survey, whether Greece's potential inventors have beyond their technological background, the skills and knowledge;

-to protect their potential invention,

-to ensure the paternity of their intellectual property,

-to benefit from their invention's exclusive commercial exploitation,

-to survive in the global technology innovation industry, in which possibly they may excel,

-to promote the country's economy by establishing a technology company, and

- to contribute to the wider society with their technological achievements.

Further the objective of this survey is to indicate that a curriculum of a Technical Institute should include IPL and all legal and managerial issues that concern a technology inventor. It is important to develop responsible inventors and scientists in industry of technology, technical universities and society generally. The technology industry has already indicated the need for technology professionals who work and take decisions led by their legal engineering skills.

This course should be included in the education of technology students in order to prepare the potential technology professionals from every perspective and for every application or transaction of technology.

To the best of the author’s knowledge, this is the first time that a survey which refers to graduate students of Technical Institutes in Greece and examines their knowhow on Entrepreneurship and on Patent Law in the direction of supporting a potential technological invention, is conducted.

The rest of the research is organized as follows; In Section 2, there is a review of the related research on legal and entrepreneurial aspects that concern technology world.

In Section 3, there is the explanation of the methodology that is been followed for this survey and the analysis of all queries that are involved. In Section 4, there is the analysis and discussion of the results of the survey through tables and figures, in Section 5, the conclusion of the current research is provided and also proposals regarding the results of the survey, lastly Section 6 is stated the future objective.

2.2 Related Work

For the purpose of this survey, previous literature was studied and analyzed, which has been published in the field of IPR, Patent Law, smart technology and industrial world. The following paragraphs present the papers which contributed in this study, some of them are surveys on the field of technical patents and entrepreneurship and some of them are utilizing elements from technical patents to conclude their value in business world.

In [68], a survey on engineering students' as for IP education is conducted in 5 China's universities, concluding the need for strengthening IP awareness in the Electronics Engineering Curriculum. A design of a course is also proposed by using a case study in integrated circuits.

In[69], two undergraduate technology management programs carried out a survey that concerns international technology management professionals. The majority of the professionals were employed in education, computers, information technology, manufacturing, and research and development. The result of the survey focuses on what elements, the technology professionals, regard as essential for managing future's technological entrepreneurship.

A survey on the harmonization of intellectual property systems in software industry from the point of view of Japanese inventors is presented in [70]. It is a questionnaire survey to inventors referring to the promotion of an invention in subjects of “Grace Period”, “Inventive Step”, “Strength of Patent Protection”, “Unitary Patent System”, “Globally Harmonized Patent System”. The results show that the inventors are positive to this harmonization.

In [71], a survey is presented in order to indicate support systems for IP activities of university students in Korea and Japan. This study intends to help the development of IP academic activities in Korea and Japan through presenting, by week, e-learning IP support program, as education for inventions. Lastly a comparison of IP support programs is applied between Korea and Japan.

In [72], a patent survey to 60 Japanese R&D directed firms is conducted through a questionnaire. The selected firms were investing in R&D and they possessed a capable number of patent applications. The results show the way that Japanese firms face the patent systems between the last decade and the next decade.

A survey of IP rights literature from 1971 to 2012 is presented in [73].This study utilizes a network of citations in order to find out the knowledge diffusion structure of the IP rights literature.

In [74], the paper suggests a course of law for computer professionals that includes: "legal aspects, ethical aspects and professional responsibility". The paper indicates the importance of students' legal awareness of IP by saying that jobs for computing graduates need not only technical knowledge, but commercial, ethical and legal awareness, too.

In [75], the study states that the challenges for IP protection in China's cultural and creative industries are the low awareness of the importance of IP protection and the choice of the IP protection that in every case best suits (among patent rights, trademark rights, commercial secret rights, and anti-unfair competition legislation).

In [76], a technology assessment to three technologies with the largest number of patents is analyzed by using patent evaluation. A common software tool is used as the analytical tool for evaluation of IP and a patent portfolio technology analysis is developed by using machine learning techniques.

In [61], is stated that AI technology challenges Patent Laws on the basis of the patent eligibility of an AI invention. The study also states that computer technology is the most important technology in the field of AI and advices patent applicants to focus on the claims of the described invention as for clearly indicating the technical problems that the invention solves with a view to survive in patent examination.

In [77] the paper notices the difference between open source licenses and the current Standard Settings Organizations legal framework regarding IP rights. It also refers to the FRAND license commitment for patented technologies and the copyrighted software.

A study is presented in [78], which measures the role of innovation through patent applications in business success. The sample for the study is Swiss companies and the results show that patent applications have a great impact on the business performance of small and medium sized enterprises.

The study in [79] focuses on the patent eligibility of AI inventions. Furthermore it states that due to the contribution of AI achievements to the society, many countries started to revise the patent examination guidelines related to the patent-eligibility criteria of AI inventions.

In [80], in order to list the emerging technologies and especially those with complexity like robotics this paper proposes as a methodology patents data containing robotics in their titles and abstract and patent citations. This study contributes to open innovation measures for organizations.

In [65], the paper refers to China's revision of the Examination Guidelines as for Patents that concern AI related inventions. This revision is valid since 2017. The paper comments the updated guidelines which state that an invention related to computer program or business model which includes a technical feature, consists a patentable subject.

In [81], the article applies a learning method for patent value estimation. Principal component analysis is used to indicate the patent value and then deep neural networks are also applied. A detailed case study of IoT patents is developed and Taiwan IoT high value patents are used to confirm the competition in technology innovation.

In [82], the writers utilize Machine Learning and patent information to provide an analysis of the nowadays companies' technology development. The patent information is analyzed from three companies and the proposed method, manages to disclose the companies' technology fields, their technological transition, and their similarities and differences.

In [83], this article compares patent measurement methods and finds that the patented coupling analysis method can depict the technical characteristics of technical fields. This method in combination with other statistical methods helps to conclude technical similarities among enterprises as for technology intelligence.

In [84], is presented the development of web-based e-learning systems in order for students to learn IPL. The system uses logic circuits in exercises to teach legal texts and also video systems.

On the grounds that Japanese Patent Office act is of great importance because Japan's and USA's AI technology leads the technological world, this paper[85] with a view to increase the patentability of AI related inventions at the JPO, analyzes the procedure and the patent examination guidelines.

In [86], it is stated that Chinese internet companies began to be an essential part of the world's digital economy. Then by using text mining and patent data and by comparing the three enormous companies in China, this paper examines the development of technological capabilities through the innovative strategies of those companies. The elements that are used from these companies are; patent portfolios, patenting patterns and trends and the paper also intends to point out differences between the three of China's companies and their respective companies in US as for technology.

In [63], a study is presented which tries to predict the industry correlation among logistics and information and communications technology industries with the influence of IoT. There is an empirical patent analysis that concludes the ability of IoT to support companies as for covering the need of new technological and market competences.

In [87], the writer wonders whether IPL is ready for AI. He states that when software implemented AI system makes choices, the legal frame adjusts. He searches between copyright and patents which better serves AI and concludes that patentability of AI inventions will probably not be decided by patent offices, but by courts and also wonders whether a machine could also be an inventor.

In [88], there is an analysis of the innovative ideas of the IoT technology and there are also future policy suggestions for the countries. The paper for the IoT technology uses bibliometric, "Patentometrics" to make the analysis. The results show that the innovation characteristics in the IoT technology differ for each country.

In [89], the writers develop a research of an intelligent patent summarization methodology using AI machine learning algorithms to conclude through given patent domains the patents' worth and technical advantage.

In [90], regarding current IPL system in China as for big data, the paper lists the issues of IP protection in software and IoTs driven by industrial innovation. Proposals are stated so as to improve the software patent system and patent examination and aims to provide digital software IP protection.

This article, [91], analyzes for technology companies the IP decisions should take by using a dataset including machine learning patents. It also analyzes patent claims and provides patent critique on the grounds of informatics, IP and technology scholarship.

In [92], the paper refers to India's IP rights across the world and also analyzes the regulations of IP rights in India, indicates the needs and roles of patents, trademarks, industrial designs, copyright, etc.

In [93], the article examines how patents impacts on university researchers. "They created a dataset of royalty-sharing policies from 152 universities, which shows substantial variation across universities and time." They conclude that for larger share of royalties, it is better to be retained by universities, because money is used to reinvest in research and education. The writers wonder for the future research whether increasing the inventor’s involvement in university patent policies leads researchers to make and use better patents.

In [94], the literature is connected to academic entrepreneurship "By relying on a sample of Italian academic spinoffs established over the period 2006–2012", the results show that necessity-oriented academic spinoffs have greater survival trend, while opportunity-oriented spinoffs have the trend to develop further.

The paper, in [95], analyzes how quality of research results manages the relation between university research collaboration and technology transfer. For this purpose the writers use Chinese universities with patents granted in USPTO. The results show that the size of university research collaboration impacts on the results of a research as for quality and that university collaboration with companies reflects also a better quality. Also, the quality of research results has a positive impact on the technology transfer.

In [96], the writers by "using a knowledge production framework, they identify empirically U.S. Small Business Innovation Research projects of 1992 to 2001". The

results in an empirical way show that if the firm collaborates with a university in this funded project, then more scientific papers follow.

In [97], the writers basing on the fact that women in entrepreneurship are few, they conducted a gender-sensitive entrepreneurship education program for women students of engineering and computer science. The student mentors were interviewed about their experiences and reported positive views on entrepreneurial "self-efficacy" and significant "awareness of diversity and gender issues". Lastly they noticed the students' interest in "becoming an entrepreneur" the years that follow

In [98], the paper refers to a new research university that provides entrepreneurial postdocs with a program that educates the scientists and turns them into entrepreneurs. The program offers education in startup intellectual property and financial aspects. "The program was launched in 2014 and has incorporated 25 postdocs and their startups." This program resulted in contribution to technology transfer.

In [99], the article examines technology transfer and entrepreneurial innovation in Egypt where there is not exist a unified system of policy to ensure the IP of university research. The study involves "interviews with experts, a questionnaire survey of Egyptian Science, Engineering and Technology academics, three case studies of Technology Transfer Offices and a 237 respondent industry survey". The results indicate that there is lack of collaboration between university and industry and there is the need for the development of a policy that promotes universities and industry to collaborate.

In the direction of developing an IP rights system in China, a survey in [100] was conducted to underline the factors that form the behavior as for IP rights in China of professional designers."A qualitative contextual interview study, conducted with 49 Chinese designers and design managers."The results of the survey show that Chinese design professionals have different motivations for their design work and different levels of IP rights awareness. Based on the findings, a theoretical model is proposed.

In [101], the paper arise the question "who should own an academic patent obtained as a result of funded research", in order innovation to be served? This paper analyzes the point of views of engineering graduate students, who are also experienced in

R&D, as for patent ownership in universities. The findings can result in the development of an ownership policy that can serve future innovation.

In [102], the article focuses on academic entrepreneurship and academic patenting. University administrations have installed technology transfer offices to promote patenting. The writers introduce "an agent-based simulation for evaluating measures" that can be used by a technology transfer office in order to promote academic patenting and the establishment of start-up companies basing on patents.

Lastly, in [103], the article analyzes the results of a qualitative study that intends to compare the structure and operation of the programs for "intellectual property management and technology transfer", and the encouragement of entrepreneurship, in five research “institutions in America”. The study presents similarities and differences among these institutions.

2.3 Methodology

For the purpose of this survey a questionnaire was compiled, which is used in empirical study. This questionnaire was distributed in 2019, to 5 Institutes of Technology in Greece, (3 University Departments of Informatics, 2 University Departments of Electrical and Computer Engineering in different regions of Greece), of which only the first Institute of Technology includes in its curriculum a course related to Law and Information Technology, to fourth-year or fifth-year graduated university students.

The total sample is 198 technological educated students out of which 161 have valid questionnaire participation. In Table I, the number of participants is listed by each one of the five Institutes of Technology, as well as the share of each Institute to the total. The 1st and the 2nd Institute of Technology have the most participants (30, % and 31,1% respectively.

There are 16 questions in the questionnaire, close-ended with binary possible answers and one question which is an open-ended question, where participants could give a short answer. The analysis that follows includes tables for all the questions (Q1 to Q16), with frequencies of the YES/NO, a/b, replies and percentages for the number of students that have replied positively. The analysis for each question is made for all five Institutes of Technology.

TABLE I
NUMBER OF PARTICIPANTS PER INSTITUTE OF TECHNOLOGY

Universities	Number of students	Number of participants	% of participation	% participants of the total
1st Institute of Technology	50	49	98%	30,4%
2nd Institute of Technology	58	50	86%	31,1%
3rd Institute of Technology	20	17	85%	10,6%
4th Institute of Technology	50	30	60%	18,6%
5th Institute of Technology	20	15	75%	9,3%
Total	198	161	81%	100,0%

Below, follows a detailed explanation of the result that we intend to derive from each question and at the end of this explanation exists Table II with this questionnaire.

Q1. Did you know that Intellectual Property Law concerns technology scientists and engineers who develop technological innovations? – We want to find out whether the students know that technology has not only scientific profile but also industrial profile and legal status among society.

Q2.Did you know that computer related achievements (e.g. smart applications, smart phones,..), IoT technological achievements (e.g.in smart homes, in smart industry, in energy,..), AI achievements (e.g. machine learning applications, robotics, haptics,..) are patentable subjects?-We want to specify what technology means and connect their technological knowhow from university to legal aspects. Whatismore, we want to introduce the institution of patents and link it to the possible inventive idea they may have conceived.

Q3.Did you know that the inventor of a technological invention can ensure the paternity of his idea and its exclusive commercial exploitation?- We intend to clarify that for all these technologies, that they have been taught so as to expertise in their professional lives, by implementing achievements and serving the technological innovation industry, they can be protected from their intellectual effort's infringement and they can be rewarded with exclusive commercial exploitation.

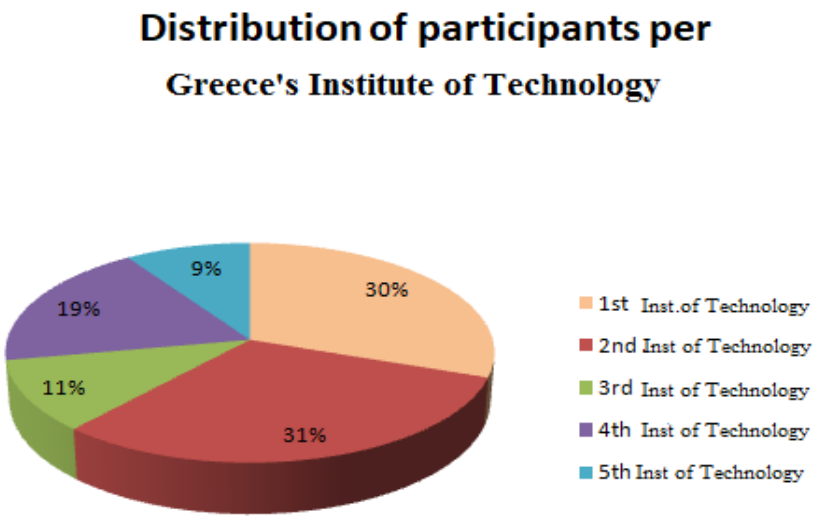


FIGURE 1. Percentage of participants per Institute of Technology

Q4. Is an algorithm a patentable subject?-We intend to find out whether they have the knowhow of distinguishing what technological subject is patented or not. An algorithm may be innovative as they regard, but it is not patentable individually as an entity.

Q5. Is the code of a computer program a patentable subject?- We intend to understand whether they regard that for the computer inventions they are familiar with, the code that was written by an expertise, is the subject of patentability. We want also to find out whether they distinguish the difference between copyrights and patents. Lastly we want to see whether they cope with a computer invention as a whole, accompanied by the effects that the software when runs, brings to a computer's hardware.

Q6. Are you a supporter of open source software?-We know that students use open source programs during their studying at university. At this point, after all mentioned, we want to find out, whether they are able to weigh the pros and cons of a patentable invention though an invention protected by Patent Law and an open source software program freely available or under conditions available to public.

Q7. A technological innovation of yours would be a) Open source software or b) Protected by Patent Law?- After thinking of what they merely support, we want to see on which side they are going to classify their potential invention. They want an invention to be protected through the grant of a patent or they want to contribute to the technological community.

Q8.A patent lasts for 20 years giving its holder exclusive rights as for commercial exploitation. Do you believe that 20 years is a reasonable time period for technology inventions, regarding that technology evolves rapidly? - We want to ascertain whether future technocrats believe that technological achievements should be profitable to their patent owners for less than 20 years, regarding that technology evolves rapidly. Afterwards inventions should be available for the common good of society. Otherwise, if they believe that the holder of a patent should benefit from his invention at least for 20 years, regardless whether the invention is technologically obsolete.

Q9.Do you think that prior to 20 years the patented invention should be available to the public?- After many years of dominance of the technological industry in the world economy and after many patents that have been issued, this question is still of great concern to the scientific community both of technological and legal direction, whether updating the law as to the duration of a patent.

Q10. Have you ever visited the patent office in Greece or have you ever visited the sites of United States/European/Japan patent office or World Intellectual property organization, in order to be informed about technological achievements and their legal protection in society?- Through this question we intend to understand whether tech-savvy graduates have ever wondered about information as for patents; where a patent can be issued, how many organizations there exist, what geographical power a patent may have, how much this process may cost, and where they can apply for a patent. This information may be provided to all these sites.

Q11. Have you ever considered or implemented an innovation? Or have you found an optimized solution to a problem?- We intend to find out, regarding the technological stimuli that these students receive from not only their everyday life but also from their technological academic community, whether they have ever conceived an

innovative idea or even implement it, or even conceived an optimized solution because this is also a subject of patentability, a fact that they may ignore.

Q12. If yes, (a) did you reveal it or b) you first consulted a lawyer?- At this question it is very important to know how they faced their potential invention. Did they have the background to support their innovation, claim it or they revealed it and possibly lost the paternity of their intellectual asset.

Q13.Have you ever considered establishing a start-up company based on a technological achievement?- We intend to realize the perception of commercializing an innovative idea and whether it is an incentive for entrepreneurship. We also want to see whether young scientists have the vision to become an active member of the technology industry and business innovation by owning a tech-company.

Q14. What is the most up-to-date, technological breakthrough you've heard, seen or used?- By this question, we intend to find out what kind of technology they admire and in what field of technology their interests are focusing.

Q15. Do you believe that in the technological industry a start-up can survive?- We intend to find out what technology graduators have in mind about the venture of starting a new business basing on their innovative idea, what they think about competition within the technological industry, whether they would be afraid of competition or if they would make the effort to get involved in technological business world.

Q16. Do you believe that a technological enterprise or an inventor should spend money on patenting a technological innovation before it is disclosed?- We intend to find out whether the students believe that it is worth the effort and money to apply for a patent in order to support and commercially exploit from an innovative idea or in case of an enterprise to expand a patent portfolio. We want to know if they have the will to utilize their technical skills to implement a technical achievement and undertake the procedure for granting a patent.

TABLE II
THE QUESTIONNAIRE

	Queries	**YES**	**NO**
1	Did you know that Intellectual Property Law concerns technology scientists and engineers who develop technological innovations?		
2	Did you know that Computer related achievements (e.g. smart phones, smart applications..), IoT technological achievements (e.g.in smart homes, in smart industry, in energy..), AI achievements (e.g. machine learning applications, robotics, haptic technology..) are patentable subjects?		
3	Did you know that the inventor of a technological invention can ensure the paternity of his idea and its exclusive commercial exploitation?		
4	Is an algorithm a patentable subject?		
5	Is the code of a computer program a patentable subject?		
6	Are you a supporter of open source software?		
7	A technological innovation of yours would be a)open source software or b) Protected by Patent Law?	Choose a or b	
8	A patent lasts for 20 years giving its holder exclusive rights as for commercial exploitation. Do you believe that 20 years is a reasonable time period for technology inventions, regarding that technology evolves rapidly?		

9	Do you think that prior to 20 years the patented invention should be revealed to the public?		
10	Have you ever visited the patent office in Greece or have you ever visited the sites of United States/European/Japan patent office or World Intellectual property organization, in order to be informed about technological achievements and their legal protection in society?		
11	Have you ever considered or implemented an innovation? Or have you found an optimized solution to a problem?		
12	If yes, (a) did you reveal it or b) you first consulted a lawyer?	Choose a or b	
13	Have you ever considered establishing a start-up company based on a technological achievement?		
14	What is the most up-to-date, technological breakthrough you've heard, seen or used? (write it down there…..……)	Write it down	
15	Do you believe that in the technological industry a start-up can survive?		
16	Do you believe that a technological enterprise or an inventor should spend money on patenting a technological innovation before it is disclosed?		

2.4 Results and discussion

In this section a presentation through graphics follows, which presents the results of the survey. An analysis is also going to be done for those results that stem from the answers to each of Q1-Q16 questions of the questionnaire. Lastly, conclusions are going to be drawn, for the 5 Institutes of Technology as for Patent Law awareness and the entrepreneurial trend of the potential inventors from Greece's Institutes of Technology.

In Q1: "Did you know that Intellectual Property Law concerns technology scientists and engineers who develop technological innovations?", the majority of the students of the first Institute of Technology (IT1), in which also a course related to Law and Information Technology is taught, declared Yes, which means that they can realize the legal protection that Law can provide to inventors of technology. The rest of Institutes of Technology declared No, indicating that they cannot realize the relation between Law and Technology.

In Q2: "Did you know that computer related achievements (e.g. smart applications, smart phones,..), IoT technological achievements (e.g.in smart homes, in smart industry, in energy,..), AI achievements (e.g. machine learning applications, robotics, haptics,..) are patentable subjects?", the majority of students declared Yes in IT1 and in the rest of Institutes of Technology the majority of students chose the No option. It is observed that what technology means to the majority of all students has not a legal point of view, even for technology achievements they do not connect them consciously with patents or they are not aware of what "patentable subject" means.

In Q3: "Did you know that the inventor of a technological invention can ensure the paternity of his idea and its exclusive commercial exploitation?", the majority of the students in IT1 answered Yes, in the rest of the Institutes of Technology the answer was No and we observe that the majority of the participants are not aware of that an inventor can protect his innovative idea, his intellectual effort and can also individually benefit from it, if it is a profitable invention.

In Q4: "Is an algorithm a patentable subject?", in IT1 the majority answered No, yet a sufficient percentage answered Yes. In the rest Institutes of Technology, the answer was Yes, by the majority of participants. This means that most of the students regarding

an algorithm and its steps as innovative they think, incorrectly, it can be patentable as it is.

In Q5: “Is the code of a computer program a patentable subject?”, the majority of all participants answered Yes, which means that they regard the code that was written by an expertise, as patentable subject. They are not aware of the difference between copyrights and patents and they do not face a computer invention as a whole, accompanied by the hardware.

In Q6: “Are you a supporter of open source software?”, the majority of students in IT1 and IT2 answered Yes, students in IT3,IT4 marginally answered No and students in IT5 marginally answered Yes, which means that the majority of the participants support open source programs. Although, in Q7: “A technological innovation of yours would be a) Open source software or b) Protected by Patent Law?”, the majority of the participants of all Institutes of Technology answered b, which means that as far as what concerns using technology they prefer this to be free and open but when we come to their potential invention, their intellectual property they would rather prefer a patented invention. So, it is observed that the majority of the students are not clearly understand what it is to support an open source program and which is the contribution of open source technology achievements. Furthermore, they do not seem to know what it really means to protect an inventor's intellectual property, beyond any economic benefit and any possible imitation of the invention, a patent ensures him morally among societies, justifies him commercially, and encourages him to create.

In Q8: “A patent lasts for 20 years giving its holder exclusive rights as for commercial exploitation. Do you believe that 20 years is a reasonable time period for technology inventions, regarding that technology evolves rapidly?”, the majority of the students in IT1,IT3,IT4,IT5 answered No. In IT2 the students marginally answered Yes. The conclusion is that future technocrats believe that technological achievements should be available for the common good of society earlier that the 20 years, regarding that technology evolves rapidly. In Q9: “Do you think that prior to 20 years the patented invention should be available to the public?”, the majority of the participants answered Yes, by supporting their previous answer.

In Q10: “Have you ever visited the patent office in Greece or have you ever visited the sites of United States/European/Japan patent office or World Intellectual property organization, in order to be informed about technological achievements and their legal protection in society?”, the majority of the students in all Institutes of Technology answered No. Despite, IT3 where all students answered No, there existed in the other Institutes of Technology positive answers. We realize that very few graduates have ever wondered about information as for patents even if this information is available online, too.

In Q11: “Have you ever considered or implemented an innovation? Or have you found an optimized solution to a problem?”, the majority of the participants answered No, but for this question it is crucial to refer to the number of students that answered Yes; 5/49 in IT1, 9/50 in IT2, 2/17 in IT3, 8/30 in IT4, 7/15 in IT5, which is a sufficient proportion of inventiveness. In Q12: “If yes, (a) did you reveal it or b) you first consulted a lawyer?”, the vast majority chose the answer a, only in IT1, where the students are taught a course regarding Law and Information Technology, 3 out of 5 students chose that they have first consulted a lawyer.

In: “Q13: Have you ever considered establishing a start-up company based on a technological achievement?”, in IT1, IT2,IT3 the minority of the students answered Yes but the positive ratio was sufficient and in IT4,IT5 the majority of the students answered Yes. Therefore, we realize that the perception of commercializing an innovative idea and the trend of entrepreneurship is positive enough.

In Q14: “What is the most up-to-date, technological breakthrough you've heard, seen or used?”, the majority of students answered; “smart phones”, “smart applications”, “smart transportation”, “IoT” and, “google”. Regarding all of the participants’ answers they admire technologies that can be applied in smart devices, smart cities, AI achievements, computer related inventions and telecommunications.

In Q15: “Do you believe that in the technological industry a start-up can survive?”, the vast majority of the participants answered Yes, which means that technology graduators regard as feasible the venture of starting a new business basing on an innovative idea, despite the competition.

In Q16: “Do you believe that a technological enterprise or an inventor should spend money on patenting a technological innovation before it is disclosed?”, similarly the vast majority of the participants answered Yes, which means that most students believe that it is worth the effort and money to apply for a patent.

Below follows the graphic analysis with tables and figures for each question. At the end, there is also one table/graph for each Institute of Technology, incorporating all the questions.

TABLE III

Q1	YES	NO	Yes%
1st Institute of Technology	38	11	77,6%
2nd Institute of Technology	20	30	40,0%
3rd Institute of Technology	3	14	17,6%
4th Institute of Technology	8	22	26,7%
5th Institute of Technology	5	10	33,3%
Total	74	87	46,0%

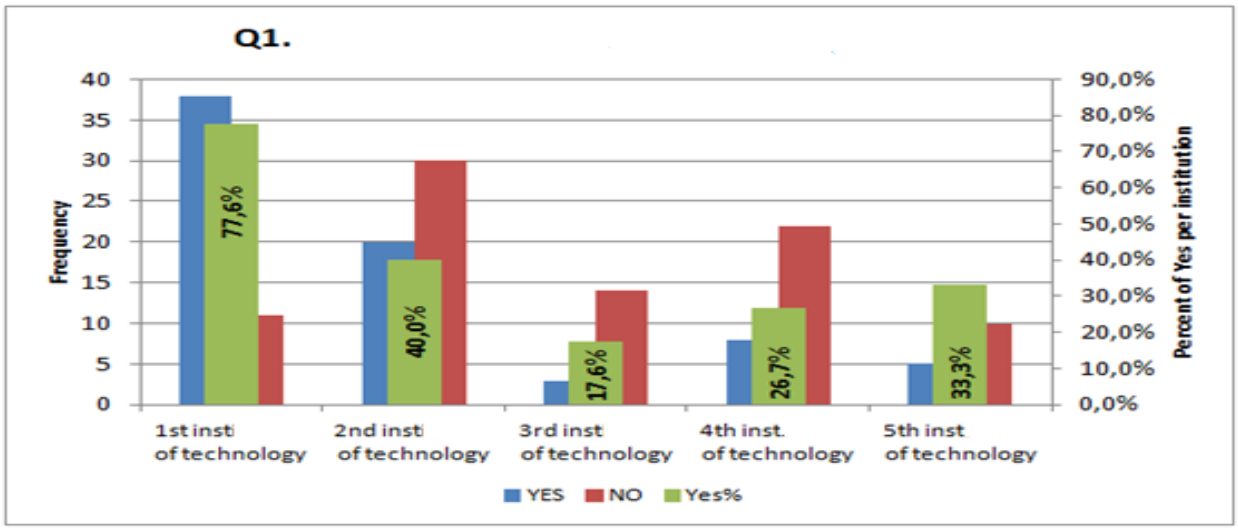


FIGURE 2. Q1:”Did you know that Intellectual Property Law concerns technology scientists and engineers who develop technological innovations?”

TABLE IV

Q2	YES	NO	Yes%
1st Institute of technology	35	14	71,4%
2nd Institute of technology	15	35	30,0%
3rd Institute of technology	2	15	11,8%
4th Institute of technology	6	24	20,0%
5th Institute of technology	4	11	26,7%
Total	62	99	38,5%

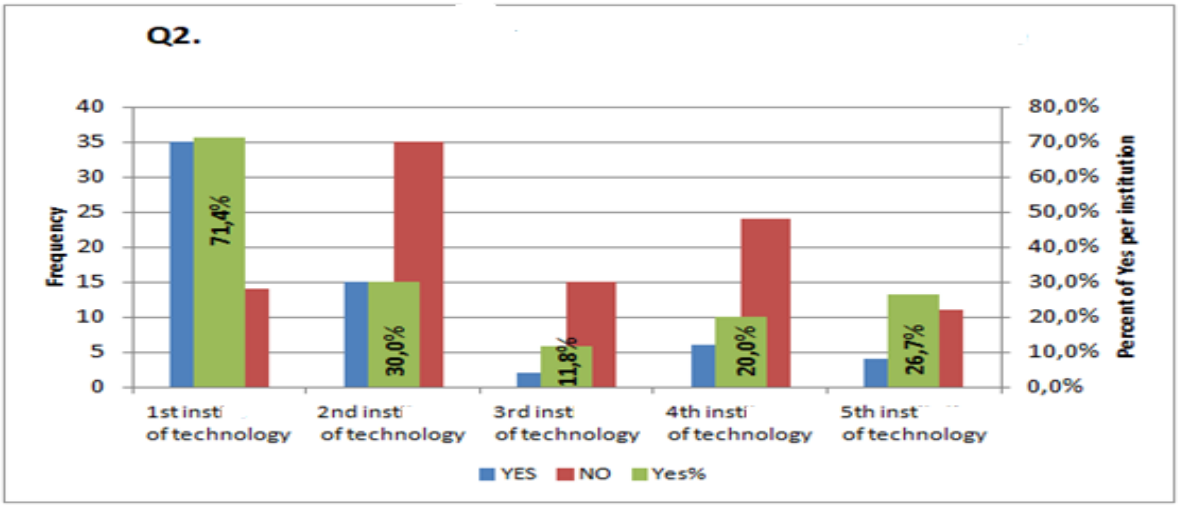


FIGURE 3. Q2.Did you know that computer related achievements (e.g. smart applications, smart phones,..), IoT technological achievements (e.g.in smart homes, in smart industry, in energy,..), AI achievements (e.g. machine learning applications, robotics, haptics,..) are patentable subjects?"

TABLE V

Q3	YES	NO	Yes%
1st Institute of technology	47	2	95,9%
2nd Institute of technology	24	26	48,0%
3rd Institute of technology	5	12	29,4%
4th Institute of technology	14	16	46,7%
5th Institute of technology	7	8	46,7%
Total	97	64	60,2%

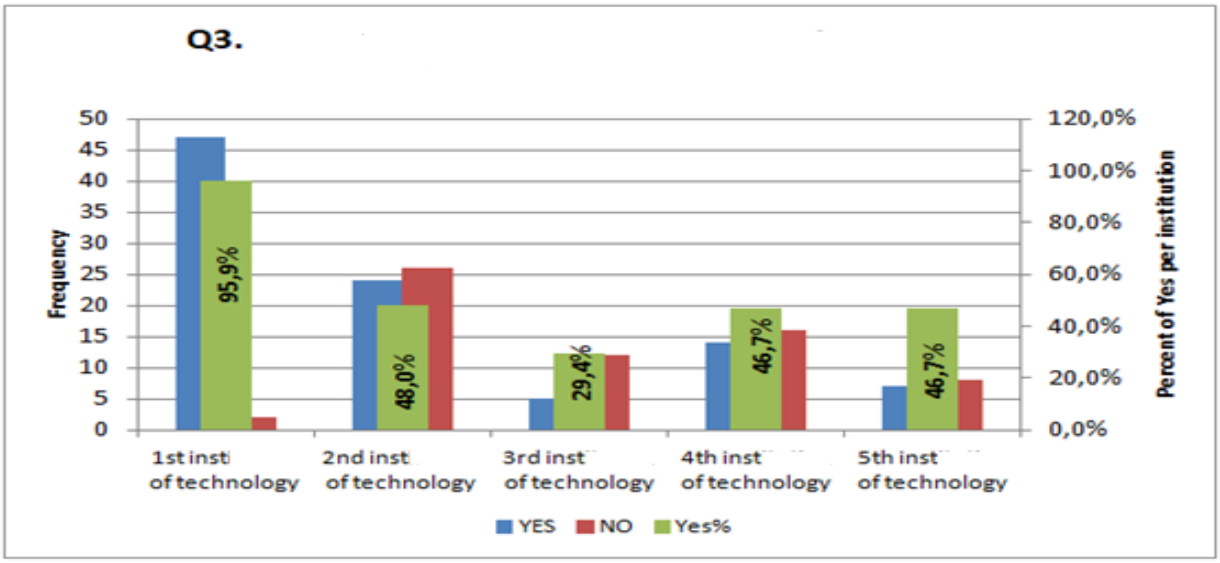


FIGURE 4. Q3: "Did you know that the inventor of a technological invention can ensure the paternity of his idea and its exclusive commercial exploitation?"

TABLE VI

Q4	YES	NO	Yes%
1st Institute of technology	22	27	44,9%
2nd Institute of technology	35	15	70,0%
3rd Institute of technology	13	4	76,5%
4th Institute of technology	25	5	83,3%
5th Institute of technology	10	5	66,7%
Total	105	56	65,2%

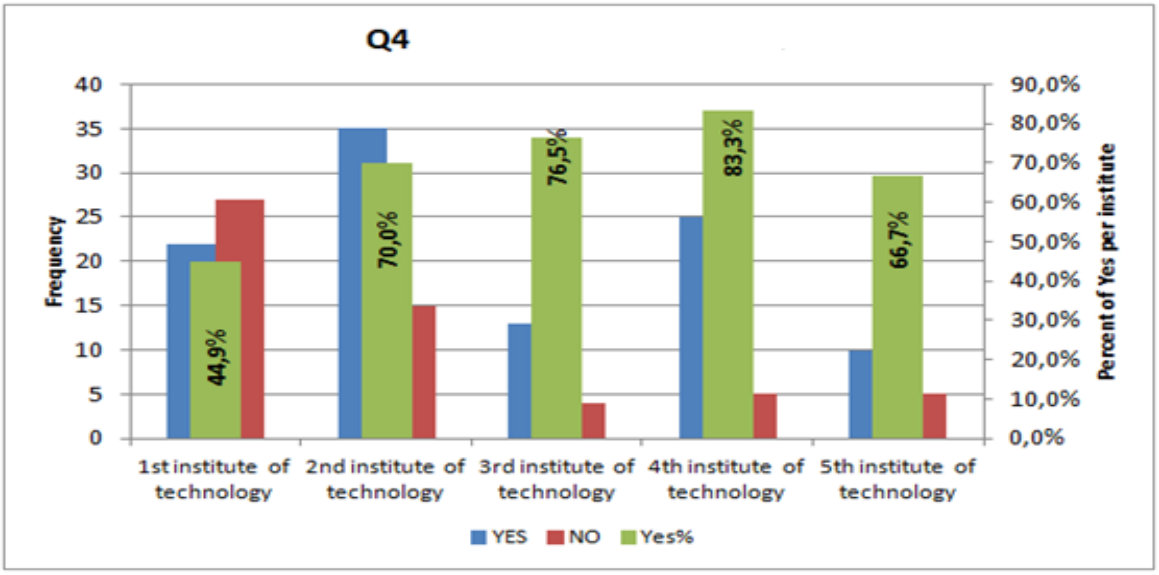


FIGURE 5. Q4: ".Is an algorithm a patentable subject?"

TABLE VII

Q5	YES	NO	Yes%
1st Institute of technology	30	19	61,2%
2nd Institute of technology	40	10	80,0%
3rd Institute of technology	15	2	88,2%
4th Institute of technology	26	4	86,7%
5th Institute of technology	12	3	80,0%
Total	123	38	76,4%

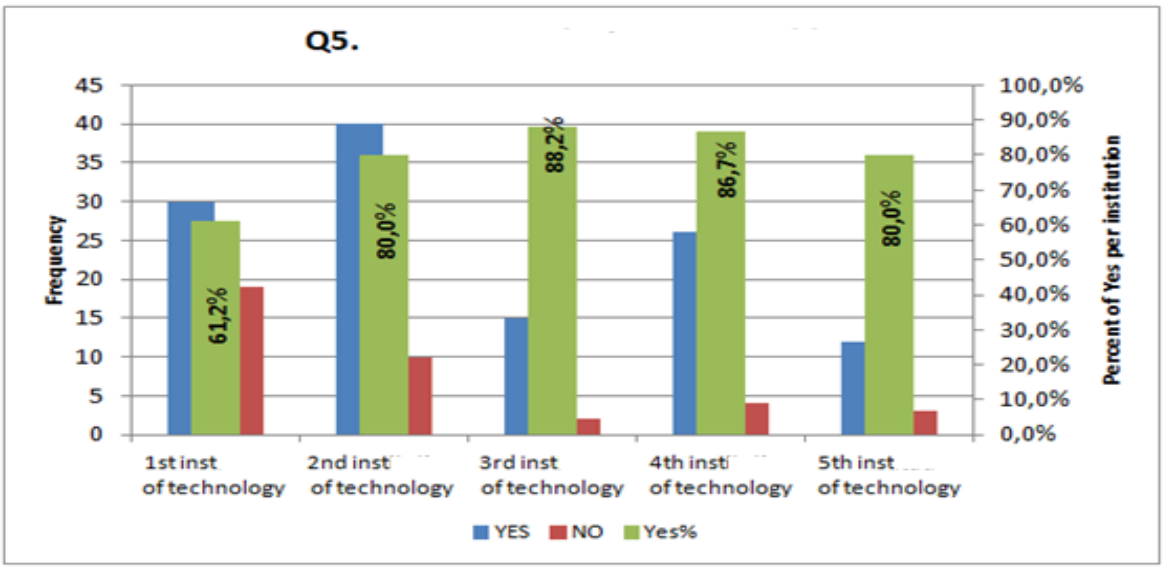


FIGURE 6. Q5: “Is the code of a computer program a patentable subject?”

TABLE VIII

Q6	YES	NO	Yes%
1st Institute of technology	46	3	93,9%
2nd Institute of technology	38	12	76,0%
3rd Institute of technology	7	10	41,2%
4th Institute of technology	14	16	46,7%
5th Institute of technology	8	7	53,3%
Total	113	48	70,2%

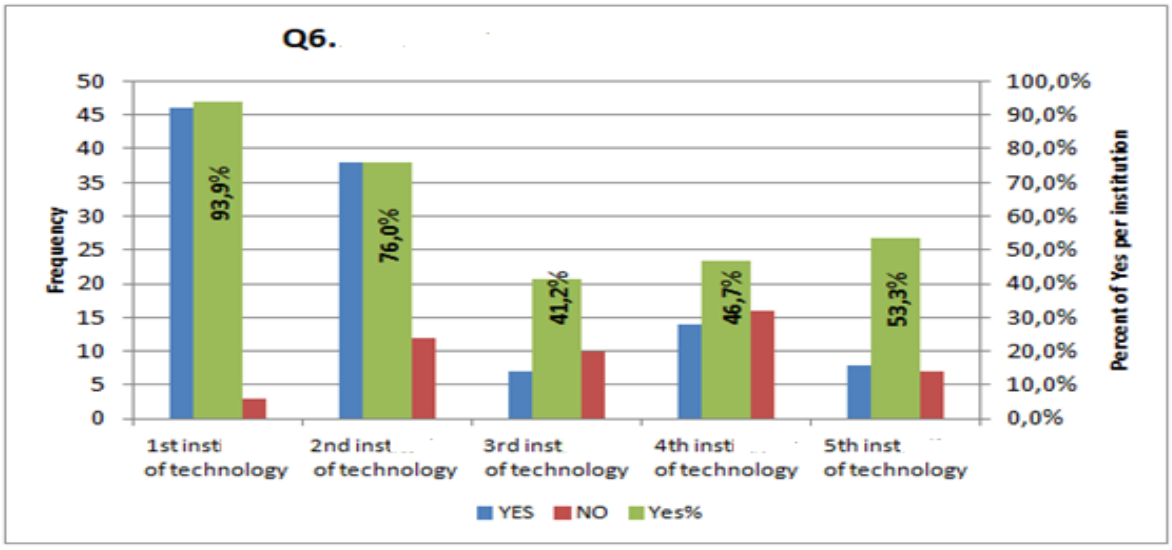


FIGURE 7. Q6: "Are you a supporter of open source software?"

TABLE IX

Q7	a	b
1st Institute of technology	20	29
2nd Institute of technology	9	41
3rd Institute of technology	4	13
4th Institute of technology	9	21
5th Institute of technology	5	10
Total	47	114

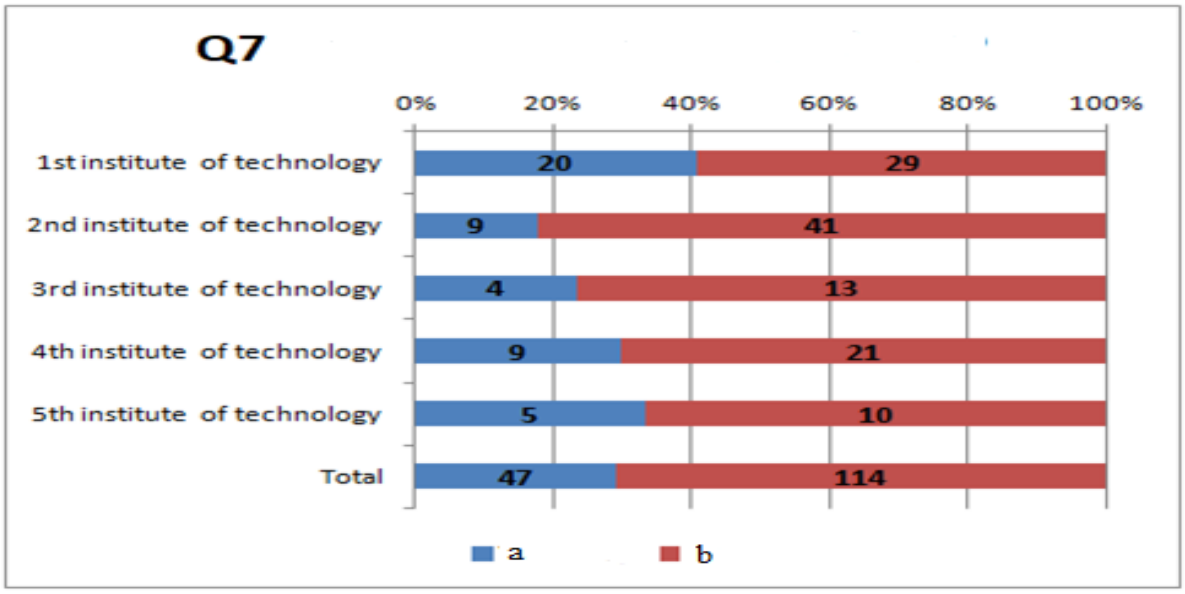


FIGURE 8. Q7: "A technological innovation of yours would be a) Open source software or b) Protected by Patent Law?"

TABLE X

Q8	YES	NO	Yes%
1st Institute of technology	18	31	36,7%
2nd Institute of technology	27	23	54,0%
3rd Institute of technology	4	13	23,5%
4th Institute of technology	10	20	33,3%
5th Institute of technology	3	12	20,0%
Total	62	99	38,5%

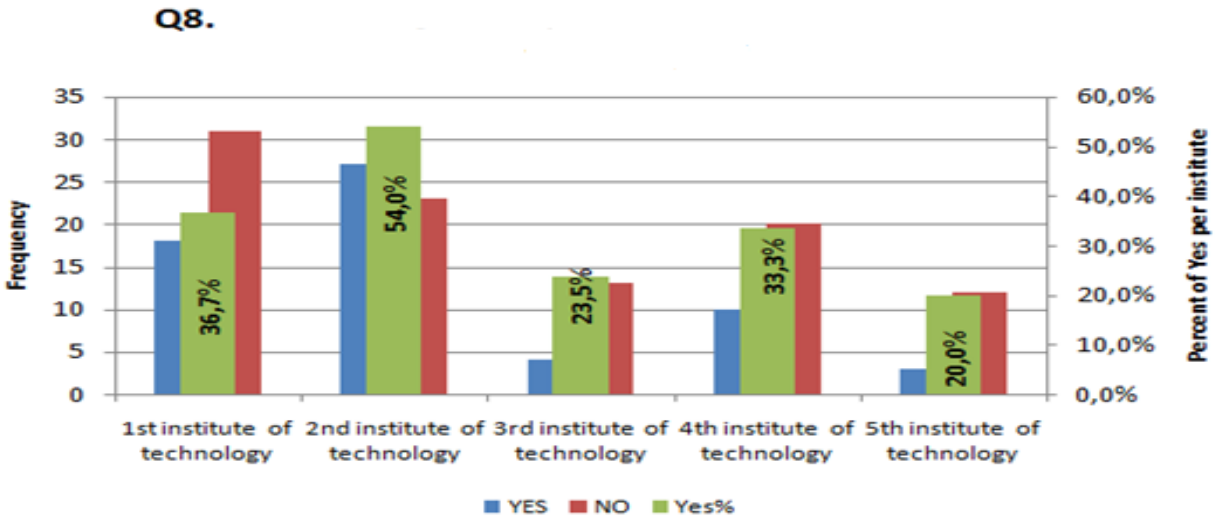


FIGURE 9. Q8: "A patent lasts for 20 years giving its holder exclusive rights as for commercial exploitation. Do you believe that 20 years is a reasonable time period for technology inventions, regarding that technology evolves rapidly?"

TABLE XI

Q9	YES	NO	Yes%
1st Institute of technology	27	22	55,1%
2nd Institute of technology	39	11	78,0%
3rd Institute of technology	15	2	88,2%
4th Institute of technology	26	4	86,7%
5th Institute of technology	14	1	93,3%
Total	121	40	75,2%

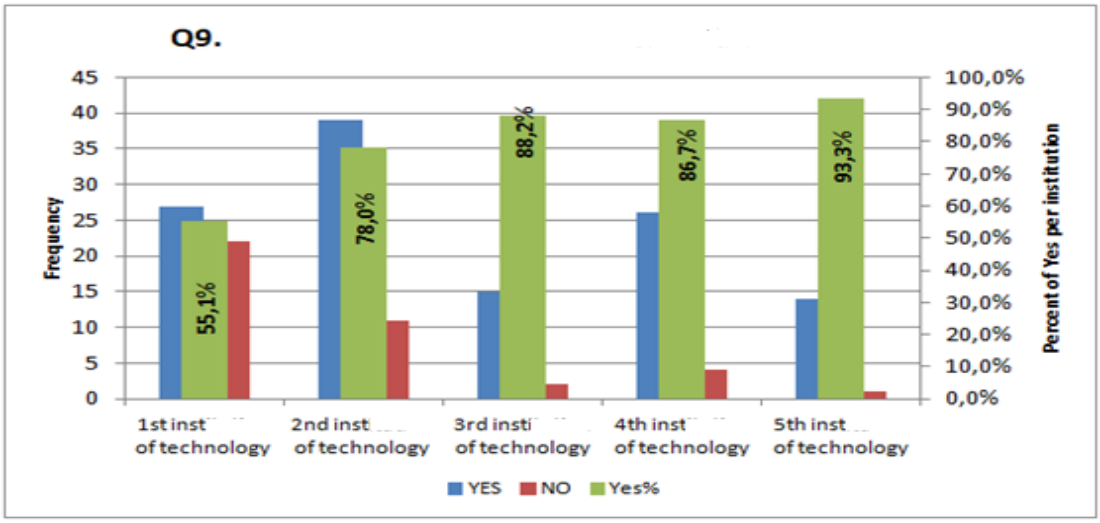


FIGURE 10. Q9: "Do you think that prior to 20 years the patented invention should be available to the public?"

TABLE XII

Q10	YES	NO	Yes%
1st Institute of technology	15	34	30,6%
2nd Institute of technology	8	42	16,0%
3rd Institute of technology	0	17	0,0%
4th Institute of technology	9	21	30,0%
5th Institute of technology	6	9	40,0%
Total	38	123	23,6%

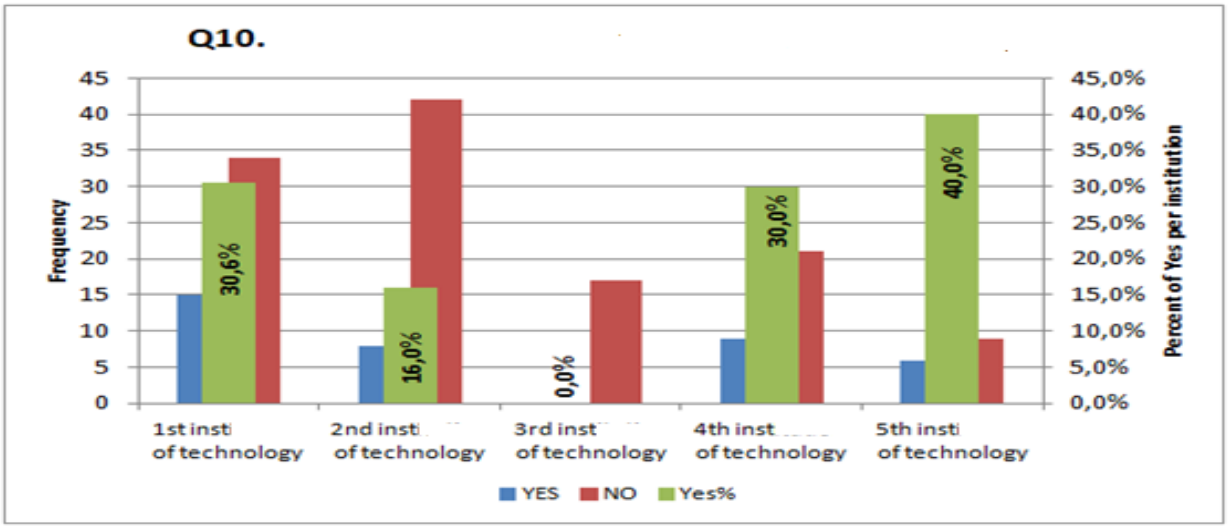


FIGURE 11. Q10: “Have you ever visited the patent office in Greece or have you ever visited the sites of United States/European/Japan patent office or World Intellectual property organization, in order to be informed about technological achievements and their legal protection in society?”

TABLE XIII

Q11	YES	NO	Yes%
1st Institute of technology	5	44	10,0%
2nd Institute of technology	9	41	18,0%
3rd Institute of technology	2	15	11,8%
4th Institute of technology	8	22	26,7%
5th Institute of technology	7	8	31,8%
Total	31	130	18,3%

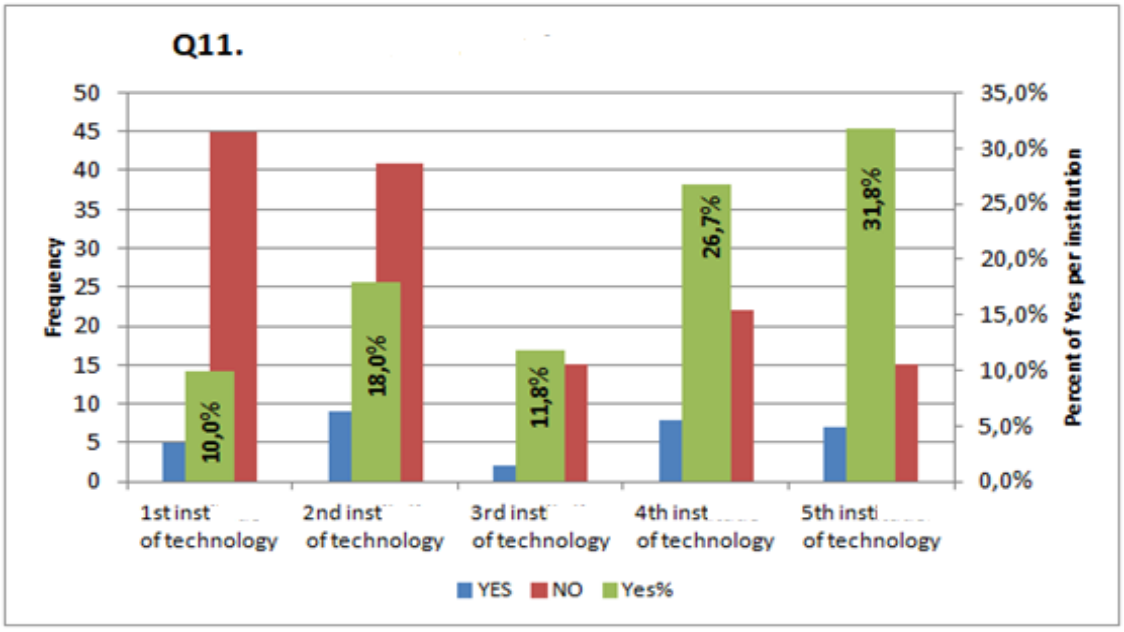


FIGURE 12. Q11: "Have you ever considered or implemented an innovation? Or have you found an optimized solution to a problem?"

TABLE XIV

Q12	a	b
1st institute of technology	2	3
2nd institute of technology	9	0
3rd institute of technology	2	0
4th institute of technology	7	1
5th institute of technology	5	2
Total	25	6

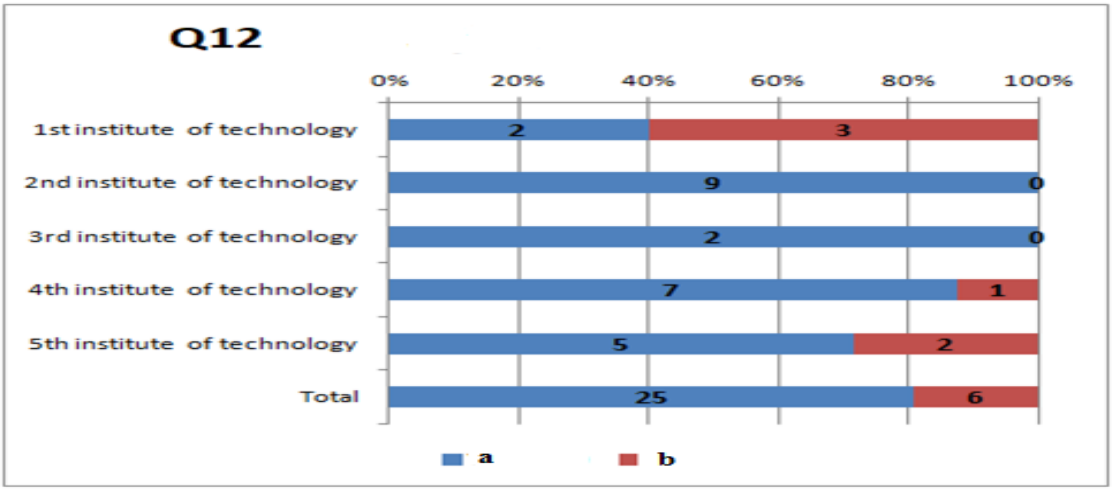


FIGURE 13. Q12: "If yes, (a) did you reveal it or b) you first consulted a lawyer?"

TABLE XV

Q13	YES	NO	Yes%
1st Institute of technology	18	31	36,7%
2nd Institute of technology	19	31	38,0%
3rd Institute of technology	7	10	41,2%
4th Institute of technology	20	10	66,7%
5th Institute of technology	11	4	73,3%
Total	75	86	46,6%

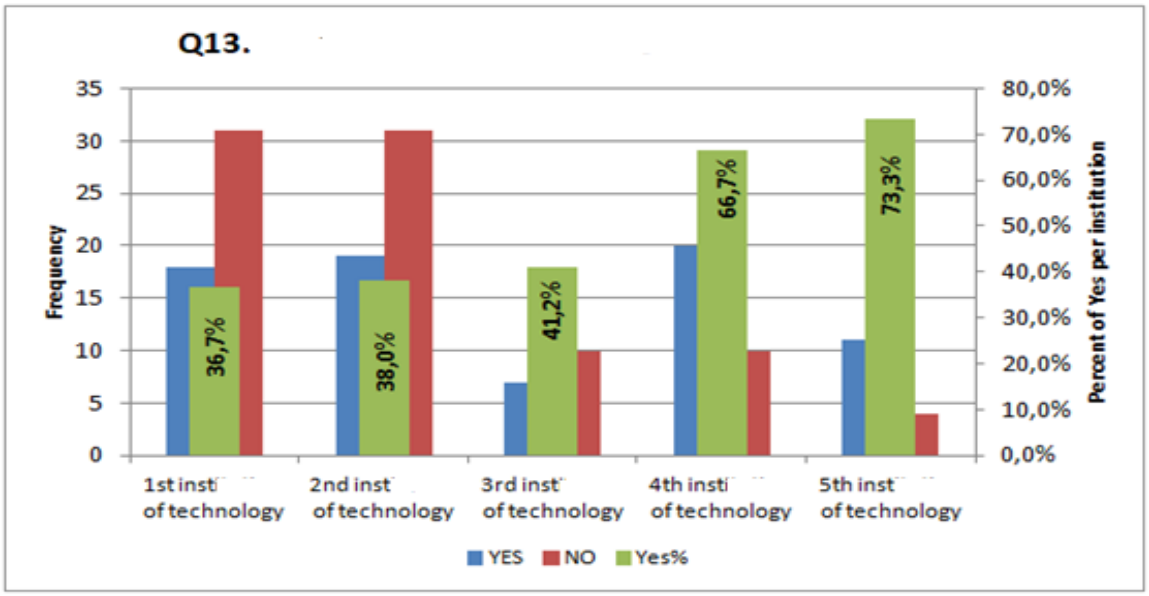


FIGURE 14. Q13: Have you ever considered establishing a start-up company based on a technological achievement?"

TABLE XVI

Q14	Institute of technology 1	2	3	4	5	Total
AI	6	5	3	5	4	23
google		9				9
haptics	2					2
internet	2	5				7
IoT	10				6	16
robots	3	3		2	2	10
smart apps	10	8	6	5		29
smart devices				3	3	6
smart hotels	4					4
smart phones	10	15	8	10		43
smart transportation	2	5		5		12
Total	49	50	17	30	15	161

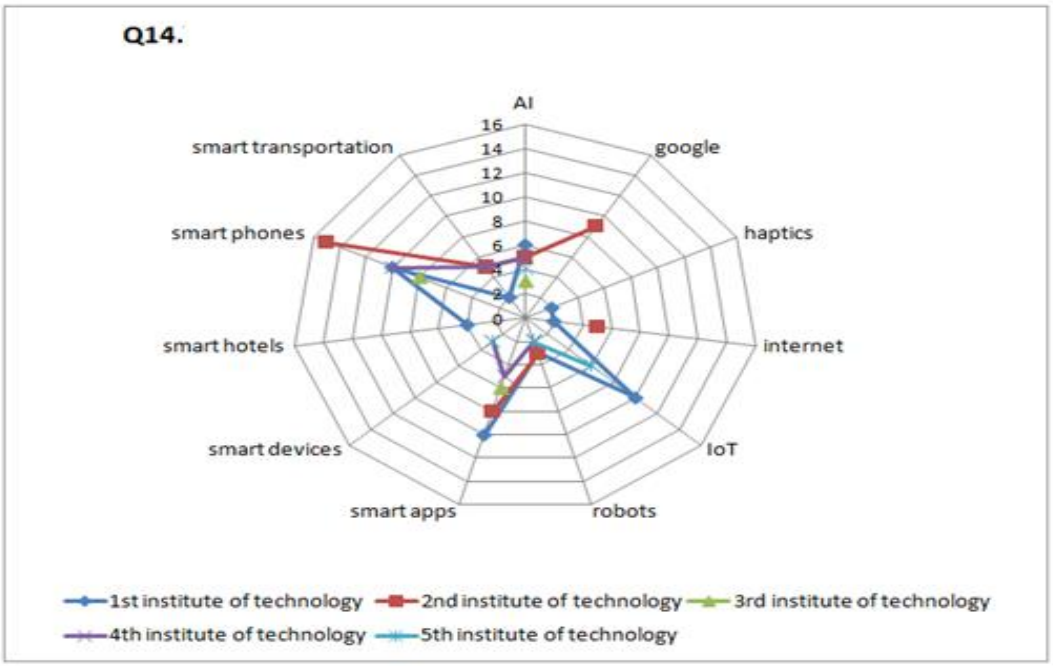


FIGURE 15. Q14. What is the most up-to-date, technological breakthrough you've heard, seen or used?"

TABLE XVII

Q15	YES	NO	Yes%
1st Institute of technology	40	9	81,6%
2nd Institute of technology	28	22	56,0%
3rd Institute of technology	11	6	64,7%
4th Institute of technology	18	12	60,0%
5th Institute of technology	9	6	60,0%
Total	106	55	65,8%

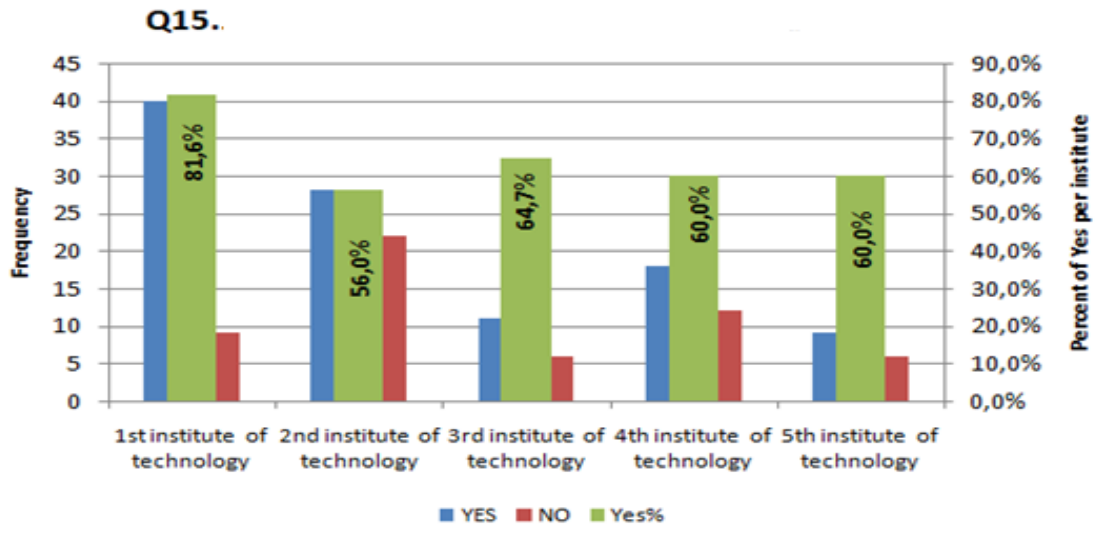


FIGURE 16. Q15: "Do you believe that in the technological industry a start-up can survive?"

TABLE XVIII

Q16	YES	NO	Yes%
1st Institute of technology	42	7	85,7%
2nd Institute of technology	37	13	74,0%
3rd Institute of technology	11	6	64,7%
4th Institute of technology	22	8	73,3%
5th Institute of technology	14	1	93,3%
Total	126	35	78,3%

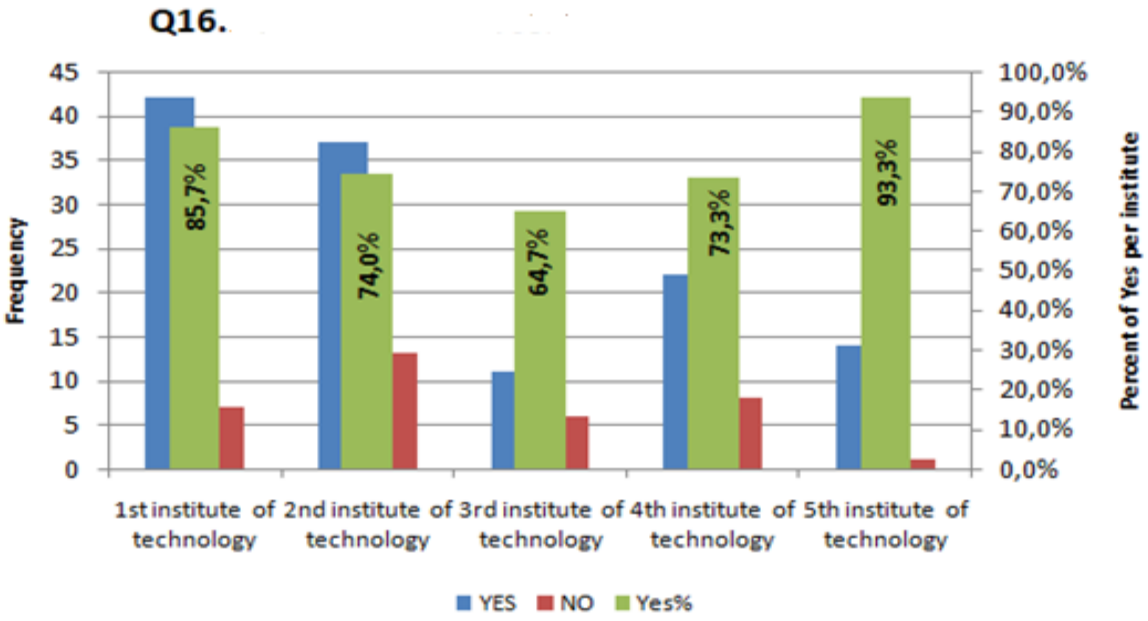


FIGURE 17. Q16. "Do you believe that a technological enterprise or an inventor should spend money on patenting a technological innovation before it is disclosed?"

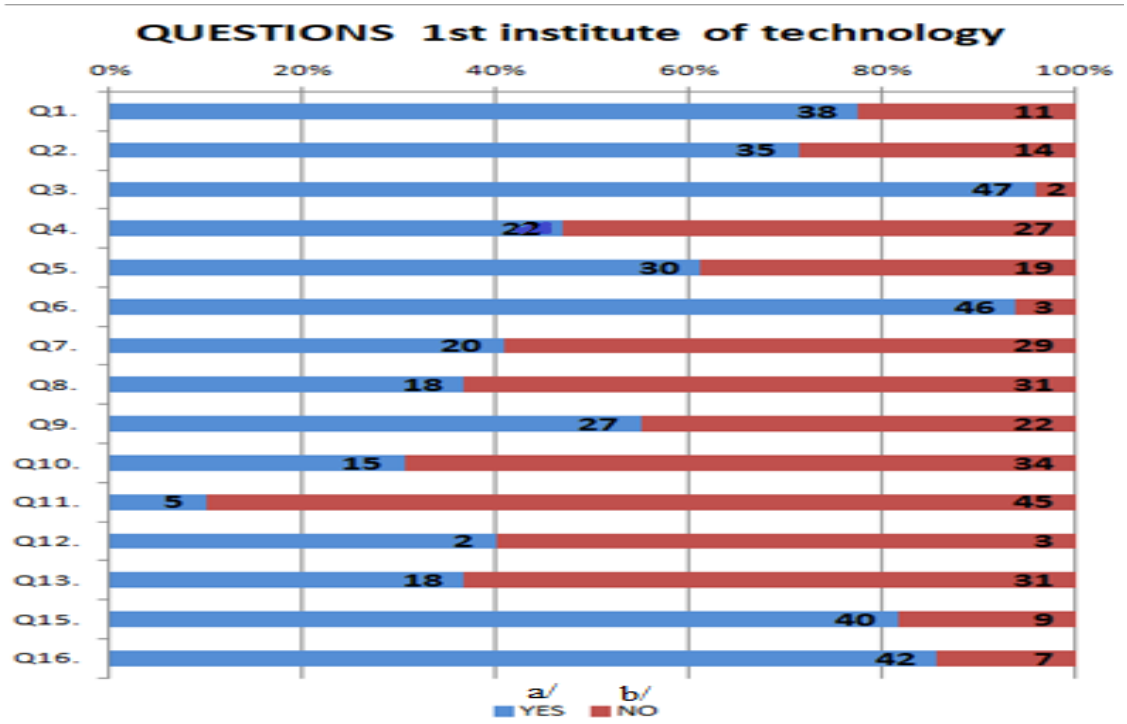


FIGURE 18. All answers for the 1st Institute of Technology

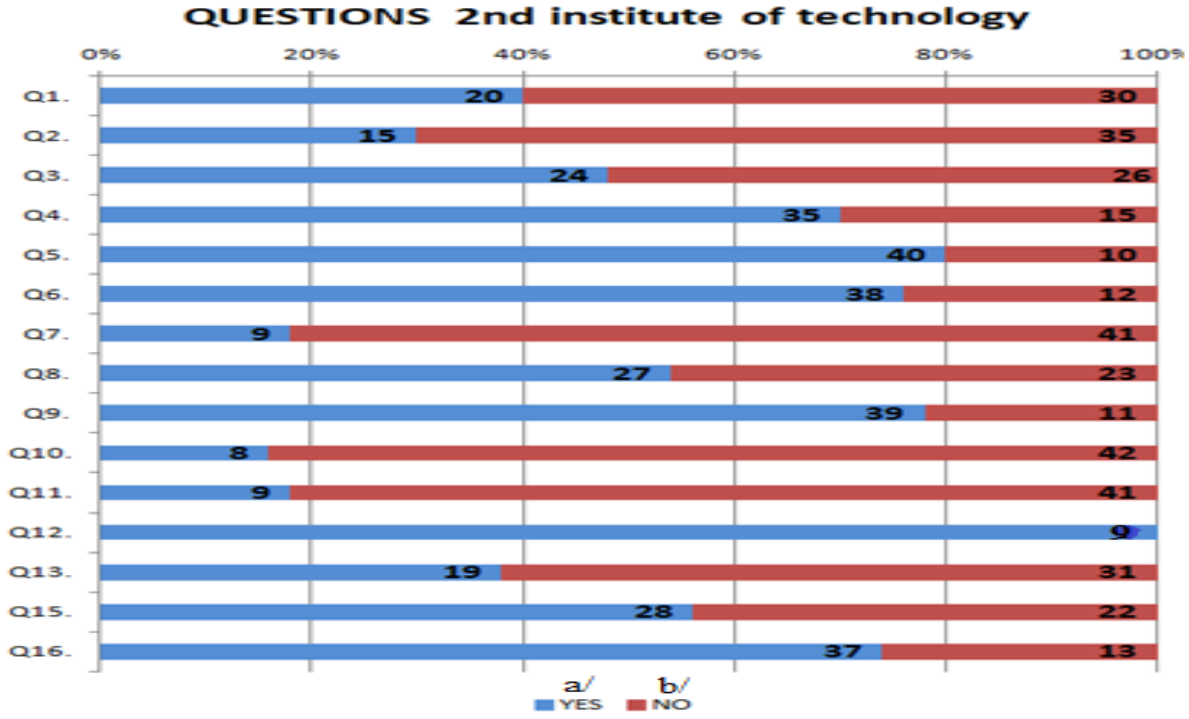


FIGURE 19. All answers for the 2nd Institute of Technology

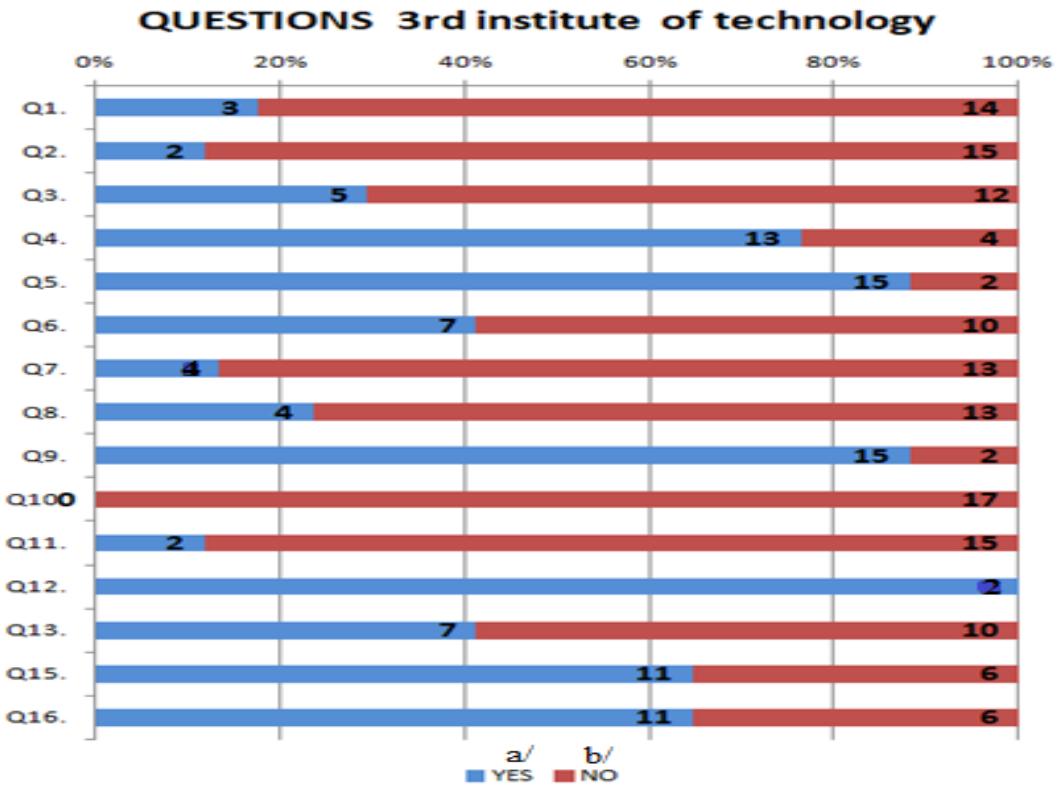


FIGURE 20. All answers for the 3rd Institute of Technology

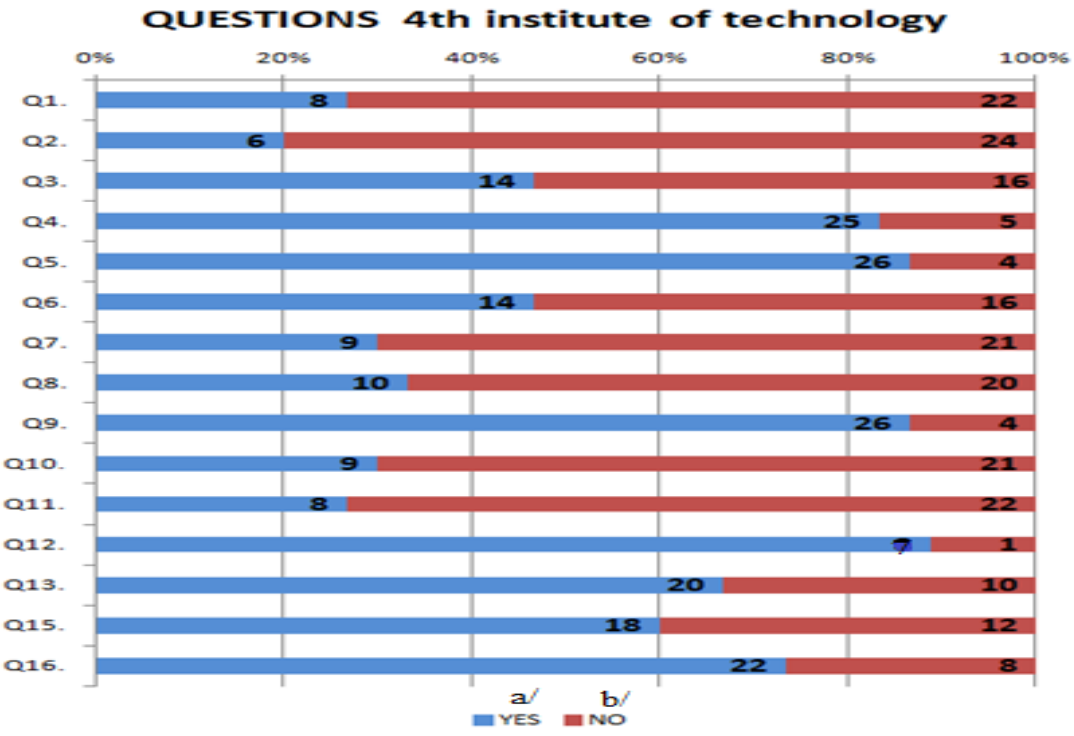


FIGURE 21. All answers for the 4th Institute of Technology

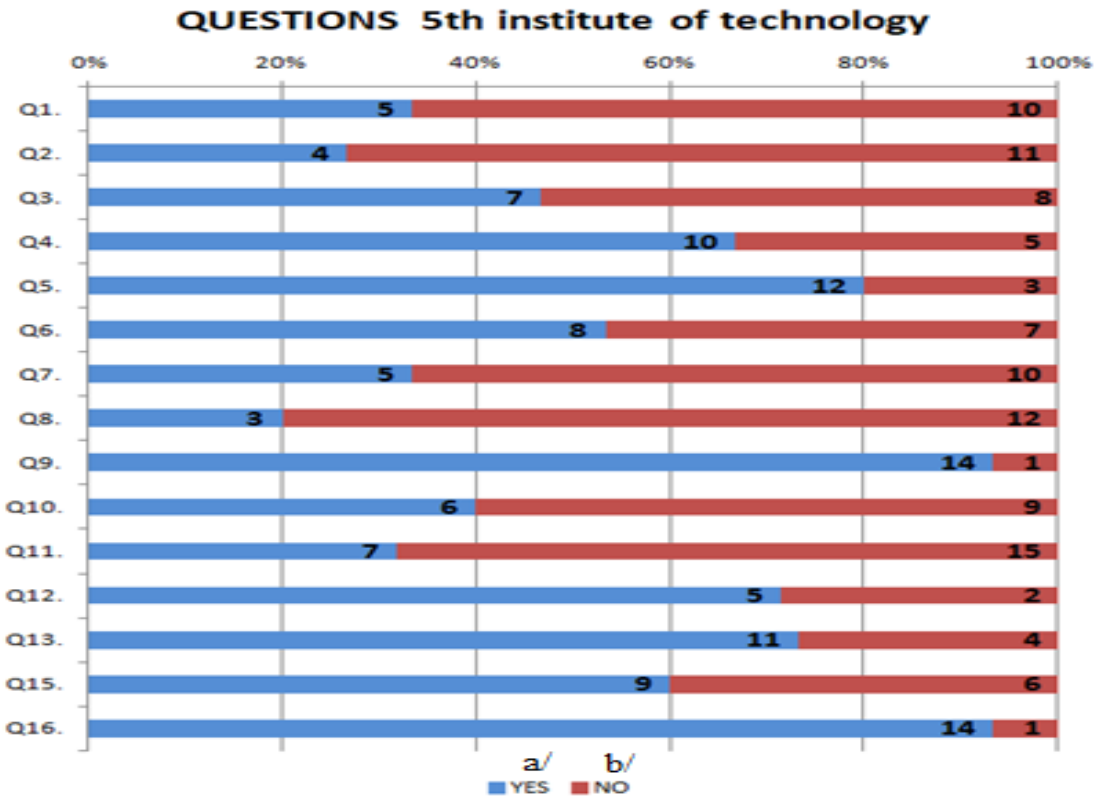


FIGURE 22. All answers for the 5th Institute of Technology

Judging from the results, it is obvious that in the most critical questions that prove students' knowledge of the relationship among technology and the law and the rights of the inventor, IT1, which is the only Institute that includes in its curriculum a course related to Law and Information Technology, gave the following answers:

- In Q1 the majority knew that IPL concerns technology scientists
- In Q2 the majority knew that computer and AI achievements may be patentable subjects
- In Q3 the majority knew that an inventor can protect the paternity of his idea and its exclusive commercial exploitation
- In Q4 the majority knew that an algorithm is not patentable, however the majority of students did not know that the code of a computer is not patentable(Q5)
- In Q12 the majority answered that in case of their invention they would consult a lawyer rather than reveal their invention

In contrast, the other 4 Institutes of Technology, in these questions had opposite percentages indicating the absence of teaching.

Afterwards, the conclusion is that graduate students of Greece's Institutes of Technology need to be aware of the legal and entrepreneurial framework of a technical invention. It is of vital importance to distinguish what is patentable and what is not, what novel means regarding an invention, what is the inventive step, what means prior art and which invention is regarded as industrial applicable. All these are the requirements in order to grant a patent. They should also have the knowhow to define the technical field of their invention, to claim their invention and to define the required protection, through the disclosed claims in the patent application. They should be capable of guiding a person state in the art, like an examiner of a Patent Office, to reach the desirable result by undertaking every step mentioned in the description of the claimed invention. Then, an inventor of technology fields can apply for a patent and ensure priority for the potential invention the day of his application.

In addition, students should have entrepreneurial knowledge. They should be able to evaluate the feasibility of their invention. They should have the knowhow to understand whether they can support and afford an invention relying on their own

strengths by establishing a start-up company, or whether they could otherwise negotiate with an existing company about the possibility of selling their intellectual property rights. They should know the value of possessing a patent portfolio and they should develop managerial skills in order to cope with the competition of the technology industry.

Further, regarding the curriculum of Greece's Institutes of Technology, we assume that the level of students' learning is offered for further development of skills in the fields of Law and Entrepreneurship. Furthermore, as far as what concerns the results of the survey, we conclude that the students trust Patent Law, are positive to enter the business world and are also motivated from technology to establish a start- up company. They are willing to fight competition and survive in the industry of technology and they are willing to undertake and finance a patent procedure for their potential invention.

Eventually, from the literature it was presented above with the papers that contributed in this study in the field of IPR, Patent Law, smart technology and industrial world, the great impact of IP on industry of technology is realized, education in the field of computer science and society. We also realized the efforts from all professionals in adjusting law to the rapidly evolvement of technology, the issue for patent eligibility of computer implemented inventions and AI implemented inventions and last but not least the utility of AI machine learning algorithms and Big data to conclude through given patent domains the value of patents and their technical advantage. Therefore, the results from relevant surveys and studies in the literature indicate the importance of focusing the education of graduates from technological Institutes in IP courses. The majority of studies and surveys in literature refer to the point of view of technology management professionals, inventors, R&D firms and technological companies and universities as far as how to develop an e-learning IP support program, a course of law for computer professionals and e-learning course of IP for students. Although, there exist a study in the literature, see [81] including a survey conducted in 5 China's universities for engineering students' as for the need of IP education, to the best of the authors’ knowledge, this is the first time that a survey, which refers to graduate students of Technical Institutes in Greece and the rest world, is conducted and examines their knowhow on Entrepreneurship and on Patent Law, in the direction of supporting a potential technological invention. In this survey, similarly with earlier results excluding from the

literature, it is realized the primordial importance of developing and inserting in the technical universities' curriculum a course for IP activities to support invention.

2.5 Conclusion

Combining the fields of IPL and technological innovation, a survey was created, using a questionnaire that was distributed in 2019 to graduated students of 5 Institutes of Technology in Greece. The purpose of the research is to determine whether Greece's potential inventors have the technical skills to support a potential innovative idea.

Based on the research the conclusions follow:

Technology students are not consciously aware of the Patent Law. However they have confidence in the patent institution. There is a lack of knowledge in the field of patenting technological inventions. Technology students should not only be able to conceive and implement an innovative idea, but should be able to support and protect their intellectual property. They need to know what subject is patented, regarding technology fields, what a patent may offer to them and they should be given the opportunity to use their intellectual asset in their own free will. They should have entrepreneurial knowledge so as to understand the value of possessing a patent portfolio and they should develop managerial skills in order to cope with the competition of the technology industry.

Furthermore, based on the results, the conclusion is that questioned students of Greece are willing to patronize their potential invention by granting a patent, as well as they intend to commercially exploit their potential invention.

At the same time they have a positive attitude and motivation for entrepreneurship and they want to get involved in the technological industry. They are willing to establish their own business which ensures a contribution to the country's future economy and believe that a nascent technology company can cope with the competition in the industry of technological innovation. They believe that it is worth to undertake and financially support a patent granting process in order to protect an innovation from infringement.

Moreover, they regard that an invention should be available to the public earlier than the 20 years that provides the Patent Law, and therefore contribution in society's technological advancement is achieved. So, maybe it is time for the law to be revised.

Furthermore, judging from the results of the survey, it is obvious that in the most critical questions, that prove students' knowledge of the relationship among technology, the law and the rights of the inventor, the students' answers, of the only Institute that includes in its curriculum a course related to Law and Information Technology, indicated knowhow that obviously comes from the teaching of the respective course. In contrast, the other 4 Institutes of Technology, in these questions had opposite percentages indicating the absence of teaching a Patent Law course.

Therefore, it is imperative that the curriculum of Greek university Technology Institutes be enriched with courses of Intellectual Property and entrepreneurship, too.

Further, it is recommended for the students of Technical Institutes to participate, by preparing a patent or a business plan for a technical invention, in patent contests or contests for innovation and startup companies. Many patent contests are organized nowadays from private and public institutions of every country with a view to promote innovation and technology.

In addition, technical universities should install technology transfer offices to promote patenting. A technology transfer office can promote academic patenting and the establishment of start-up companies basing on patents. The collaboration between industry and university through this action may also be encouraged.

Last but not least, it is recommended that Patent Offices, included the national Patent Office in Greece, should collaborate with the Institutes of Technology and take action for the preparation of distance learning programs regarding the information of new inventors about the procedures for applying for a patent and the legal protection, national or wider, they may require for their potential invention.

Consequently, only then we can refer to integrated scientist technocrats who can protect their Intellectual Property, are able to manage a competitive business and therefore contribute to smart technology industry and society's well being.

2.6 Future Work

As it has been already mentioned, the technology industry is increasingly pointing out the need for IPL education at technical universities. Therefore, in the near future, the intention is to conduct this survey in other European countries and the rest of the world, in order to draw conclusions about the knowhow of graduate students, of Technological Institutes, on Patent Law, Entrepreneurship, and their skills in managing a potential technological invention.

In this direction, we will have a more comprehensive view of the overall education of young scientists in the global industry of technological innovation and then measures may be applied, where it is deemed useful, in terms of integrating IP courses in the curriculum of technical universities.

Further, my intention is also to develop an IPL course for undergraduate students of technical universities to serve the purpose of educating students in terms of Intellectual Property and both legal and managerial issues that concern an inventor. This course will require 2 hours of lectures per week for 15 weeks, which will not be time consuming and will not burden an existing compulsory education program.

2.7 REFERENCES

[60] S. Shamim, S. Cang, H. Yu, Y. Li, L. Y. Chen and X. Yao, "How firms in emerging economies can learn industry 4.0 by extracting knowledge from their foreign partners? A view point from strategic management perspective," *2019 International Conference on Advanced Mechatronic Systems (ICAMechS)*, Kusatsu, Shiga, Japan, 2019, pp. 390-395. doi: 10.1109/ICAMechS.2019.8861622

[61] S. Hu and T. Jiang, "Artificial Intelligence Technology Challenges Patent Laws," *2019 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*, Changsha, China, 2019, pp. 241-244. doi: 10.1109/ICITBS.2019.00064

[62] C. Stergiou, K. E. Psannis, A. P. Plageras, G. Kokkonis and Y. Ishibashi, "Architecture for security monitoring in IoT environments," *2017 IEEE 26th International Symposium on Industrial Electronics (ISIE)*, Edinburgh, 2017, pp. 1382-1385. doi: 10.1109/ISIE.2017.8001447

[63] S. Okara, S. Broering and N. Sick, "Anticipating Industry Convergence in the Context of Industry 4.0," *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*, Honolulu, HI, 2018, pp. 1-8. doi: 10.23919/PICMET.2018.8481794

[64] A. P. Plageras and K. E. Psannis, "Algorithms for Big Data Delivery over the Internet of Things," *2017 IEEE 19th Conference on Business Informatics (CBI)*, Thessaloniki, 2017, pp. 202-206. doi: 10.1109/CBI.2017.27

[65] S. Hu, "Patent Protection for Artificial Intelligence in China," *2019 International Conference on Virtual Reality and Intelligent Systems (ICVRIS)*, Jishou, China, 2019, pp. 295-298. doi: 10.1109/ICVRIS.2019.00078

[66] Bernd Carsten Stahl, Job Timmermans, and Brent Daniel Mittelstadt, "The ethics of computing: A survey of the computing-oriented literature," ACM Comput. Surv. 48, 4, Article 55, Feb. 2016.

[67] Convention on the Grant of European Patents, EPC,1973, https://www.epo.org/law-practice/legal-texts/epc.html

[68] W. Liu and X. Yu, "Cultivating Intellectual Property Education in the Electronics Engineering Curriculum: A Case Study in Integrated Circuit Design," in *IEEE Access*, vol. 7, pp. 101401-101414, 2019. doi: 10.1109/ACCESS.2019.2931343

[69] C. Hanewicz, P. Becker and P. Alin, "Maintaining the Relevance of Technology Management Programs in an Entrepreneurial Environment," *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*, Honolulu, HI, 2018, pp. 1-7. doi: 10.23919/PICMET.2018.8481791

[70] M. Sako and K. Kato, "Research on the harmonization of intellectual property systems from the point of view of Japanese inventors," *2017 IEEE Technology & Engineering Management Conference (TEMSCON)*, Santa Clara, CA, 2017, pp. 245-251.
doi: 10.1109/TEMSCON.2017.7998384

[71] J. Shim and Y. Deguchi, "Conjoint comparison of support systems for intellectual property activities of university students in science and engineering majors in Korea and Japan," *Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012*, Hong Kong, 2012, pp. W2D-4-W2D-6. doi: 10.1109/TALE.2012.6360303

[72] T. Saiki, "Patent survey to Japanese R&D-directed firms," *Proceedings of PICMET '14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration*, Kanazawa, 2014, pp. 1431-1436.

[73] L. Y. Y. Lu and J. S. Liu, "A survey of intellectual property rights literature from 1971 to 2012: The main path analysis," *Proceedings of PICMET '14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration*, Kanazawa, 2014, pp. 1274-1280.

[74] A. Wilk, "Cyber Security Education and Law," *2016 IEEE International Conference on Software Science, Technology and Engineering (SWSTE)*, Beer-Sheva, 2016, pp. 94-103.
doi: 10.1109/SWSTE.2016.21

[75] Q. Lin and Z. Lian, "A study of the innovation and protection mechanisms for the cultural and creative industries," *2017 International Conference on Applied System Innovation (ICASI)*, Sapporo, 2017, pp. 133-135.
doi: 10.1109/ICASI.2017.7988603

[76] S. Nemet, M. Barić, F. Bencić and D. Kukolj, "Comparative Technology Assessment using Patent Evaluation," *2018 Zooming Innovation in Consumer Technologies Conference (ZINC)*, Novi Sad, 2018,pp.162-165. doi: 10.1109/ZINC.2018.8448935

[77] J. Li, "Intellectual property licensing tensions in incorporating open source into formal standard setting context — The case of Apache V.2 in ETSI as a start," *2017 ITU Kaleidoscope: Challenges for a Data-Driven Society (ITU K)*, Nanjing, 2017, pp. 1-8.
doi: 10.23919/ITU-WT.2017.8246986

[78] D. Müller, Y. Te and P. Jain, "Predicting business performance through patent applications," *2017 IEEE International Conference on Big Data (Big Data)*, Boston, MA, 2017, pp. 4159-4164.
doi: 10.1109/BigData.2017.8258438

[79] S. Hu, "The Influence of Artificial Intelligence Development on Patent Legislation," *2019 International Conference on Robots & Intelligent System (ICRIS)*, Haikou, China, 2019, pp. 110-113.
doi: 10.1109/ICRIS.2019.00036

[80] T. Kose, H. Yamano and I. Sakata, "Detecting Emerging Complex Technological Fields in Robotics," *2019 Portland International Conference on Management of*

Engineering and Technology (PICMET), Portland, OR, USA, 2019, pp. 1-12. doi: 10.23919/PICMET.2019.8893969

[81] A. J. C. Trappey, C. V. Trappey, U. H. Govindarajan and J. J. H. Sun, "Patent Value Analysis Using Deep Learning Models—The Case of IoT Technology Mining for the Manufacturing Industry," in *IEEE Transactions on Engineering Management*. doi: 10.1109/TEM.2019.2957842

[82] M. Shibata, Y. Ohtsuka, M. Takahashi and K. Okamoto, "Advanced FPGA technology trend based on patent analysis with link mining," *2018 International Conference on Electronics Packaging and iMAPS All Asia Conference (ICEP-IAAC)*, Mie, 2018, pp. 147-151. doi: 10.23919/ICEP.2018.8374691

[83] J. Zhang, Y. Guan, X. Qu, H. B. Liaqat and Y. Li, "Research on Technology Similarity of Enterprises Based on Patent Bibliometrics," *2018 IEEE International Conference on Smart Internet of Things (SmartIoT)*, Xi'an, 2018, pp. 204-209. doi: 10.1109/SmartIoT.2018.00044

[84] T. Akakura, T. Kawamata and K. Kato, "Development and Use of a Video On Demand e-Learning System with Logic Circuit Exercises for Teaching Intellectual Property Law," *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, Wollongong, NSW, 2018, pp. 883-886. doi: 10.1109/TALE.2018.8615187

[85] T. Jiang and S. Hu, "Intellectual Property Protection for AI-Related Inventions in Japan," *2019 International Conference on Virtual Reality and Intelligent Systems (ICVRIS)*, Jishou, China, 2019, pp. 286-289. doi: 10.1109/ICVRIS.2019.00076

[86] C. Zhang, K. Tsukioka, D. Yin and K. Motohashi, "Innovation Strategy and Technological Catch-Up of Chinese Internet Giants: Evidence Based on Patent Data," *2019 Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, USA, 2019, pp. 1-14. doi: 10.23919/PICMET.2019.8893774

[87] Daniel Gervais, Is Intellectual Property Law Ready for Artificial Intelligence?, GRUR International, Volume 69, Issue 2, February 2020, Pages 117–118, https://doi.org/10.1093/grurint/ikz025

[88] Xiang Li, Chanil Pak & Kexin Bi (2020) Analysis of the development trends and innovation characteristics of Internet of Things technology – based on patentometrics and bibliometrics, Technology Analysis & Strategic Management, 32:1, 104-118, DOI: 10.1080/09537325.2019.1636960

[89] Amy J.C. Trappey, Charles V. Trappey, Jheng-Long Wu, Jack W.C. Wang, Intelligent compilation of patent summaries using machine learning and natural language processing techniques, Advanced Engineering Informatics, Volume 43, 2020,101027, ISSN 1474-0346, https://doi.org/10.1016/j.aei.2019.101027.

[90] Wang Y., Zhang L. (2020) Research on Intellectual Property Protection of Industrial Innovation Under the Background of Big Data. In: Huang C., Chan YW., Yen N. (eds) Data Processing Techniques and Applications for Cyber-Physical Systems (DPTA 2019). Advances in Intelligent Systems and Computing, vol 1088. Springer, Singapore, DOI https://doi.org/10.1007/978-981-15-1468-5_210

[91] Haney, Brian S., AI Patents: A Data Driven Approach (January 28, 2020). Brian S. Haney, AI Patents: A Data Driven Approach, 19 Chi.-Kent J. Intell. Prop. __ (2020)(Forthcoming). Available at SSRN: https://ssrn.com/abstract=3527154 or http://dx.doi.org/10.2139/ssrn.3527154

[92] Kadian, T. (2020). An Introduction To Intellectual Property Rights and Their Importance In Indian Context. *Our Heritage*, *68*(1), 6252-6256. Retrieved from https://archives.ourheritagejournal.com/index.php/oh/article/view/1664

[93] Lisa Larrimore Ouellette, Andrew Tutt, How do patent incentives affect university researchers?, International Review of Law and Economics,Volume 61,2020,105883 ,ISSN 0144-8188, https://doi.org/10.1016/j.irle.2019.105883.

[94] Alice Civera, Michele Meoli, Silvio Vismara,Engagement of academics in university technology transfer: Opportunity and necessity academic entrepreneurship,European Economic Review,Volume 123,2020,103376,ISSN 0014-2921, https://doi.org/10.1016/j.euroecorev.2020.103376.

[95] Sun, Y., Zhang, C. & Kok, R.A.W. The role of research outcome quality in the relationship between university research collaboration and technology transfer: empirical results from China. *Scientometrics* **122,** 1003–1026 (2020). https://doi.org/10.1007/s11192-019-03330-6

[96] Audretsch, D.B., Link, A.N. & van Hasselt, M. Knowledge begets knowledge: university knowledge spillovers and the output of scientific papers from U.S. Small Business Innovation Research (SBIR) projects. *Scientometrics* **121,** 1367–1383 (2019). https://doi.org/10.1007/s11192-019-03260-3

[97] Elliott, C., Mavriplis, C. & Anis, H. An entrepreneurship education and peer mentoring program for women in STEM: mentors' experiences and perceptions of entrepreneurial self-efficacy and intent. *Int Entrep Manag J* (2020). https://doi.org/10.1007/s11365-019-00624-2

[98] de Haan, U., Shwartz, S.C. & Gómez-Baquero, F. A startup postdoc program as a channel for university technology transfer: the case of the Runway Startup Postdoc Program at the Jacobs Technion–Cornell Institute at Cornell Tech. J Technol Transf (2019). https://doi.org/10.1007/s10961-019-09764-7

[99] Kirby, D.A., El Hadidi, H.H. University technology transfer efficiency in a factor driven economy: the need for a coherent policy in Egypt. *J Technol Transf* **44,** 1367–1395 (2019). https://doi.org/10.1007/s10961-019-09737-w

[100] Sun, X., Zhou, X., Wang, Q. et al. Understanding attitudes towards intellectual property from the perspective of design professionals. Electron Commer Res (2019). https://doi.org/10.1007/s10660-019-09378-z

[101] Sohn, S.Y., Han, E.J. Engineering graduate students' views on the effective ownership of academic patents. *J Technol Transf* **44,** 132–154 (2019). https://doi.org/10.1007/s10961-017-9598-4

[102] Backs, S., Günther, M. & Stummer, C. Stimulating academic patenting in a university ecosystem: an agent-based simulation approach. *J Technol Transf* **44,** 434–461 (2019). https://doi.org/10.1007/s10961-018-9697-x

[103] Jefferson, D.J., Maida, M., Farkas, A. *et al.* Technology transfer in the Americas: common and divergent practices among major research universities and public sector

institutions. *J Technol Transf* **42,** 1307–1333 (2017). https://doi.org/10.1007/s10961-016-9516-1

Chapter 3:

Smart buildings with emphasis in Energy Efficiency: Regulatory approaches

3.1 Introduction

We are moving through the era of technological innovation, artificial intelligence, Industry 4.0, as it is called. The integration of smart technology into all sectors of society is a reality and a mean to facilitate and simplify everyday life.

In this thesis, the legal framework that concerns software related inventions was presented. Furthermore, by researching topics related to the education of technology students in technology law, the trend in Greek technological universities was observed, in terms of inventing and commercializing a potential innovative idea.

In addition, in this research, the Regulatory framework that concerns the energy efficiency of smart buildings will be presented, as well. This topic connects the limits that are set by laws in European society with IoT technology, which is an example of modern technology applied in smart cities. IoT's devices and applications, according to their design and development, achieve specific results and consist of software and hardware which means that as inventions, they are protected by Patent Law.

Further, the application of smart technology in society is introduced and presented, by directly exploiting the positive effects of technology on energy management. The reference to European's Union legislation of the gradually transformation of the building potential of all European Member States into smart buildings, is significant. This transformation process is in progress with the proposals from the European Union for using technological means with a view to save energy, with the corresponding proposals from all Member States for the cultivation of energy behavior to European citizens, and with the progressive adjustments of all technical systems in a building, in order to operate without energy losses. The development of a more efficient building certification and compliance checking for the building inspections will contribute in this direction and the total transformation of buildings into energy efficient buildings will imply reduce of carbon emissions and environmental sustainability.

3.2 Smart Technology strengthens cities' sustainability

A Smart City utilizes technology and data in order to improve the sustainability of the city and the environment and offer to the citizens, quality of life. A smart city generally focuses on the resilience of the city. Specifically focuses on energy efficiency, on the reduction of energy consumption, on the energy performance of all technical systems, on the replacement of technical systems with others that achieve energy savings, on the reduction of the Co2 emissions, on simplifier the citizen's life, offer them convenience and healthy living conditions and last but not least, on protecting and ensuring the longevity of the planet.

The 2012 Energy Efficiency Directive, EED (2012/27/EU)[104] establishes a set of binding measures to urge the Europe to live in a more energy efficient manner. According to this Directive the target for Europe is to decrease by 20%, the total energy consumption, by 2020. The Directive refers to all European countries and focuses on reducing energy consumption in all stages of the energy chain, "energy generation, transmission, distribution and end-use consumption."

For the purpose of implementing the 2012 Directive, measures have been already adopted throughout the Europe to improve energy efficiency, in favor of the benefit of the European citizens. Initially, these measures achieved for new buildings to consume half of the energy that buildings consumed in the 1980s, energy consumption in European industry decreased by 16% between 2005 and 2014, the share of refrigerators in the highest energy efficiency labeling classes (A and above) increased from less than 5% in 1995 to more than 90% in 2010. According to the European Commission, [105], these measures include:

- The preparation of long-term renovation strategies from all European Member States, for the period from 2021 to 2030, which is a 10-year integrated national energy and climate plan (NECP) stating the targets to achieve for 2030, including energy efficiency.

- the preparation of national energy efficiency action plans (NEEAPs) every three years to report the progress as for energy efficiency on a national and annual basis.

- national long-term renovation strategies for the building stock in each European country

- buildings' inspections and energy efficiency certificates for the building stock in each European country

- energy efficient renovations in each European country, to at least 3% per year of the building stock that is owned or occupied by central governments

- European countries should establish the energy efficiency obligation scheme according to which energy companies should achieve yearly energy savings of 1.5% of annual sales to final consumers.

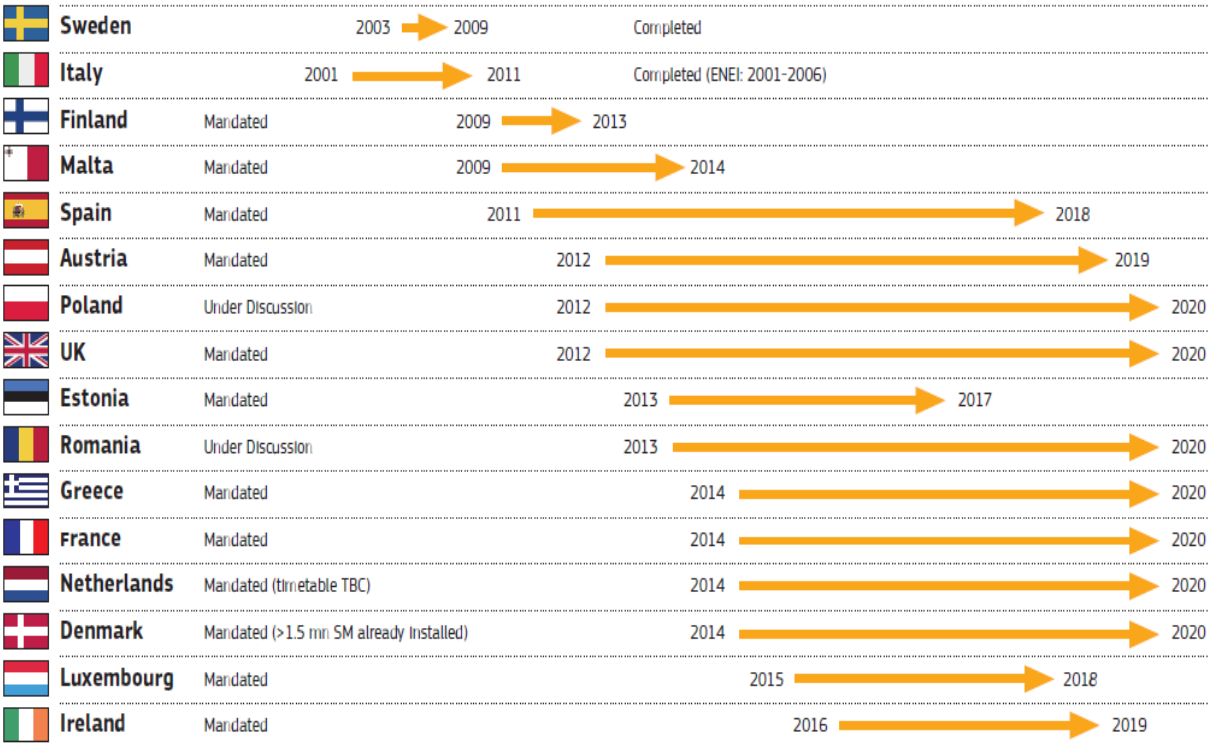
- minimum energy efficiency standards and ecodesign for products such as boilers, household appliances, lighting and televisions. More efficient appliances are expected to save consumers €100 billion annually or about €465 per household on their energy bills by 2020

- the distribution of 200 million smart meters for electricity and 45 million smart gas meters by 2020, in order to achieve savings for consumers, in respect to Art 9 and 10 of the EED, see Fig.3.1

- the introduction of Energy Efficiency Obligation Schemes (EEOSs) which states the obligation of energy companies to achieve yearly energy savings of 1.5% of annual sales to final consumers, see Fig.3.2 , in respect to Art 7 of the EED

- large companies conducting energy audits every four years

Figure 4: Roll-out timing of smart metering in EU Member States



Source: Odyssee Mure (2015)[8] based on European Commission data (2014)[9]

Fig.3.1 Smart metering in EU States[106]

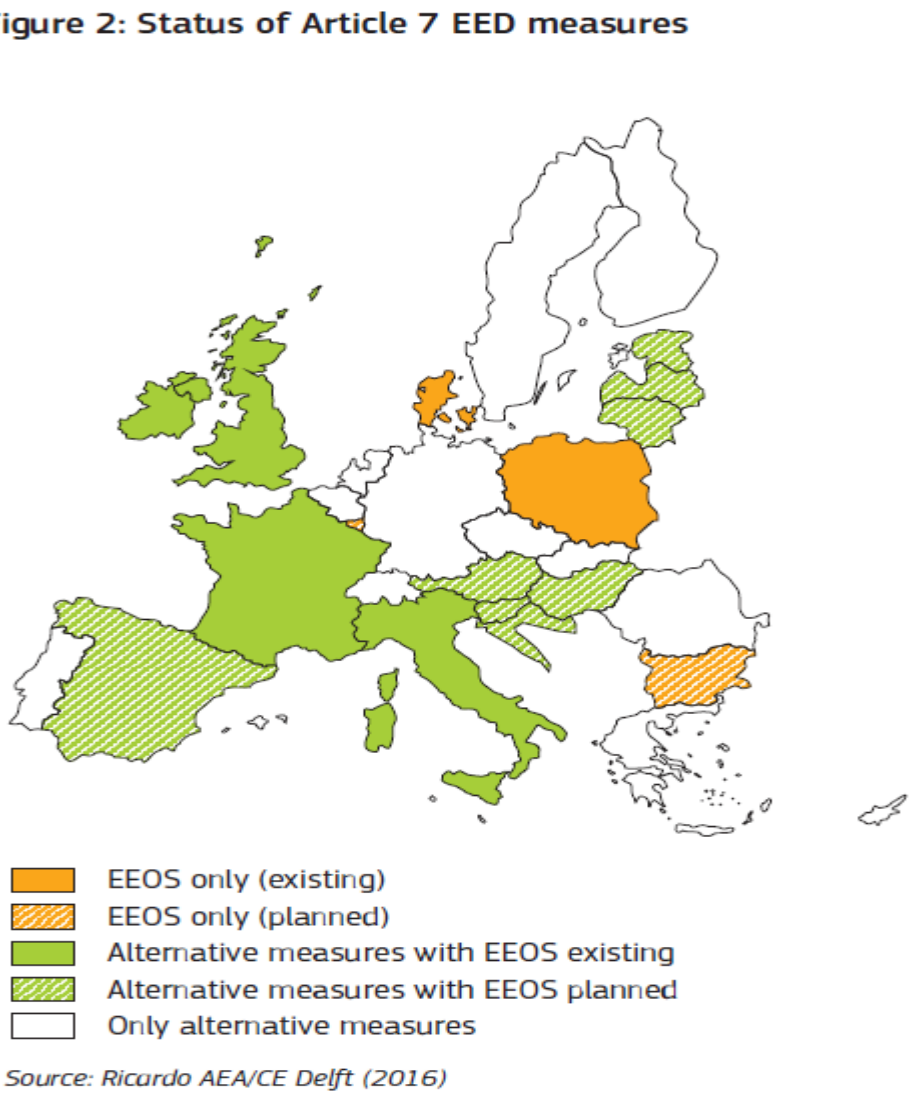


Fig.3.2 Status of art 7 of the EED measures [106]

According to the European Commission, [105], European countries may also implement alternative policy measures in order to reduce final energy consumption such as:

- energy taxes in case of energy wasting or CO2 taxes
- financial motivation in order to use energy efficient technology
- energy labeling schemes beyond those that are already mandatory under European Law
- training and education, including energy advisory programmes

3.3 Energy Performance of Buildings

According to the European Commission "Nearly zero-energy buildings (NZEB) are buildings with very high energy performance. The low amount of energy that these buildings require comes mostly from renewable sources [107].

The Commission's intention is to monitor the efforts and the progress regarding the transformation of existing buildings into nearly zero-energy buildings or the construction of new smart buildings that the Member States attempt. The Commission progress report (COM(2013)483) found that European countries need to increase their efforts regarding the topic NZEBs and that they should implement all perspectives of NZEBs.

In 2014, the Commission monitored and reported on the progress of European countries regarding the NZEB target. This information was presented through a report, considering information on targets and policy measures for NZEBs and through a table which refers to the national application of the NZEBs. The results were that, in 2014, European building stock contributed to the European Union's greenhouse gas emissions by a percentage of 30 % and this means that the building stock consumes about 40% of the European Union's total energy consumption and 36% of the CO2 emissions. Therefore, it was obvious that an increase in the number of buildings would lead to an increase in energy consumptions and Co2 emissions, if the minimum requirements for energy performance would not have been applied. At this point it was important for all Member States of European Union

1)to develop long term strategies regarding the renovation of the national building stock

2) to comply with energy efficient standards and legislation, not only for the new constructions of buildings ,but also to establish laws for the transformation of the existing buildings into NZEB.

In December 2018, with a view to expand the Directive on Energy Efficiency to 2030 and beyond, the new amending Directive on Energy Efficiency (2018/2002)[108]

was entered into force by the European Member States. This amending directive which should be transposed into national law by Member States by 25 June 2020, states an energy efficiency target of 32.5% by 2030. According to 2018/2002 amending directive, for the period 2021-2030, the European countries will have to reduce final energy consumption by 0.8% each year.

The amended directive stipulates strict rules regarding buildings and thermal energy. The citizens should have the right to be informed for their energy consumption through their heating bills and metering and billing of thermal energy should be checked on a frequent and strict basis. Furthermore, all Member States are obliged to establish national rules available to the public regarding multi-apartment and multi-purpose buildings with collective systems, as for the allocation of the cost of heating, cooling and hot water consumption. In addition, all Member States should monitor the energy efficiency levels also in new technical systems to observe the energy performance and the energy savings and they should reduce the primary energy factor for electricity generation from 2.5 to 2.1.

At this point, it is important to mention that 35% of the Europe's buildings were over 50 years old and almost 75% of the building stock, energy inefficient. At the same time, only about 1% of the building stock was renovated each year. Therefore, the amended Energy Performance of Buildings Directive (EU)2018/844,[109] EPBD, introduces measures relating to national long-term renovation strategies basing on technological improvements. The Renovation of the building stock can lead to energy savings, by reducing the Europe's total energy consumption about 6% and reduce CO2 emissions by 5%.Investments in energy efficiency will be beneficial for the economy, SMEs represent the 70% of European's industry of construction and will benefit from renovation, as well.

According to the EPBD, from 31 December 2020. all new buildings that will be constructed must be nearly zero-energy buildings (NZEB) and since 31 December 2018, all new public buildings should already be NZEB. Therefore, European countries

- need to establish strong long-term renovation strategies, in order to decarbonise the national building stocks by 2050, with indicative

milestones for 2030, 2040 and 2050. The long-term renovation strategies should include:

  - an overview of the national building stock
  - policies and actions to target the worst performing buildings,
  - national initiatives to promote smart technologies, education in the construction and energy efficient behavior to the citizens

- should introduce cost effective and optimal energy performance requirements
  - for new buildings,
  - for existing buildings under major renovation,
  - for the replacement of building's technical systems (heating and cooling systems, roofs and walls).
- should establish inspections for heating and air conditioning systems
- should issue energy performance certificates when a building is sold or rented,
- should establish Management Systems for the buildings to achieve automation and control with smart devices, by utilizing smart technologies.
- should ensure well-being of building users and healthy conditions, regarding the air quality and the ventilation system in a building.
- should introduce national financial measures to improve the energy efficiency of buildings

- should purchase only in energy efficient buildings to be used as central government buildings and also under the Energy Efficiency Directive (2012/27/EU)[104].

- should transform every year into energy efficient at least 3% of the total floor area of buildings owned and occupied by central governments. Up to now, public building inventories of all government buildings with a total useful floor area of over 500 m^2, were prepared from:

    - Greece
    - Cyprus
    - Estonia
    - Latvia
    - Lithuania
    - Luxembourg
    - Spain

The Commission has also established standards to support the EPBD with the name: "the energy performance of buildings standards" (EPB standards), [110]. In addition, the Commission has also published recommendations on the building renovation (EU)2019/786[111] and building modernisation (EU)2019/1019 [112].

3.4 Energy Performance Certificates

The Energy Performance of Buildings Directive 2010/31/EU (EPBD),[113] states that all Member States must take measures to ensure that the minimum requirements for energy performance in new buildings or in new building units or in major renovations are applied. However, Scotland, England and Wales introduced minimum standards for energy performance of letting, too. The Energy Performance certificates, under the Energy Performance of Buildings Directive (2010/31/EU), asks from European countries to provide information on the certificates, regarding the energy performance of buildings during an inspection of it. European countries should also through the certificates present cost-effective ways and financial instruments to improve the energy performance of the building to the owners or tenants of the buildings.

European countries must especially consider in the inspection of a building the monitor of the Heat, Ventilation, Air condition (HVAC) technical systems as for their energy performance. Then regarding the results of the inspection they should recommend measures for energy savings. Therefore, under the Energy Performance of Buildings Directive (2010/31/EU), all European countries have established independent control systems for energy performance certificates and inspection reports for heating and cooling systems due to the fact that heating and cooling in buildings and industry energy is the half of the total Europe's energy consumption. According to Eurostat in 2018 the 75% of heating and cooling is still generated from fossil fuels and only the 19% is generated from renewable energy sources. Consequently, it is of great importance to increase the use of renewable energy and decrease the use of fossil fuels and the waste of energy. Smart solutions through technology and renewable sources of energy should be utilised on construction and renovation of buildings to manage the energy consumption of the HVAC technical systems of a building. According to Art 14 of the Energy Efficiency Directive (2012/27/EU)[104], all European countries are requested to conduct a report on energy efficiency in heating and cooling. European countries should submit their reports until 31 December 2020 and this report may be conducted every 5 years under the Commission's judgment.

In order to have an approximate view of the energy performance of a country's buildings, nowadays, there exist a database with sources come from: Eurostat, the European Commission's Joint Research Centre, EU funded projects ,data from national and official statistics in the EU countries, databases on energy performance certificates and data from market providers. The European Building Stock Observatory (BSO) was established in 2016 as part of the Clean energy for all Europeans package and intends to provide conclusions on the energy performance of each country's national buildings through reliable data that stem from the buildings' inspections and encourage the application of measures and policy. The BSO ,[114] ,contains a database, a data mapper and factsheets for monitoring the energy performance of buildings across Europe.

There are 250 indicators feeding into the BSO database that refer to energy topics and provide information on

- building stock characteristics
- building shell performance
- technical building systems
- nearly Zero-Energy Buildings
- building renovation
- energy consumption
- certification
- financing
- energy poverty
- energy market

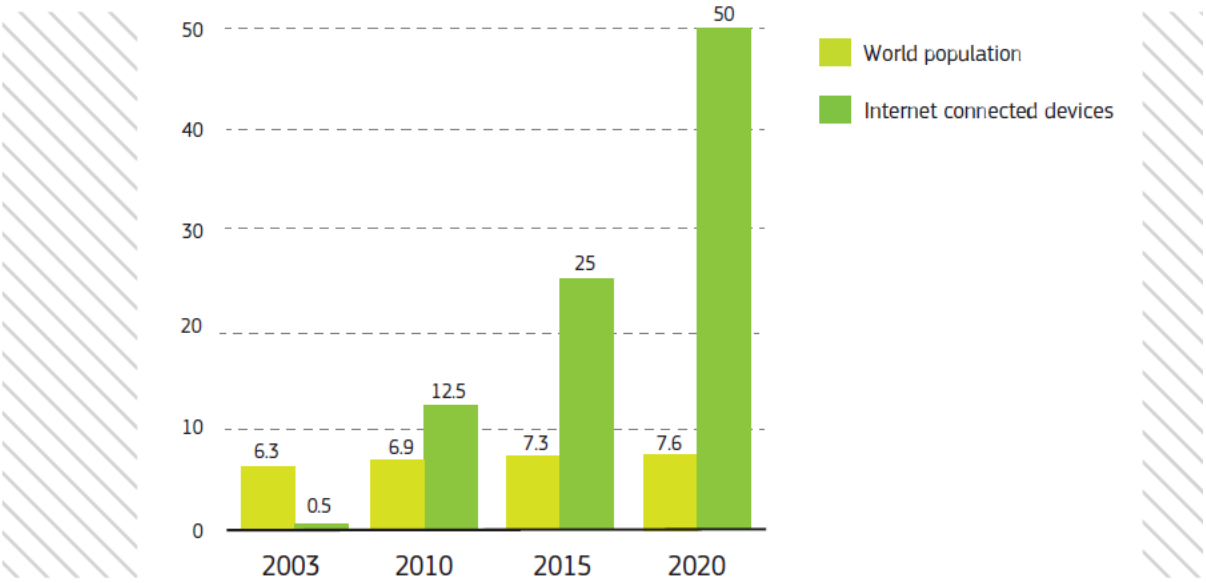
There also exists the BSO datamapper,[115] , which uses maps and graphs to present indicators and enables comparison regarding data among European countries. Further, there is the option to publish the results from the database, through factsheets. The factsheets of every country are a national policy context by presenting indicators and recommendations, in relation to implementation of European buildings legislation.

3.5 Smart Buildings and Smart Technology

Information and telecommunication technology (ICT), the Internet of Things (IOT) and the Internet of Energy (IOE) has a crucial role to play in the transformations of cities to sustainable smart cities. They can be utilised to develop an optimised energy management system in order to monitor and control the demand-supply of energy among the technical systems of a building in real time, to manage the energy distribution optimally, and integrate, during a technical system's operation, energy consumption from renewable energy sources alternatively. This Building Energy Management System (BEMS) will provide to the occupant real time information and interaction with the grid and will adjust all smart building's systems according to the occupant's convenience.

The target to achieve, is to keep internet-connected the technical systems and devices of a building, to check energy consumption, energy performance, the correlation between energy savings and occupants' green behavior. Through an IoT system the establishment of a connection between energy markets and end-users, so as to promote the consumption of renewable and low priced electricity from the spot market, by using a dynamic electricity tariff, can also be true. The following figure illustrates the number of smart devices that are connected to the internet through the years 2003 to 2020.

Figure 10: Number of internet-connected devices comparing to the world's population



Source: 'The Internet of Things – How the Next Evolution of the Internet is Changing Everything', Dave Evans, Cisco, April 2011, p.3

Fig.3.3 The number of internet connecting devices in compare with the world's population[106].

All in all, the building's stock transformation into smart buildings will save the greatest amount of energy in Europe. Increasing the energy efficiency in the technical performance of buildings can have a positive impact, not only in European economy, but also in public health, by improving indoor and environmental conditions, by reducing gas emissions. Considering energy efficiency in buildings, many advantages may stem from this issue such as overcoming fuel poverty. However, it is very crucial to realize that an optimized energy performance of buildings means technical improvement and therefore improved technical skills for the professionals of the buildings' construction, renovation and technology upgrade.

Training and qualification schemes should be developed to ensure that technical skills keep pace with the technical complexity of buildings and building components.

In the future the benefits that are expected from the implementation of the energy efficiency legislation in Europe, according to European Commission, include:

- lower demand for European gas imports
- lower energy costs for people who live and work in energy efficient buildings
- improved air quality and protection from external noise provided by energy efficient windows
- lower energy costs for companies
- less need for additional generation and grid capacities with higher energy efficiency levels
- energy efficiency investments will bring new business opportunities for European companies and consequently a positive impact on the Economy of Europe
- new jobs in construction, manufacturing, research, and other industries investing in energy efficiency.

3.6 REFERENCES

[104] "DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32012L0027.

[105] "The European Commission:The Energy Efficiency Directive (2012/27/EU)." [Online]. Available: https://ec.europa.eu/energy/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive_en.

[106] Directorate-General for Energy (European Commission), Good practice in energy efficiency, For a sustainable, safer and more competitive Europe. EU publications, 2017.

[107] "Nearly Zero Energy Buildings." [Online]. Available: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en.

[108] "DIRECTIVE (EU) 2018/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 amending Directive 2012/27/EU on energy efficiency." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L2002&qid=1588931253613.

[109] "DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L0844.

[110] "the energy performance of buildings standards" (EPB standards)." [Online]. Available: https://epb.center/epb-standards/energy-performance-buildings-directive-epbd/.

[111] "COMMISSION RECOMMENDATION (EU) 2019/786 of 8 May 2019 on building renovation (notified under document C(2019) 3352)." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588932281603&uri=CELEX:32019H0786.

[112] "COMMISSION RECOMMENDATION (EU) 2019/1019 of 7 June 2019 on building modernisation." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588932366308&uri=CELEX:32019H1019.

[113] "DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588932634472&uri=CELEX:32010L0031.

[114] "EU buildings database." [Online]. Available: https://ec.europa.eu/energy/eu-buildings-database_en.

[115] "EU buildings Datamapper." [Online]. Available: https://ec.europa.eu/energy/eu-buildings-datamapper_en.

Chapter 4:

Energy efficiency in smart buildings: IoT approaches. Published in *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.2984461 [2]

ABSTRACT

The Internet of Energy (IoE) impacts on smart cities' power sector. IoE is an implementation of the Internet of Things technology (IoT) into distributed energy systems and aims to achieve energy efficiency, to avoid energy wasting, and improve environmental conditions. IoE technology includes, among others, utilizing smart sensors and renewable energy integration. Therefore, the IoE is becoming a legal science tool to serve the purpose of a smart city. In this research, the reasons that led the European Union to compile Regulations for facilitating transformation of existing cities, starting from existing buildings, into smart buildings, are referred. A smart building template, is proposed, that manages the performance of all technical systems through IoT technology with the view of achieving energy efficiency. In addition, in order to improve the certification of existing buildings, as for energy performance, a proposal is made for an automated remote, control method supported by cloud interface. This method minimizes time consuming procedures and stores, on a cloud platform the energy performance of each building, for the purpose of drawing conclusion and applying measures.

KEYWORDS:

Energy efficiency, Energy Performance of existing buildings, Internet of Things, Smart building template, Smart energy management.

4.1 Introduction

In a smart city, technology is placed in the serve of society in order to achieve the smart objectives of every living factor that motivates society, such as the administration, citizens and industry. This way prosperity of the city is ensured. Energy is the driving force of a city and the energy saving is a major issue for the whole world. The use of alternative energy sources, the reduction of gas emissions, the contribution of the Internet of Things (IoT) technology to monitor energy consumption and control energy performance is of vital importance.

To meet the objectives of a smart city and energy efficiency, not only the reconstruction of new smart buildings and the transformation of existing buildings into Nearly Zero Energy Buildings (NZEB) is crucial, but also the transparency of Energy Performance Certificates should be improved. According to the European Commission's impact assessment, provisions concerning the inspections of Energy Performance Systems were found to be inefficient, because they could not guarantee the initial and continued performance of a building's technical systems. The Energy Performance Certificates should ensure that the performance of installed, replaced or upgraded technical building systems are documented and all necessary parameters for measuring energy consumption are checked, as well as, all the requirements for minimum energy performance are stated. The adaption of the IoT technology in building certification and compliance checking could facilitate inspections.

The European Union acting in this direction and willing to ensure Europe's energy security, competitiveness and sustainability, proposes a gradual implementation plan of the smart cities institution in its Member States. These solutions are structured in conjunction with IoT technologies. According to European Legislation [117], the European Union indicates to the Member States to fulfill the Union's target of reducing its greenhouse gas emissions by 30% below 2005 levels, in 2030 (an initial period from 2021 to 2030) and this contribution of each Member State will be evaluated annually.

According to Directive 2018/844/EU [118], the European Union indicates the need to decarbonise "its building stock" considering that almost 50% of Union's final energy consumption is used for heating and cooling, of which 80% is used in buildings.

The Union's goal is to follow renovation strategies that give priority to energy efficiency and renewable sources of energy in order to transform the existing buildings into NZEB. In this direction the European Union forces all Member States to propose actions [118] so as to accomplish the Union's purpose, underlying that these actions should focus on technical systems that reduce the energy needs in a building, improve environmental conditions inside the building and energy performance, as well, see Table I.

TABLE I

Proposals for existing and new buildings according to 2018/844/EU[118]

Proposals	**Proposals**
Focus on:	**Improve:**
Eggshell	Insulation
Heating	Thermal Comfort
Domestic Hot Water	Functionality
Cooling	Thermal comfort
Lightening	Visual comfort
Ventilation	Healthy conditions inside

Furthermore, the European Commission in order to measure energy savings, apply benchmarking and realize the flexibility of turning into NZEB processes, shall

adopt a delegated act by 31/1/2019, by establishing a common Union indicator for rating [118] the Smart Readiness of buildings, see Table II. This indicator applies in all Renovation Strategies of Member States, in order to conclude the progress for each Member State as for the transformation into smart city, see Table III.

TABLE II
ESTABLISH THE DEFINITION OF THE SMART READINESS INDICATOR[118]

	The Smart Readiness Indicator	
measures	enhanced functionality	energy performance
uses	information, communication technologies	electronic systems
points out the needs of	the occupants	the grid
indicates the value of	building automation	electronic monitoring
achieves	energy efficiency	confidence to occupants about saving

TABLE III
TO CALCULATE THE SMART READINESS INDICATOR[118]

	The Building Systems through interconnected and intelligent devices should	
maintain	energy performance	operations of the Building
adapt	energy consumption through energy efficient sources (e.g. renewable sources)	dynamic and interchangeable Operation mode
achieve	user friendiliness	healthy indoor climate conditions
report	energy use	electricity demand
enable	intervention on grid demand	grid's Proper distribution

According to the 2019 Assessment of Second Long-term Renovation Strategies [119] under the Energy Efficiency Directive (EED) [120], about the strategies that were submitted in 2017 from 30 Member States, 27 strategies out of 30 were considered fully or almost fully compliant to EED, as for energy efficiency and renovation of the existing buildings and 3 strategies were considered as noncompliant, see Table IV.

TABLE IV

THE 2019 ASSESSMENT FOR COMPATIBILITY WITH EED FOR THE RENOVATION STRATEGIES PROPOSED IN 2017[119]

Best Renovation Strategies 2017	**Precentage of compliance with EED**
France	84%
Spain	84%
Belgium Wallonia	80%
Croatia	80%
Czech Republic	80%
Greece	80%
Sweden	80%
Cyprus	76%

It seems of great importance the collaboration of the following factors in the direction of securing future's environmental conditions: The guidelines that are provided in the EED, the proposals of each European contracting State to implement those directives which will ensure a better life, as for quality and sustainability, to European citizens and the grant of efficient Building Certificates, as for energy performance. The IoE which is an implementation of the IoT into distributed energy systems can contribute in this direction, applying IoT tools such as cloud technology and Wireless Sensor Networks (WSNs). These sensing devices which are wirelessly connected can communicate with each other and with the Internet [121], can conduct measurements and collect data from all building's technical systems remotely and automatically. Then, this information can be stored in a database using cloud technology and will be accessible to

the authorities in order to monitor the energy consumption of the building, to observe possible energy wasting, to draw conclusions about energy performance and check the negative or positive impact of each building to the indicator of Smart Readiness. Consequently, solutions can be proposed in order to improve energy efficiency of the building that is inspected. The result of this procedure is that all building will gradually be able to be transformed into NZEB with consistently in the timeline.

Contrary to fragmented and unverified as for compatibility with European legislation technological proposals in the literature, which they might not all be feasible and applicable in reality for smart cities, due to legislation, in this research the contribution is that a research is presented based on European legislation and therefore the legality of applying the presented technology proposals to smart cities, is ensured. This research for the compatibility of the proposed technology with European legislation has not been carried out in other technology proposals, so far. An effort is made to develop a smart technology building template, according to the legal frame mentioned above, choosing from a technological background, technologies feasible and in accordance with the law. This smart technology building template will be a sensor-based architecture that supports the operation of energy consuming technical systems. This whole smart building will be controlled by a smart management system with the aim to achieve energy efficiency.

In addition, for existing buildings, regarding the Smart Readiness indicator and bearing in mind the aim of European legislation for the gradual transformation of buildings into smart buildings, which has not been considered in literature before, and furthermore with the view to improve Building Certification and compliance checking of existing buildings as for energy performance, an effort is made to develop a management system, which will check the energy consumption of a building's technical systems remotely and will propose solutions in case of energy inefficiency. In this way, the instantaneous presence of an inspector in a building which reflects instantaneous and approximate measurements of technical systems, with the possibility of a major error, could be replaced with remote and continuous measurements under various conditions, which is not regarded in the literature. All mentioned above will be developed

considering European standards, the legal framework introduced by the European Union for smart cities and with a view to improve well-being in European societies.

This research is going to follow a qualitative and bibliographic methodology in order to list actions for the problem of energy wasting. The rest of the research is organized as follows; In Section 2 there is a review of the related research on smart solutions for Smart Buildings that use smart technology and IoT solutions, in order to achieve energy efficiency. Section 3 proposes a smart technology template for a building in terms of smart technology and energy efficiency. Section 4 discusses an optimally way for monitoring energy consumption in existing buildings. This could be a remote and automated approach for the supervision of a building and for reducing the energy consumption that stems from its operation. Moreover, in this section proposals are stated for controlling energy losses in existing buildings. Last but not least, Section 5 provides the conclusions of the current research and Section 6 proposes new possibilities for the development of future work.

4.2 Related Work

For the purpose of this study a review and analysis is done to the previous literature which has been published in the field of smart buildings, energy efficiency and IoT technology, in order to collect all representative technologies regarding Heat, Ventilation, Air Condition systems (HVAC), Renewable Energy systems (RES), Building Energy Management Systems (BEMS) and generally energy efficient methods applicable to smart buildings. The methodology that is followed, utilizes European certification, European legislation and literature in order to propose a smart building template for new buildings and a management system for checking all technical systems in existing buildings in order to contribute to the gradually transforming of existing buildings into smart buildings and to the remotely Building Certification as for energy performance in existing buildings.

The following paragraphs present the papers which contributed significantly in this study. To begin with the eggshell of a smart building, an optimized thermally control storage, using phase change materials (PCM) integrated to walls, is presented in [122]. The problem of the shift between energy production and heating energy demand is solved by using isolated PCM panels inside the building walls and a heating system that uses a pumped hot water circuit to load the PCM plates. The heat stored in the PCM is achieved due to the increase of heat exchange surface by PCM's low thermal conductivity and its incorporation into microcapsules, and due to the heat return which is controlled by forced transfer. The PCM plates are separated from the wall insulation by an air layer which allow ventilation on request from all wall's surface in order to extract the heat stored in the PCM.

By using sensors the temperature of the room and the temperature of the PCM plates can be monitored and through weather forecast the temperature of the outside air is disclosed, so as to check the effectiveness of the system. It ensures 10-15% energy savings, quick heat distribution on request and therefore comfort for the users inside the building.

In [123] is proposed the use of thermal images to detect insulation problems of the eggshell of a building. This method identifies temperature variance in a building with

thermal images of segments of the building. Higher variation of temperature is proven to mean poor insulation or damages in the wall surfaces. A FLIROne camera and an android Smartphone was used to collect 50 thermal images from inside and outside of the building that cover moisture problems, insulation problems, thermal bridging, electric outlet holes. The researchers identify insulation problems with 75% accuracy.

In [124] it is stated that the durability of the material used in a building's walls, such as concrete can be monitored through IoT real time sensors. These sensors transmit data like humidity, wirelessly to a mobile application but have limited lifetime. Therefore a low cost, screen printed, resistivity sensor is presented that has the ability to be implanted in concrete during the construction of a building and collect real time measurements for a lifetime. These measurements concern the moisture degree of concrete which is vital for a structure in order to ensure durability. This sensor implements preventative monitoring which is vital for a building's structure.

In [125], an Indoor Air Quality low cost and energy efficient sensor that is easy to operate, is presented. The IAQ sensor is monitoring the indoor air and report in a smart device the existence of PM2.5, CO2, CO and O3.This sensor will notify to the occupants of a building, the absence of fresh indoor air in order to take measures. This is a matter of health and will contribute in building ventilation, in reducing gas emissions and only by monitoring continuously the indoor air quality.

In [126] is stated that occupancy and occupant behavior in a building impacts on energy efficiency, due to the use of Heat, Ventilation, air condition, lightening and other electric devices by occupants. Therefore, a building occupancy prediction model is introduced that gives 90% accuracy and uses 8 sensors to collect data every 20min, or 5 sensors to collect data every 15min. Building data that are used refer to indoor temperatures, humidity, Co2 level, windows and door state, outdoor temperatures and humidity and they are obtained from different sensors that exist inside and outside the building and they are associated with building occupancy.

In [127] is stated that smart solutions and IoT can help to predict a sudden burst of a fire by monitoring and quick reacting. The described system includes an internet connection for communication and control between fire alarm pull, fast-response and slow-response sprinklers, fire bell, a local security operator and air exchange module.

Sensors on sprinklers monitor fluid consumption. A smart device can be used to monitor the whole system, so the security staff can receive alarms and notifications, all the time. Based on IoT communication, in case of a fire, the air exchange system is activated, the fire bell starts to ring, the sprinkles are activated, the whole procedure is monitored and the people in charge are informed about the emergency.

In [128], the SAFETY Project is presented for fire prevention in buildings. This project is an environmental monitoring system and operates 24hours every day. Its implementation is based on an IoT system used for monitoring and controlling several environmental parameters through custom smart boxes installed in each room of the building. The system uses an efficient software platform that is cloud based in order to handle requests from many devices. It also manages and monitors every element of the infrastructure. The Smart Box which is an intelligent device of the system is able to manage several environmental sensors connected to it. 6 environmental sensors tests humidity, temperature, carbon monoxide, smoke presence (PIR sensor), and identifies a building set on fire. The system sends data to cloud to be stored, processed and analyzed and is monitored through a mobile application.

To continue with the indoor conditions in a building a search was done for lightening technology. In [129] a lightening design is implemented using temperature and light intensity which ensures increasing of power efficiency up to 82.77% at a day time and minimizes carbon emissions by cancelling the use of florescent devices and static power control. The proposed design uses LEDs and sensors that sense the surrounding light and temperature and then control power dynamically. When the environmental light intensity increases, the power supply decreases dynamically in time.

A connected indoor lightening system is presented in [130] with embedded sensing, control and networking technologies that optimize lighting operations. This system connects sensors, luminaries, controllers and gateways using the internet. Luminaries with sensors stated on the roof are easy to maintain, and provide high spatial resolution of data. These data ensures lighting optimization and improvement in operations. The system consists of an application programming interface (API) that enables users to control lighting system settings and a data API for monitoring the system and the lighting data.

Focusing on the interior conditions of the building, we continue with automated heat supply management which is referred in [131], which optimizes with accuracy the temperature of a building. This method based on IoT platform, ensures reduce in costs and comfortable temperature for the occupants. The system through sensors that are located inside and outside the building, gathers information,(temperature, weather, wind, pressure), in real time and through 3 layers it produces the heat map of the building and builds a digital twin of the building by analyzing all streaming data collected from sensors.

To continue with renewable energy sources that can be used in a building in order to reduce gas emissions and power consuming, Solar Energy Photovoltaic (PV) system allows to store solar power in batteries, for using when the power grid goes down [132]. There is also the Grid Connected PV System which is a solar electricity system without batteries and these are the simplest systems and the most cost-effective to install in a building.

In [133] is presented a Photovoltaic (PV) generator which is connected with storage units and supplies the electrical loads and the thermal demand in order to turn into electrical by using heat pumps. The system purpose is to maximize the self-sufficiency and to minimize the use of the grid. Sensors are applied in the rooms of the building so as to monitor the energy exchange between them. The authors say that an energy simulation must perform on a yearly basis in order to evaluate the size of the batteries and the costs and they state that a future purpose of this system is to achieve yearly self-sufficiency instead of seven months per year (April to October).

In [134] a real time NZEB prototype is developed using wireless sensors to achieve home automation with IoT. NZEB concept, which includes the use of renewable energy (like solar), intelligent controllers configured with Arduino UNO and IoT technology like sensors (light sensor and temperature sensor) and also a mobile application, ensures that the net energy consumed from the utility grid over a period of time (monthly/annually) will close to zero because the net energy is the difference of the energy imported from grid, to the energy exported to grid over a period of time. So, the sensors will measure the room illumination and temperature levels and send the measurements to cloud in order to control the electrical demand.

In [135] a model which is proposed for energy efficiency by using the Fuzzy Control System, achieves to reduce the water flow rate without disturbing the comfort of the occupants of the building. This model is suitable for buildings with central heating system and uses artificial intelligence technology in every room. The benefit that this method offers is that with smart rooms and intelligent control, the unused rooms are not supplied with hot water and therefore heat calories are distributed more effectively and energy efficiency is achieved.

In [136] a smart hot water control system is presented which is performed automatically based on IoT data. This means that the control of the hot water heating system adapts the heating times to the data collected of the user's behavior and this leads to energy savings. The models that are developed are based on Gaussian processes and neural networks and are supposed to compute optimized heating schedules that lead to significant energy savings (saves between 20 and 34% of the energy used with a default schedule) for all users over a testing period of six months.

In [137] the presented prototype allows remote monitoring of electricity consumption in a home, based on a web application, using the XBee technology, which allows the implementation of a wireless sensor network with energy efficiency and low consumption, and a protocol for data communication. It is a real-time system which collects data by areas to check the variation of consumption in each room with 1-minute time intervals and the results are stored in a database in the cloud. The XBee operates as a coordinator in the system and collects data from 4 Mmod sensors , that sense the current consumed by the electrical appliances and the supply voltage and transmits it to the client PC, so it can send it to the cloud. This web application notices unnecessary electrical consumption, minimizes waste of energy, and relocates the demand of electricity.

An IoT-based smart system able to control the Air Conditioning in order to produce a thermally comfortable indoor environment by monitoring air temperature and humidity inside a room is presented in [138]. The system will interact with the user by inserting his / her thermal feeling from -1 to +1. Together with sensors' data, the information will be integrated with a Predicted Mean Vote (PMV)-based algorithm to the cloud server so that the occupant can feel thermal comfort by controlling smartly the AC.

According to [138], the system has three input variables which are users' feeling or user PMV preference (-1 to +1), humidity (from 40% to 90%) and room temperature (from 19°C to 34°C) and two output variables which are temperature of the AC (from 17°C to 26°C) and fan speed (from 0.1m/s to 0.5m/s). Lastly Arduino software is used to program the system.

A building management system that achieves the reduction of energy consumption and optimization of the lighting and HVAC (Heat Ventilation Air Conditioning) control is presented in [139]. Passive infrared sensors are proposed to predict the presence of occupants in each room. Temperature and humidity sensors adjust the lighting, air cooling and humidity in a room. An acceleration sensor monitors doors and windows in case a window glass is broken or a window is opened in a non-occupant room. Through light sensor and for the purpose of reducing the electricity consumption, the lights automatically are switched off when the rooms are unoccupied. This real time, cost effective and automated system can be configured using a web interface to control the actuator nodes which control HVAC and lighting systems in the building, dehumidifiers, air coolers and security alarms. Lastly, cloud computing is responsible for storing the data, analyze and develop actions, and visualize the data to ensure efficient management of the building.

The method proposed in [140] is low cost and implemented as an application on Building Energy Management System (BEMS). It uses IoT technologies and "a plug & play" learning framework to automatically identify the thermal model of each thermal zone in a building. This thermal model is using a learning framework with low-resolution temperature readings from IoT-based smart thermostats connected to the cloud. Given the indoor temperature gradient prediction model, the indoor temperature can be forecasted using an algorithm. One of the inputs is the operating schedule of AC units and the output is the indoor temperature profile under such operating schedule.

A multi-HVAC system which consists of a set of HVAC subsystems (heat pumps, chillers, cooling towers or boilers) is presented in [141]. The proposal is adaptable to multi-HVAC or single-HVAC systems, both centralized and distributed. This approach does not need to invest in changing the existing HVAC installations or redesigning the building. The multi-HVAC system consists of HVAC subsystems for heating or cooling

generation. ACODAT is used for the management of building's multi-HVAC systems by noticing the optimal operation that maximizes energy savings with the highest possible indoor comfort. It adapts the multi-HVAC system to accomplish this optimal operation with the BMS (that analyze the data sensed from the environment in order to obtain the optimal operational mode in a given moment) and control modules (to control the active HVAC subsystems).

The first module explores different combinations of HVAC sub-systems and selects the best one for the current conditions. The second module then translates the decision made to the control and BMS modules. ACODAT management controls, forecasts, plans, organizes and improves the energy consumption, the indoor comfort and the equipment performance.

A novel distributed Model Predictive Control (MPC) proposal is presented in [142] that reduces energy consumption and billing costs and ensures comfort to the occupants of the building. The described model uses a heat pump connected to thermal energy storage, a consumer unit (e.g. a building) and renewable energy sources. The authors consider a subsystem composed of two components: the thermal storage coupled with heat pump and the electrical grid coupled with PV panels and heat pump. The usage of a Thermal Energy Storage (TES) gives the chance to satisfy demand in an economic way by storing energy in thermal terms during off peak hours. The solution uses predictive controllers that exchange data in order to optimize the energy spent. One MPC satisfies indoor comfort in a way that the thermal storage temperature follows the predicted inlet temperature demanded by the room and the other MPC makes economic control decisions to optimize the cost of keeping the TES at the requested temperature that satisfies indoor comfort. The results show that the goal is achieved by 37% cost saving and 15% load energy saving.

Table V lists the findings and the concepts examined in each paper about smart solutions for smart buildings that use smart technology and IoT solutions, in order to achieve energy efficiency. The papers are described through the published year, the authors and the problems and solutions that they deal with.

TABLE V
PAPERS EXAMINED ABOUT SMART SOLUTIONS FOR SMART BUILDINGS

Technical System	Smart Tech Tools	Smart Solution	Author	Year
AC	Sensors	Control the AC by monitoring air temp and hum	A. M. Ali et al.[22]	2019
DHW	sensors	Hot water is supplied by predicting occupant's behavior, saves heat	T. Sonnekalb et al.[20]	2019
DHW	Sensors and actuators	The unused rooms are not supplied with hot water, saves heat	İ. Ilhan et al.[19]	2019
Eggshell, Heat	Phase Change Material inside walls and sensors	Store heat in PCM panels and achieve heat on request	R. Wegmueller et al. [6]	2018
Eggshell insulation	Thermal images	Detect insulation problems	N. Khan et al. [7]	2019
Eggshell insulation	Resistivity sensors	Monitor concrete's durability	M. Sophocleous et al.[8]	2018
Electric energy	PV generator connected with storage units and heat pumps	Minimizes the use of electrical grid	P. D. Leo et al.[17]	2019
Electric energy	Sensors controllers and Solar Energy	The utility grid over a time-period is zero	K. R. Babu et al. [18]	2017
Electric energy	Wireless sensor network	Notice unnecessary electrical consumption	D. Alulema et al.[21]	2018
Fire prevention	sensors	Monitor fire, set alarms and water sprinklers on	S. Antonov [11]	2019
Fire prevention	sensors	Cloud based platform manages sensors and id fire	G. Cavalera et al. [12]	2019
Heat	IoT platform and sensors	Optimize the temp of the building, reduce costs	A. Zakharov et al.[15]	2019
HVAC, Lightening, Electric Energy	Sensors for: windows-doors, humidity, Co2, indoor-outdoor temp	Monitor occupancy and adjust room's energy mode	N. Haidar et al.[10]	2019

HVAC, Lightening	Infrared sensors, sensors	Optimizes lightening and HVAC control	G. Alsuhli et al.[23]	2019
HVAC	IoT thermostats	Automatically identifies the thermal model to use in each building's thermal zone	X. Zhang et al.[24]	2019
HVAC	Sensors	Use the optimal operation that maximizes energy savings and indoor comfort	J. Aguilar, A. Garcès-Jimènez et al. [25]	2019
HVAC	Model Predictive Controllers	Comfort inside, cost saving, load energy saving	S. Rastegarpour et al.[26]	2018
Lightening	Led and sensors	Power efficiency, control power dynamically by sensing temp and light	P. G. Jeyasheeli et al.[13]	2017
Lightening	Embedded sensors and controllers in luminaries	Optimize lightening operation	A. Pandharipande et al.[14]	2019
RES, Solar energy Photovoltaic	PV system	Store solar power in PV grid for use when electrical grid is off	N. M. Elsayed et al.[16]	2019
Ventilation	Indoor air quality sensor	Monitor indoor air quality	A. Kumar et al.[9]	2017

4.3 A Smart Technology building template

In this Section a proposal is developed of a smart technology template for a building in terms of technology and energy efficiency. The proposed template, see Fig. 1, is a sensor-based architecture that supports the operation of energy consuming technical systems with the aim to achieve energy efficiency in a building and develop an eco-aware behavior to the residents of it.

The whole smart building is controlled by a smart management system which is a connection among the building and the residents of it. The Building Energy Management System, (BEMS), interacts with a wireless sensor and actuator network in order to collect data from the surrounding internal and external environment. Then, it stores the data to the cloud and then use those data for controlling actuators and technical systems.

The BEMS also interacts with the residents of the building in order to be informed about their thermal and lightening feeling. Therefore, the BEMS is user-friendly and aims to monitor and coordinate all technical systems, provide warnings and notifications, apply adjustments and devise strategies with a view to evaluate energy consumption, reduce energy costs and offer indoor convenience to the residents of the smart building.

Firstly, the solution for ensuring energy efficiency in a building focuses on the envelope of a building in order to face insulating problems. Concrete is the major building material used in construction industry. In [143] the authors propose to use in buildings: concrete block walls of 140mm which are plastered expanded, polystyrene of 350 mm for roof insulation, concrete of 200mm for exposed floors and internal floors and for stairs and internal partitions concrete of 100mm, in order to solve insulation problems. In the state of the art, biobased building materials such as hemp concrete is referred. According to [144] hemp is a renewable resource which stores Co2 and therefore contributes in the reduction of gas emissions.

Furthermore, smart materials in [145] are explained to have the ability to respond to the environmental changes that they are exposed to, such as pressure, temperature and wind. Concrete is a low-cost material and easily available, but has the tendency of cracking in difficult environment conditions and consequently reduces the lifetime of the structure. The author describes a new type of smart concrete that contains dormant

bacteria which when they come into contact with water, they create limestone, filling up the cracks and thus creating a self-healing repair mechanism. So, the smart concrete increases lifetime of the structure and reduces building cost. Another type of smart material is referred in [145], aerogels which have low thermal conductivity and therefore, they can be used in building construction, indoor air-purification and fire retardation. They also have insulating properties, sound and heat retarding properties.

Lastly in [145] transparent concrete is described. This is concrete that contains fiber optics inside. This material can transmit light and the room will be naturally illuminated and can also use the optical fibers as heat insulators. Both of these characteristics of the transparent concrete intend to ensure energy savings and reduced costs.

Therefore, at this point, the suggestion for the eggshell of a smart building is concrete with dormant bacteria for the external of the building. This is because a structure exposed to any environmental conditions should ensure to the residents not only comfort but also life-enhancing infrastructures. Through the self- healing repair mechanism which fills up the cracks with limestone this is achieved. Transparent concrete is proposed for the inside walls of a building, because it ensures natural illumination inside through fiber optics and also heat insulation. Especially, to build the inside walls of a room as a kitchen, Aerogels are proposed because they ensure air-purification, fire retardation and have sound retarding properties.

The next proposal is that the low cost, screen printed, resistivity sensor which is presented in [124] should be implanted in concrete during the construction of the building in order to implement preventative monitoring by collecting real time measurements as for the condition of the concrete and send those information to the cloud for further analysis and draw conclusions throughout building's lifetime.

Furthermore, sensors should be mounted on the external walls of the building in order to sense the outdoor temperature and humidity. This information will be send to the cloud, so as to adjust the building's indoor environment and manage all the technical systems that operate inside the building in order to ensure comfort to the residents.

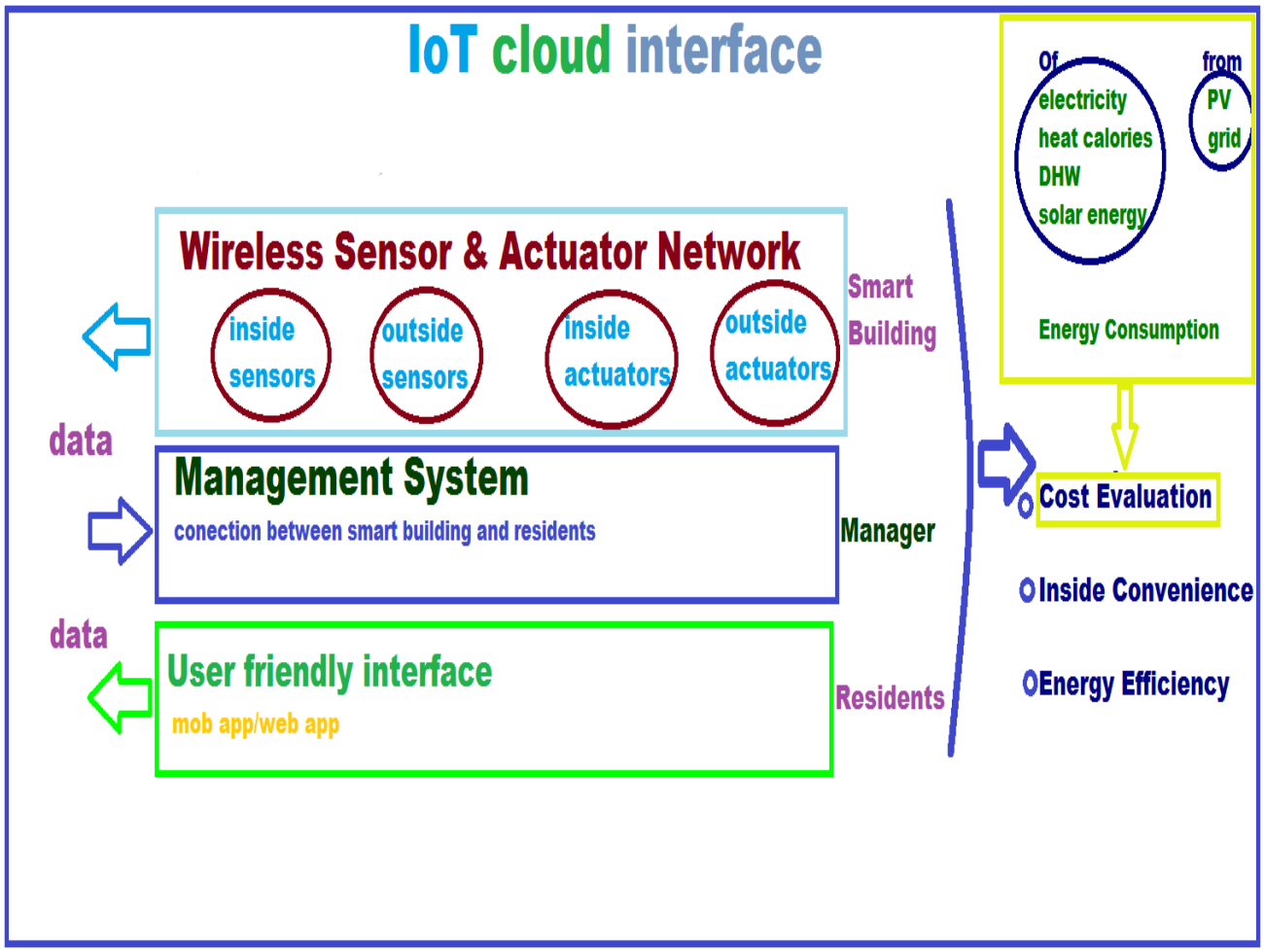


FIGURE 1. The proposed Management System for the Smart Building Template

Last but not least, referring to the eggshell of a building, the proposal is to apply Renewable Energy Sources (RES) to optimize a smart building's operation. By installing on a building's roof, Solar Energy Photovoltaic (PV) systems, which allow to store and exploit solar power, gas emissions will reduce and electrical power consumption, too.

To continue with the indoor conditions in a smart building, the most important information to begin with is the occupancy of each room, because a smart building should serve the occupants and adjust its environmental conditions according to their needs. Sensors inside a smart building can be used to collect data during a specific time interval referring to each room's temperature and indoor humidity. Acceleration sensors on windows and doors inform the BEMS about changing doors' and windows' state [139] and infrared sensors [146] check occupancy in a room. Those data will be sent to the cloud and the management system will act and manage all technical systems with accuracy ensuring a friendly and energy efficient environment inside.

The indoor Air Quality sensor that is presented in [125] which is low cost and energy efficient will monitor the indoor air for Co2, Co, O3 levels and send this information to the cloud. Then, the management system will set on or off the ventilation according to the levels of fresh air absence and the weather outside. The management system, see Fig.2, will check the cloud for the information that the sensors in the external walls of the building sent about humidity and temperature outside and also check online weather conditions and if they are favorable, through actuators and servo-motors the windows may open.

The SAFETY Project [128] can be used to predict and face a possibility of fire in the building. The sensors will sense carbon monoxide and smoke presence in order to identify a fire burst. The information will be sent to cloud in order to activate fire alarm, ventilation, actuators for doors, windows and response sprinklers through the management system, see Fig.2.

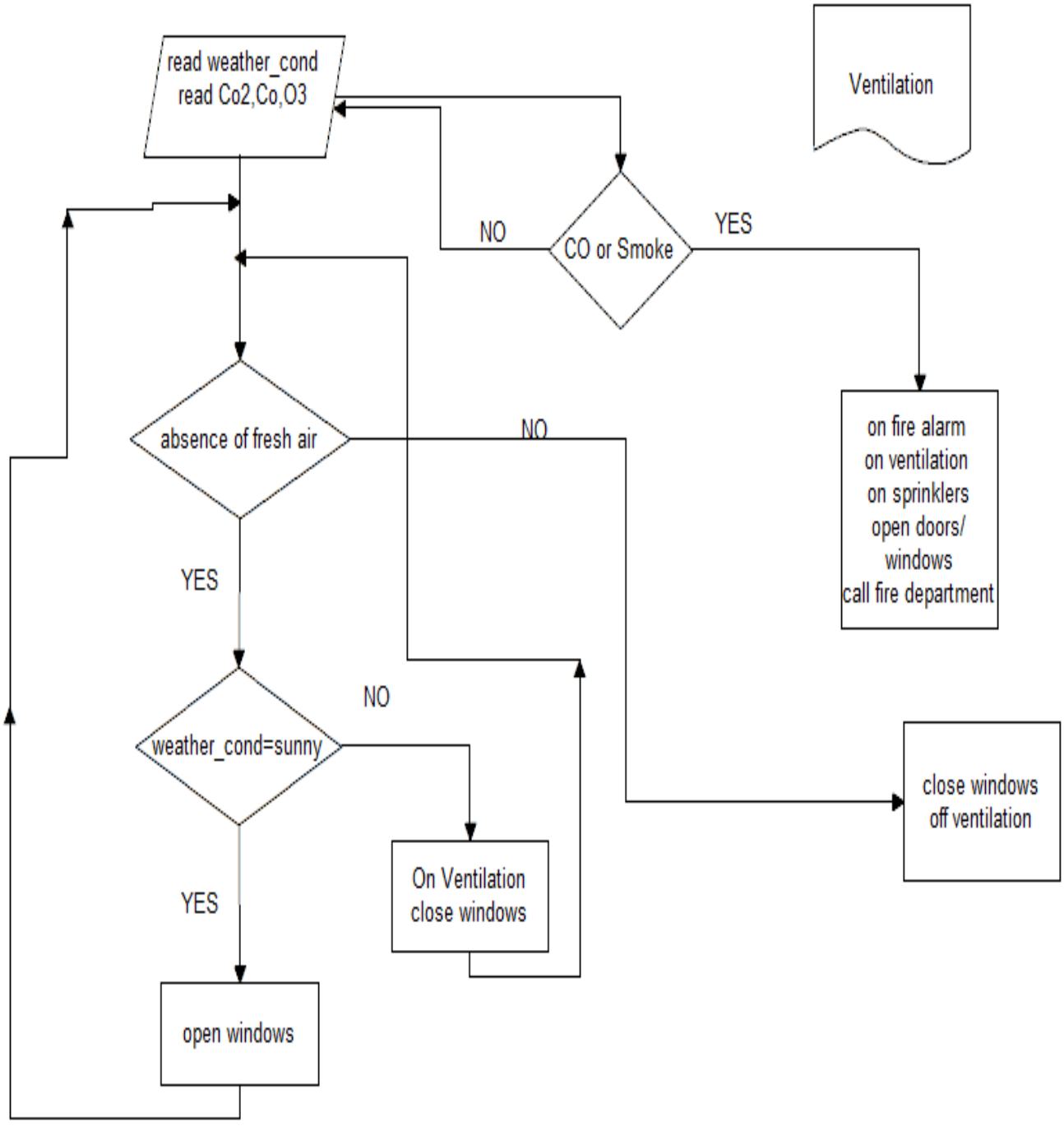


FIGURE 2. The proposed Ventilation System

To continue with the HVAC technical system of the smart building, as mentioned above, the proposal is to utilize RES, in order to reduce energy consumption from the grid and to avoid the use of fossil fuel that provokes gas emissions which contribute to the contamination of the environment.

Photovoltaic thermal panel named PVT are also listed in RES and can be easily mounted on a building's roof. A PVT system [150] uses photovoltaic and solar thermal components to produce both electricity and heat at the same time composing one integrated system which is capable of satisfying the needs of a household to a sufficient extent. Consequently, the thermal energy supplied by a PVT system can be used to cover the heat demand of a building. However, when there is low heat demand like in summer, the heat supply can exceed the demand [150], which means, surplus heat which is the thermal energy that if it is not utilized by any technical system, it will be then released to the environment. This important fact will be used in the following technical systems that are developed below.

To provide heating in a smart building, the proposal is Thermal Energy Storage and the use of heat pumps, which in a dynamically and economic way allows load shaping and the storing of thermal energy during off peak hours. The management system is following on demand control approach to manage weather conditions and electricity price in order to ensure comfort inside the building and also achieve energy efficiency. The thermal storage tank will firstly store energy from a Photovoltaic (PV) panel and if it is off peak period and the storage tank is not full, then it will store energy from grid. This energy stored in tank is thermal energy and the management system during the peak hours will release it to cover thermal needs [142]. The management system will act as described in Fig. 3.

Firstly, the management system will check occupancy in every room through infrared sensors, in order to cut off the heating in unoccupied rooms and try to maintain the default temperature that was inserted from the user, see step1-Fig.3.

In the meantime, the management system, see step2-Fig.3, will check the weather through sensors: if conditions are favorable will store energy from the PV panel to the tank.

The management system considers also energy supplies in tank (tank_storage), inside temperature, heating set point from the user and period. If inside temperature equals to heating set point and therefore desirable temperature inside is achieved and it is peak period, then the management system will be able to sell energy to the grid, see step3-Fig.3. Otherwise, if it is off peak period and also the tank is not full from energy provided from the PV panel, then energy from the grid is going to be stored in the tank, see step4-Fig.3.

In case the management system is informed by the sensors that the inside temperature is lower than the heating set point that was inserted from the user and in addition, the room is occupied, then, if there is energy supplies in the tank, the supplies will be used to achieve heat comfort inside, see step5-Fig.3. Otherwise, if the supplies of energy in tank are zero, then the management system will use energy from the grid to fulfill the needs of heat and comfort inside for every room of the building, see step6-Fig.3.

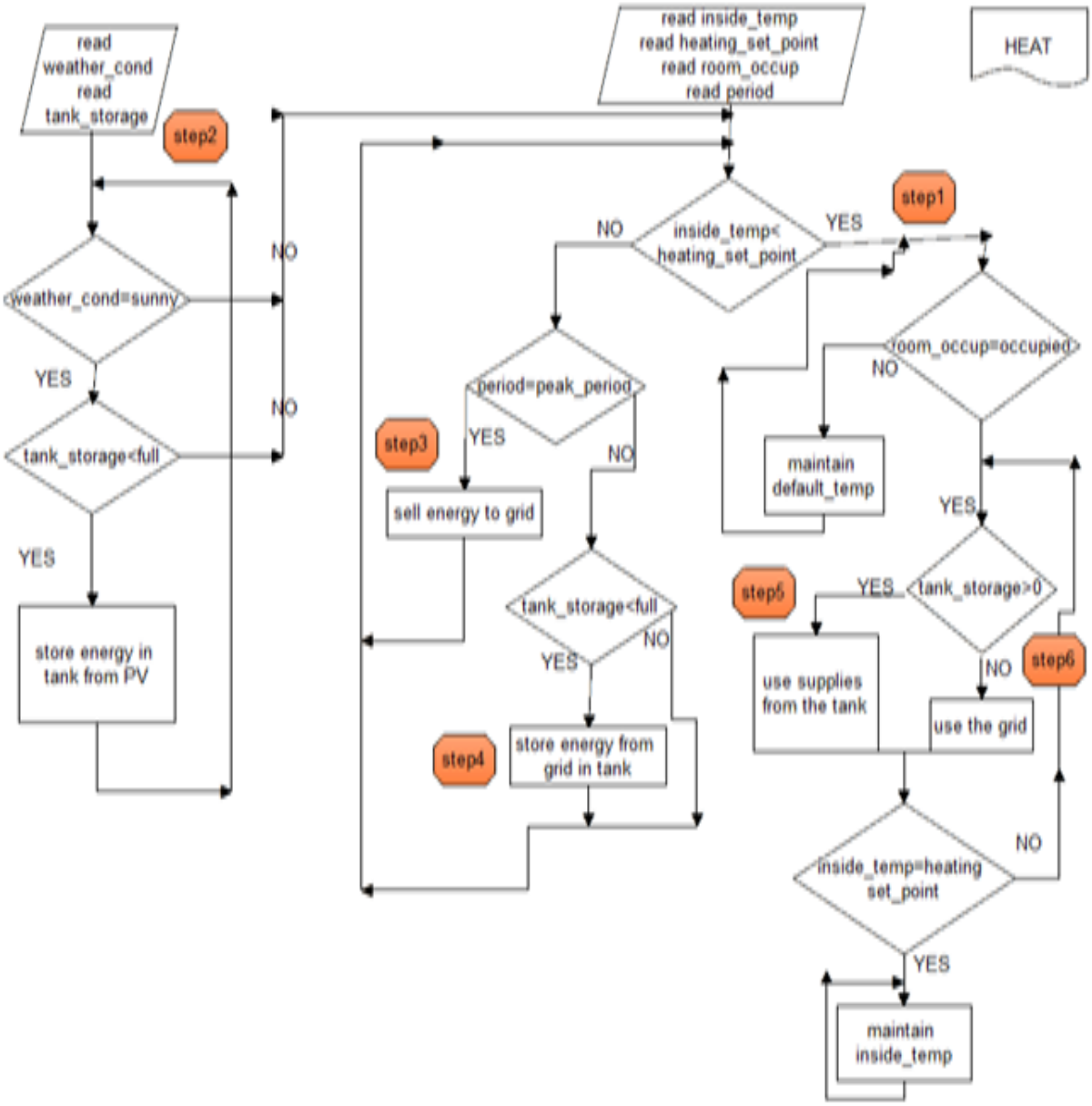


FIGURE 3. The proposed Heating System

In summer, cooling is of great importance for the building's indoor conditions and the occupants' comfort. It is also obvious that the heat supply from the PVT system exceed the heat demand, which is possibly turns to zero. Therefore, a cooling system, that uses Air conditioners driven by an absorption chiller that uses the heat surplus from PVT panels, is proposed for the smart building's air conditioning [150]**.**

The functionality of the proposed system is that the absorption chiller takes the surplus heat of a PVT panel to produce cold water that can be used to satisfy the demand for cooling the building.

Therefore, thermally comfortable indoor environment in a smart building is ensured in an energy efficient way. The management system actions follow in Fig. 4. The management system takes consideration of the infrared sensors to check occupancy in a room, acceleration sensors to check the status of doors and windows and also the sensors that inform for the inside and outside temperature and humidity. Then the decision is taken dynamically and with respect to energy efficiency, whether to switch off or on air conditioning and even close windows and doors. Further, the management system is proposed to interact with a user in order to insert his/her thermal feeling [138] for each room and then manage and adjust all technical systems.

As for DHW, the management system should consider occupancy in a room by checking the information given from infrared sensors and cut the supply of hot water in every unused room, see step2-Fig.5. In this way, heat calories are saved and energy efficiency is achieved. The proposal is also to use in a smart building, a solar water heating system (SWH), which is a structure that transfers solar energy into thermal energy [149]. The system uses a solar flat collector, a storage tank for the hot water and heat pumps.

The suggestion is that an electric heater that produces heat energy in the absence of solar energy will be useful in order for the thermal system to be reliable. The approach that the system is following is on-demand control approach that aims to maximize the utility of solar energy because this approach uses firstly solar energy to heat up water and stores the surplus solar energy, see step3-Fig.5, into the tank for future usage. Only when solar energy supplies run out, then electric heater is turned on, see step4-Fig.5, by the management system and therefore electricity cost is reduced and energy is saved.

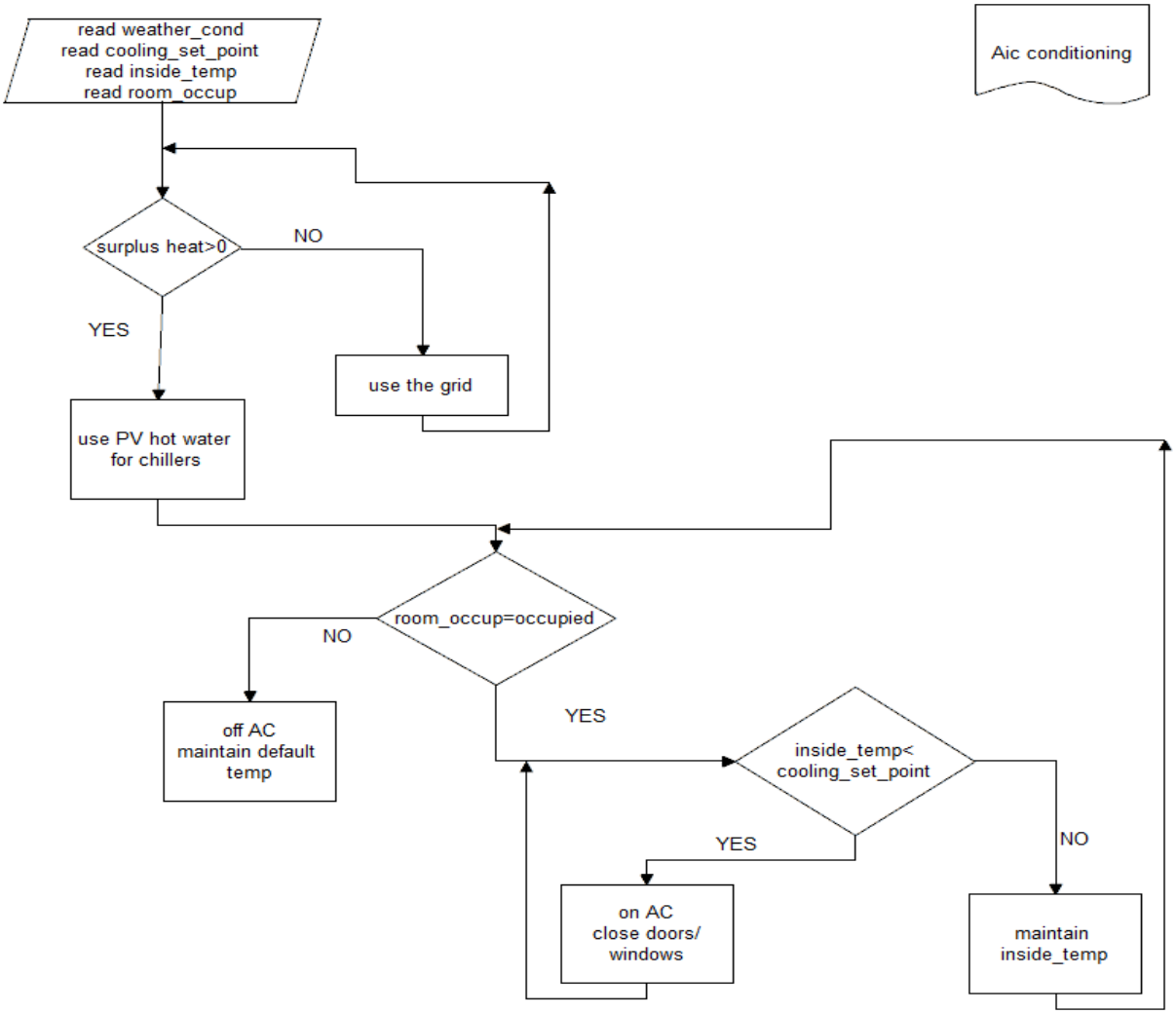


FIGURE 4. The proposed AC System

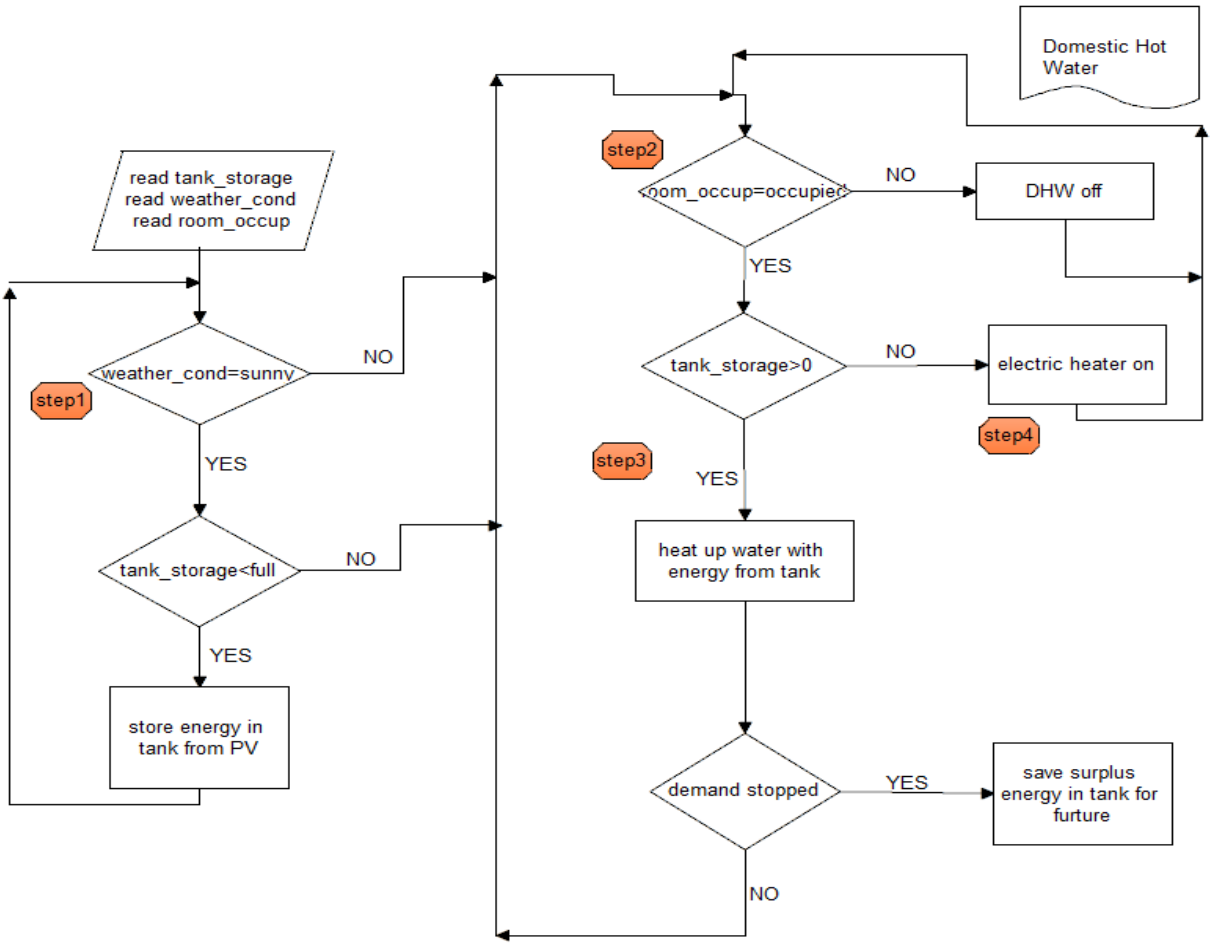


FIGURE 5. The proposed DHW System

As far as how to achieve savings in electrical energy consumption, the proposal is to use smart sockets in a smart building to control autonomously and remotely all electrical devices [147]. The proposal is that when the infrared sensors inform the management system for an unoccupied room, see step1-Fig.6, then the power should be cut off for all the electrical appliances that are connected to the sockets, even if they are switched off or placed on standby mode.

The suggestion is also that the use of the real-time system [137] which collects data from sensors that sense the current consumed, see step3-Fig.6, by electrical appliances and the supply voltage, in order to monitor the variation of consumption in each room at a specific time interval. Then, the management system will cut unnecessary electrical consumption and relocate the demand of electricity in the building.

These are proposed with a view to achieve electric energy savings during the day to day functionality of the building.

As far as what concerns the electrification of the building, a PVT system will electrify the building and electric energy from the grid will be used only in case the electricity supplies from the PVT system run out, see step2-Fig.6.

Continuing with the lights which are of great importance for the convenience of the occupants and should provide optimum operation but also reduce energy consumption. Firstly, the proposal is the use of LED lights for the whole building area. The suggestion is the use of sensors to sense lights' intensity, inside every room of the building and the management system should also consider the light intensity that the user inserts in the system as ideal. Integrating Light actuators in the lights will turn the lights off when the management system is informed from the infrared sensors for an unoccupied room, in order to ensure power savings.

Moreover, light sensors should be mounted on the external walls of the building to sense the surrounding light. When the management system is informed for the outside surrounding light, then directions can be given to open curtains through actuators and also awnings [148] so as to let the sunlight in, switch off the LEDs and therefore save energy, see Fig.7

The most important element of this smart building template is the wireless sensor and actuator network, see Fig. 8, which is responsible for informing the BEMS with vital data during a specific time interval, in order to act in an optimized way regarding energy savings.

As described in detail above, this network in Fig.8 consists of inside and outside sensors that sense the surrounding conditions and inside and outside actuators that operate on the BEMS direction. Every sensor has an initial state which changes, after sensing, to a final state. This happens after a specific time interval which is defined from the user of the management system. According to the value of each state, the management system drives all technical systems to adjust.

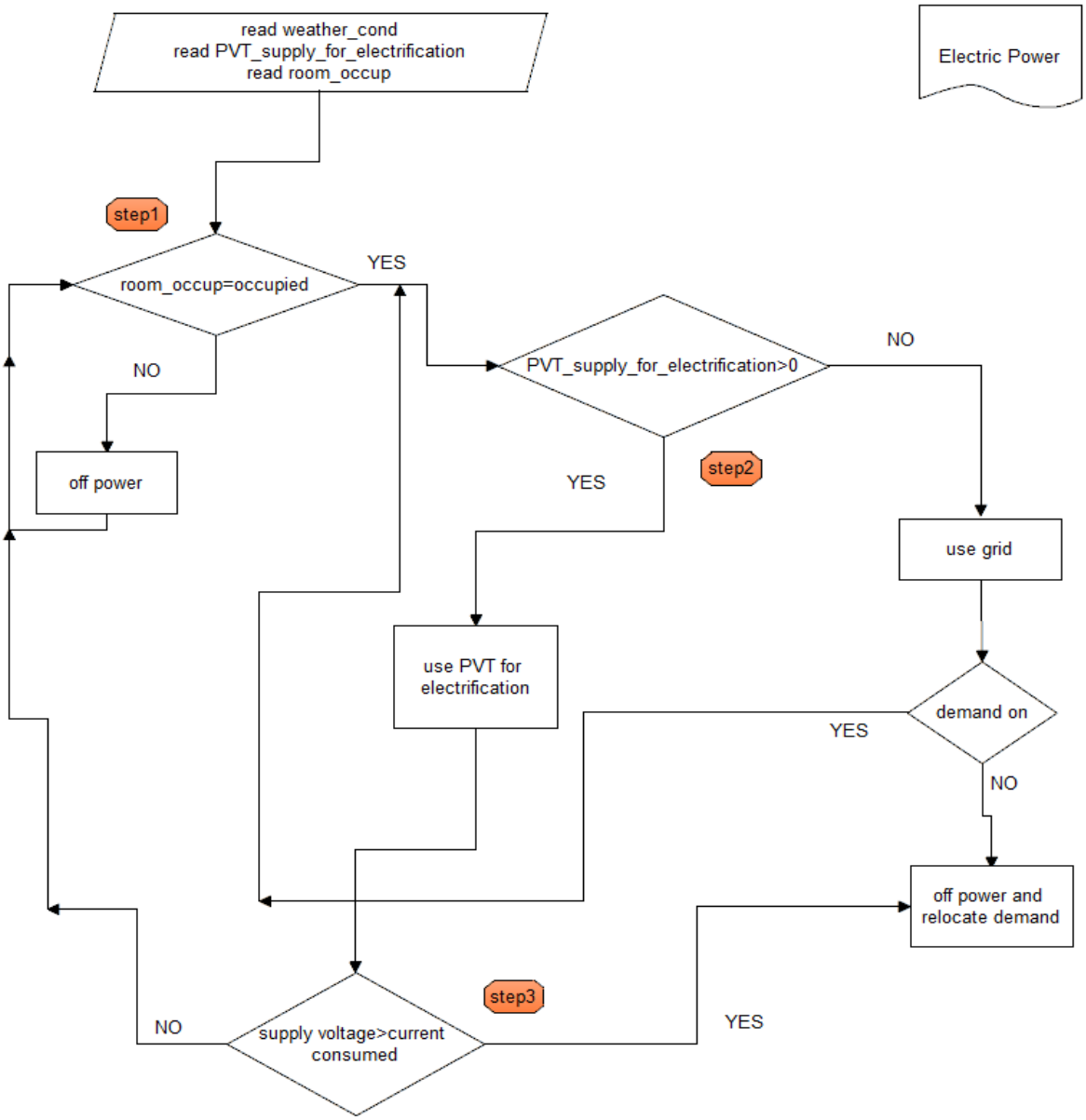


FIGURE 6. The proposed System for Electrification

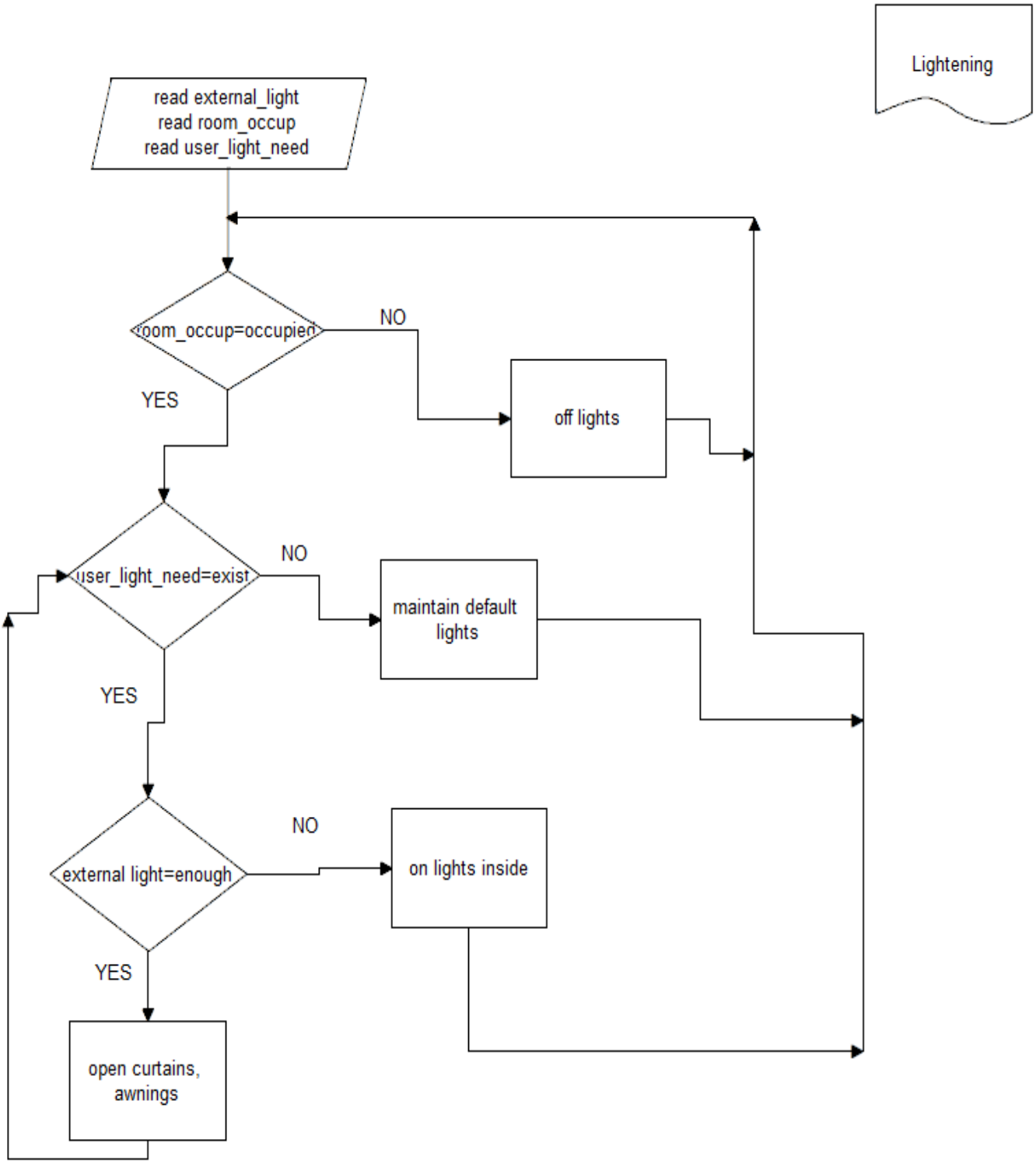


FIGURE 7. The proposed Lightening System

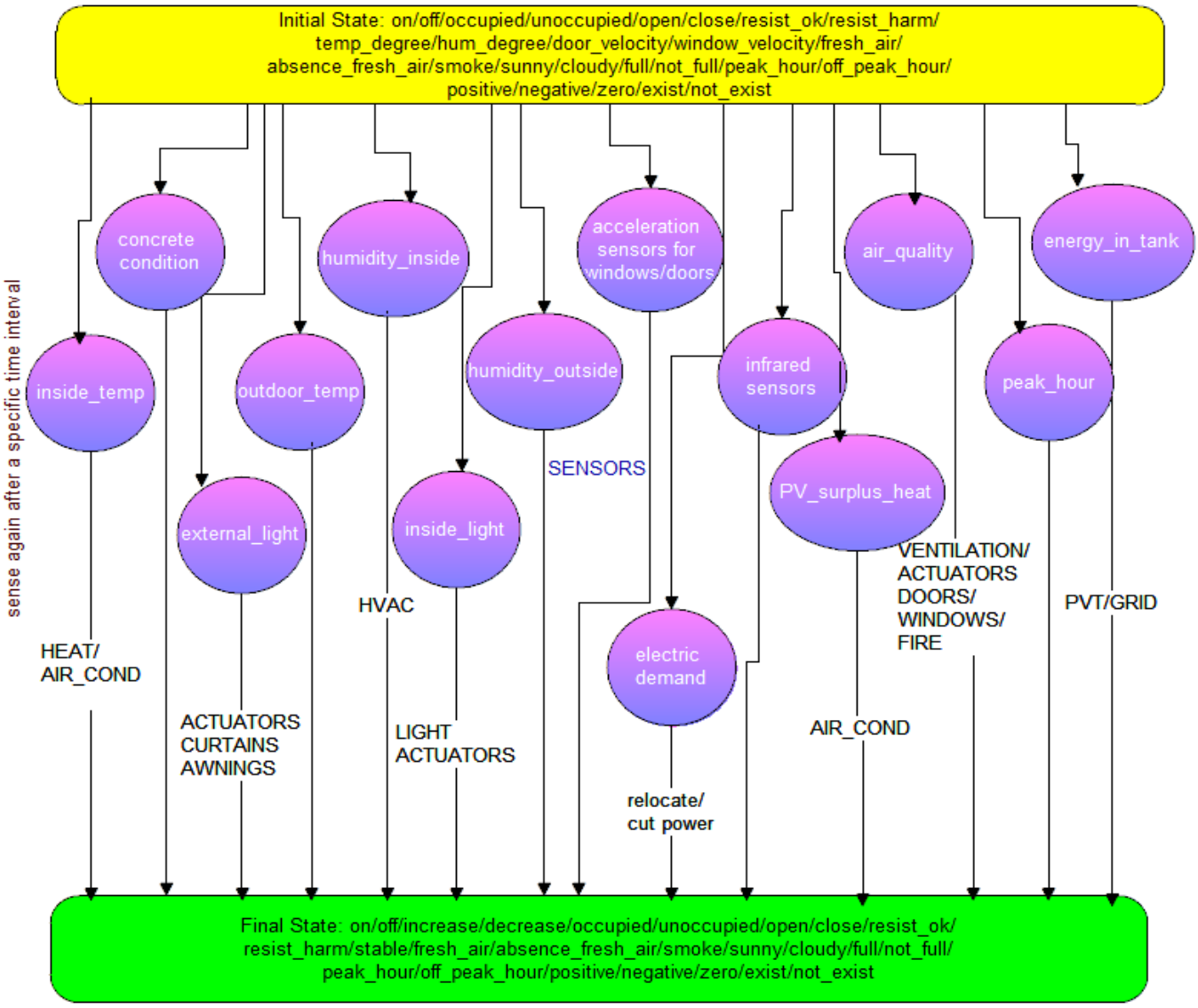


FIGURE 8. **T**he proposed Wireless sensor and actuator network

To summarize, the proposed management system for a smart building intends to offer value to the residents by ensuring their inside convenience and reducing their functionality costs by cutting off power in all technical systems in case of unoccupied rooms. It also achieves energy savings by using RES and replacing the unreliable existing technical systems. Lastly, it reduces gas emissions, which is vital for the environment, regarding a city with energy efficient buildings.

4.4 Monitoring energy consumption in existing buildings

This section discusses an optimally way for monitoring energy consumption in existing buildings. This remote and automated approach can be used for the supervision of a building and can contribute in Building Certification and compliance checking.

At first it is important to refer to European standards, as for energy performance of buildings that are defined and developed from CEN, the European Committee for Standardization. Those standards state the energy requirements of a building and consult the experts in Building Certification and in energy efficient Building construction.

According to [151], a building is separated in zones which are defined in respect of the activities that are carried out on them and the conditions that are required for each of those activities. This standard fully specifies an hourly method modeling for each building zone.

To begin with the system level, regarding the HVAC system of a building, the energy balance for heating and cooling should take into account the following: the energy requirements for the heating and cooling needs of every building zone; the energy provided to the HVAC system from renewable energy systems; the input energy provided after all to the HVAC system; the losses of energy that come from the buildings' eggshell and the operation of the HVAC system (actions like production, storage, distribution, transmission of energy).There are two issues regarding the indoor environment of a building and they are related to the distribution of temperature inside a room and the achievement of converting the inside conditions to the required heating or cooling temperature, taking into account energy consumption.

Temperature variation adjustment is a major issue. Vertical room temperature variation increases the average air temperature and therefore the heat loss in rooms with great height between down floor and up floor. Usually, HVAC systems that can reduce heat loss depending on the height between up and down floor (room height), consume more energy for their operation.

If we suppose that there is a linear temperature change in height with the required comfort temperature tc maintains at 1.5 m above the floor, at this height the air temperature is t1.5.

The average air temperature is

(1)$tav = t1.5 + \text{grad} * (\text{h}/(2 - 1.5))$

Where, h is the room height and grad is the temperature difference between up floor height and down floor height, K / m.

Supposing that surface temperatures in a room remains unaffected, the temperature during operation of the HVAC system is: $(tr + t1.5)/2$, so the rated heat loss is:

(2)$U * ((tr + t1.5)/2 - to)$

Ignoring how the losses vary between floors, walls and ceilings, the real heat loss is:

$U * \quad ((tr + tav)/2 - to$

The heating requirement for a room [152] is:

(3)$Qt = (ti - to) * (U' + V) - dt * V$

Where:

- ti is the room temperature
- to is the outside air temperature
- U ′ is the total conductivity associated with the building material (U′=U * A), A is the floor area.
- V is the ventilation conductivity.
- $dt = k * Qt$

Replacing and rearranging, we have:

(4)$Qt = (ti - to) * (U + V)/(1 + k)$

The usual heat requirement is multiplied by a factor of 1 / (1 + k).Given k, V ventilation conductivity is 0.33N * room_ volume, where N is the ventilation rate in ac / h, (air changes per hour).

Thus,

(5) $$k = 2 * a * r * d * 0.33 * N * room\_volume * \frac{\eta r}{\eta t * A}$$

room_volume / A is equal to room height, h. The standard value of α is 0.9, of r is 0.123, of ηr/ηt is 0.5 and represents the proportion of energy produced due to transmission.

The energy requirements of the building for heating [151] each zone of the building, for a period of time (usually per month) is calculated as follows:

(6)$QNH = QL,H - \eta G,H * QG,H$

Provided that $QNH \geq 0$

Where, (for every building zone and for every month):

- QNH is the building energy requirement for heating, in MJ
- QL,H is the total heat transfer for the heating period, in MJ
- QG,H are the total heat sources for the heating period, in MJ
- QG,H is the two-dimensional profit-making factor. It is a function mainly of the gain-loss ratio and the thermal inertia of the building.

The energy requirement of the building for cooling [151] each zone of the building, for a period of time (usually per month) is calculated as follows:

(7) $QNC = QG,C - \eta L,C * QL,C$

Provided that, $QNC \geq 0$

Where, (for every building zone and for every month):

- QNC is the building's energy requirement for cooling, in MJ
- QL,C is the total heat transfer for the cooling period, in MJ
- QG,C are the total heat sources for the cooling period, in MJ
- QL,C is the dimensional factor of using heat loss. It is a function mainly of the loss-to-profit ratio and the inactivity of the building.

The total heat transfer in a building Q_L, is calculated as follows:

(8) $QL = QT + QV$

Where, (for each building zone, and for each month):

- QL is the total heat transfer, in MJ
- QT is the total heat transfer from transmission to MJ
- QV is the total heat transfer from ventilation to MJ

The total heat sources, QG, of the building zone for a given calculation period, are:

(9) $QG = Qi + Qs$

Where, (for each building zone, and for each month of calculation period):

- QG are the total heat sources, in MJ.
- Qi is the amount of internal heat sources during a given period in MJ.
- QS is the amount of solar heat source during a given period, in MJ.

The total heat transfer from transmission is calculated for each building zone z and for each month, as follows:

(10) $$Q_{T=\sum_k \{H_{T,k}(\theta_i - \theta_{\varepsilon,k})\}tf}$$

Where, (for each building z zone, and for each month):

- QT is the total heat transfer from the transmission, in MJ
- *H*T, *k* is the heat transfer coefficient from the transmittance of element K to a room, the external environment or zone with the temperature θe,k , in W / K. The values for the *H*T, *k*, of element K shall be calculated [153], taking into account the standards for the specific elements such as windows [154], masonry and ceilings [155], and floor in contact with the ground [156].
- θi is the internal temperature of the building zone, in degrees Celsius obtained from the activity database (designated heating point)
- θe,k is the outside (atmospheric) temperature (the monthly average temperature obtained from hourly climate data of the position)of element K, in degrees Celsius, as obtained from the climate database t is the length of the calculation period, i.e., the number of days per month,
- f is a factor for the conversion from Watt hours to MJ

The total heat transfer is done by summing all the building elements that are part of the building and separating the interior from the outdoor conditions. It should be noted that heat transfer or part of the heat transfer may have a negative sign during a certain period of time.

The Domestic Hot Water requirements for each zone [157], is calculated as follows;

(11)DHW Requirement (MJ / month) = Database Requirement

$$* 4.18/1000 * ZoneSize * \Delta T$$

Where;

- Database requirement = l / m^2 (per month) from activity database.
- ΔT = temperature difference (degree K when the water is heated) is considered as 50K.
- 4.18 / 1000 = specific heat of water in MJ / kgK

The Lighting energy requirement is calculated below [158]. The input data in this calculation include the lighting power, the duration of their operation, lighting equipment including the effects of building users, and conditions that consider the contribution of daylight under different control conditions.

Lighting Equation:

$$W_{light} = \frac{\sum_{j=1}^{12}[N_j * (\sum_{i=1}^{24}[P_j (F_{Dji} * F_{Oji})]) + 24 * (P_p + P_{dj} * F_{Od})]}{1000} \quad (12)$$

Where:

- N_j = [31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31]. Number of days randomly chosen, in each month
- P_j = Light Power in W / m2 for each hour of the month j
- P_p = Parasitic power in W / m2 / hour
- P_{dj} = Power of projection lighting in W / m2 for each hour of the month j
- *FDji* = Daylight Correction Factor for Time i of Month j
- *FOji* = Building Correction Factor for i hour of the month j
- *FOd* = Usage correction factor for projection lighting throughout the year.

Considering the European standards, the management system that is proposed for existing buildings, is an IoT sensor oriented system. This system is going to use information provided through sensors connected to cloud for a specific period of time, in order to conclude the energy losses of a building, the energy consumption of all technical systems that operate in this building and the Co2 emissions that derived from them. Then this information will be used to calculate whether the building is energy efficient. At this point the management system regarding which technical system is energy inefficient will suggest solutions to minimize the ineffective energy performance of the building. The

proposed management system for existing buildings that manages energy performance is shown in Fig.9.

The minimum required sensors that is suggested, in order to extract the required information are visualized in Fig.10. The sensors sense the temperature, the light and the air quality inside a room. Sensors also sense the temperature and the humidity outside and then they inform the management system of the current conditions so as to drive all the technical systems; Heat, Ventilation, Air Condition, Lights and Domestic Hot Water, through actuators. During the technical systems' operation the management system also calculates energy losses, the consumption of electric energy and the total amount of Co2 emissions.

At this point we have to apply an efficient design for interactions between sensors and cloud.

In [159], an efficient interactive model is developed "for the sensor-cloud integration to enable the sensor-cloud to simultaneously provide sensing services on-demand to applications with various latency requirements". In this method, complicated operations are loaded to the cloud, and only the light-weight processes are served by sensor nodes.

For the development of this sensor-cloud method the authors define the following:

- Physical sensor nodes which collect data from the real environment and send them to sensor-cloud.
- Sensor-cloud which illustrates the physical nodes into the virtual sensors.
- Applications or users that request the sensor-cloud for sensing services on demand periodically, with different latency requirements.
- A QoS controller implemented on the sensor-cloud to control the latency of sensing flows, gather feedback information from sensing flows, compute control parameters, and guide sensor nodes through scheduling controller.
- The scheduling controller implemented at physical sensors is used to schedule sensor nodes according to QoS controller and in this way latency requirements of the applications are satisfied while energy consumption of sensors is optimized.

- A mechanism for interactions between the QoS controller on the sensor-cloud and the scheduling controller at the sensor nodes, in order to automatically adjusts the wakeup schedule of sensors to satisfy applications' latency requirements.

The authors' model is developed based on a down-stream from cloud-to-sensors for serving application requests and an up-stream from sensors-to-cloud that serves sensing traffic.

To begin with physical sensors modeling, each sensor has an ID which is a unique integer, type i_τ with

(1) $$i_\tau \in \tau = \{\tau 1, \tau 2, ..., \tau_N\}$$

a set of sensor types (such as temperature, humidity,..) registered with the sensor-cloud: S, which represents scheduling parameters (such as wakeup and sleep interval). For a sensor node i:

(2) $$i = (i_{ID}, i_\tau, i_S), i_\tau \in \tau$$

To continue with a sensor- cloud c, it is described also with ID, a set of τ sensor types, and price options P (such as price P1) for sensing services with the QoS, Q_1 (such as packet latency) provided by a sensor. The price which sensing service consumers are charged depends on the QoS packet latency that they request (such as, $P_1 > P_2$ with $Q_1 < Q_2$). For the sensor-cloud c model:

(3) $$c = (c_{ID}, c_\tau, c_p)$$

The authors in order to characterize an application α use: ID, a set of sensing data types of interest α_{SI} (such as temperature, humidity,..), a region of interest α_{RI} (such as sensors in the region R_{E1}) and quality of service requirements (such as packet latency L_r^α requirement, sensing interval, or data accuracy).

The authors describe that every new application, α, requests a sensing service from the sensor-cloud system, giving region of interest and packet latency requirement. An application α is modeled as:

(4) $\alpha = (\alpha_{ID}, \alpha_{SI}, \alpha_{RI}, L^{a}{}_{r})$

The application requests are then forwarded to the Request Aggregator for processing. The aggregator is looking for a new latency requirement for the physical sensors. If the aggregator does not find any change in latency requirement then the application request is hidden from sensor nodes.

The authors explain that if a new requirement for latency is found, the aggregator pushes it to the QoS controller for latency requirement update. The QoS controller processes the new request first by checking, if current situation satisfies the new request or not. If current situation satisfies the new request, the request is then hidden from physical sensor nodes. If not, the QoS controller calculates a new queue threshold for physical sensors. Then the sensor management system sends the queue update to physical sensors. The physical nodes update their queue threshold as well and adjust their schedule for execution.

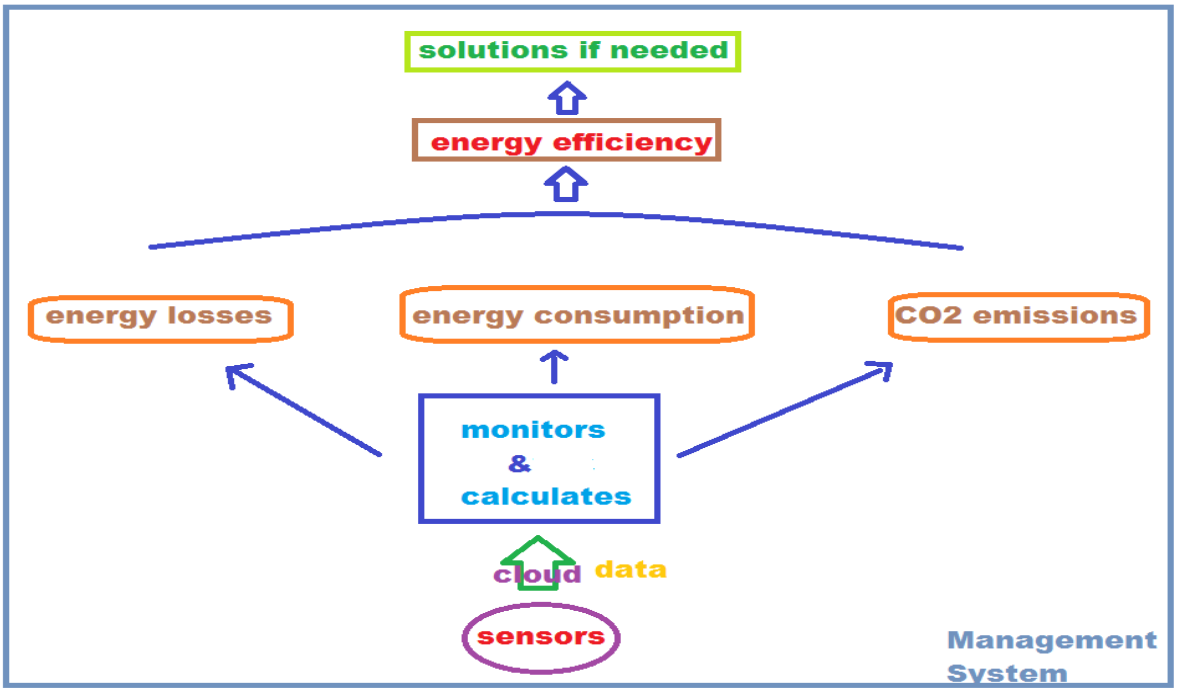


FIGURE 9. The proposed Management System for existing buildings

The sensor management system, according to [159], uses a mapping function to map a set of physical sensor nodes ζ

(5) $$\zeta = \{p_1, p_2, p_3, \ldots\}$$

With p_i is the i^{th} physical sensor,

to a set of virtual sensors γ

(6) $$\gamma = \{v_1, v_2, v_3, \ldots\}$$

with v_i is the i^{th} virtual sensor

(7) $$f_{phy \to vir(\zeta)} = \gamma$$

and vice versa

(8) $$f_{vir \to phy}(\gamma) = \zeta = f_{phy \to vir}{}^{-1}(\zeta)$$

This implementation of the sensor- cloud system is going to be executed by the Management System that is illustrated in Fig.9.

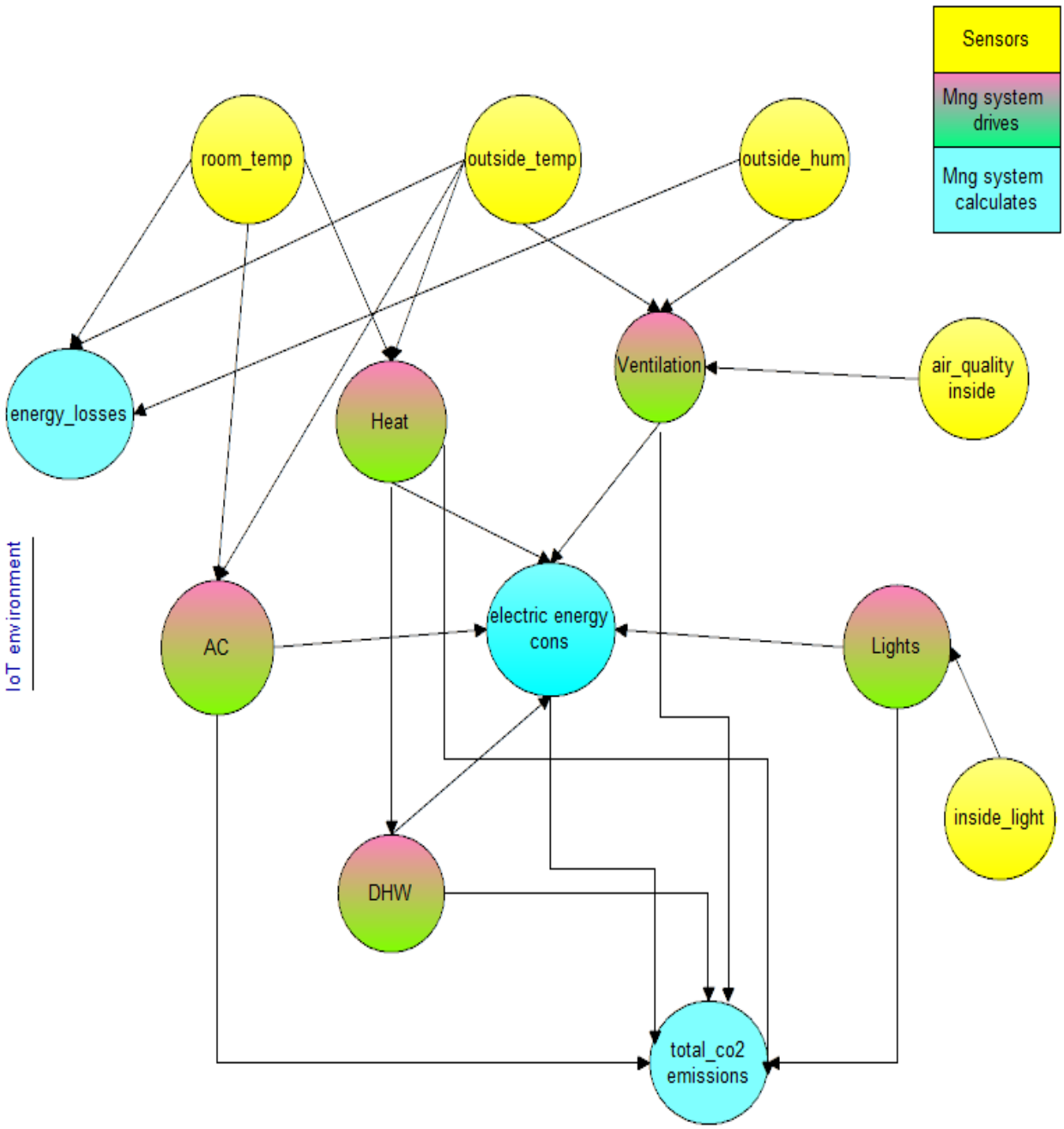


FIGURE 10. Connected Sensors inform the management system to drive technical systems and calculate.

To continue with the functionality of the proposed management system that is going to be described below, a flow chart is used to illustrate it in Fig.11.

Supposing there is an occupied building to check, the management system should monitor all its technical systems for 24 hours for a specified period of days. The management system will use data from the sensors to conclude energy efficiency of the HVAC system, the Lightening system, the building's eggshell, the use of DHW and the electric power consumption. In case energy consumption is over or equal to the allowed limit value or Co2 emissions is over or equal to the allowed limit value, then the building is not characterized as energy efficient and the management system should suggest actions for the specific technical system that operates in an energy inefficient manner**.**

To clarify it further, in case the management system concludes that the heating system operates in an inefficient energy manner, it will propose measures to reduce inefficiency. For instance, the placing of sensors in every room will be helpful in order to check and control the temperature accordingly with the residents' feeling of comfort. That means that the residents could use also IoT-based smart thermostats [160] so as to prevent heating system from uncontrolled operation which also results in pollutant emissions and costing in fuel. Choosing smart thermostats over a temperature sensor network is costless and smart thermostats can control the HVAC of a building and monitor indoor temperature because they can reflect the thermal condition of every room. Therefore, it is possible to develop thermal models according to energy efficiency and the residents' indoor convenience.

Another solution could be the utility of sensors for occupation in every room, in order to cut heat in unoccupied rooms but predict to preserve a default temperature to avoid over-operation for re-heating. If the heating system is centralized then an individual heating system is proposed. If oil boiler is used then, if possible, natural gas is proposed in order to reduce polluted emissions. Solar PV panels could also facilitate the heating system by exploiting energy from the sun for the heating operation and reduce both the consumption of oil and electric power and also the polluted emissions. In case doors' and windows' frame are not appropriate for thermal insulation, due to them we may face energy losses. In this case the heating system should again over-try to heat every room and as a result heating calories and polluted emissions will increase. Then, waterproofing

frames and with low heat permeability are proposed. In the same way, concrete supplement should be mounted in every internal or external wall that has a concrete rift, in order to face heat losses.

In case the management system concludes that the AC system operates in an inefficient energy manner, the placing of temperature sensors in every room will be in this case helpful, too. The residents could also use IoT-based smart thermostats, so as to prevent AC system from uncontrolled operation which results in polluted emissions and costing in electric bill.

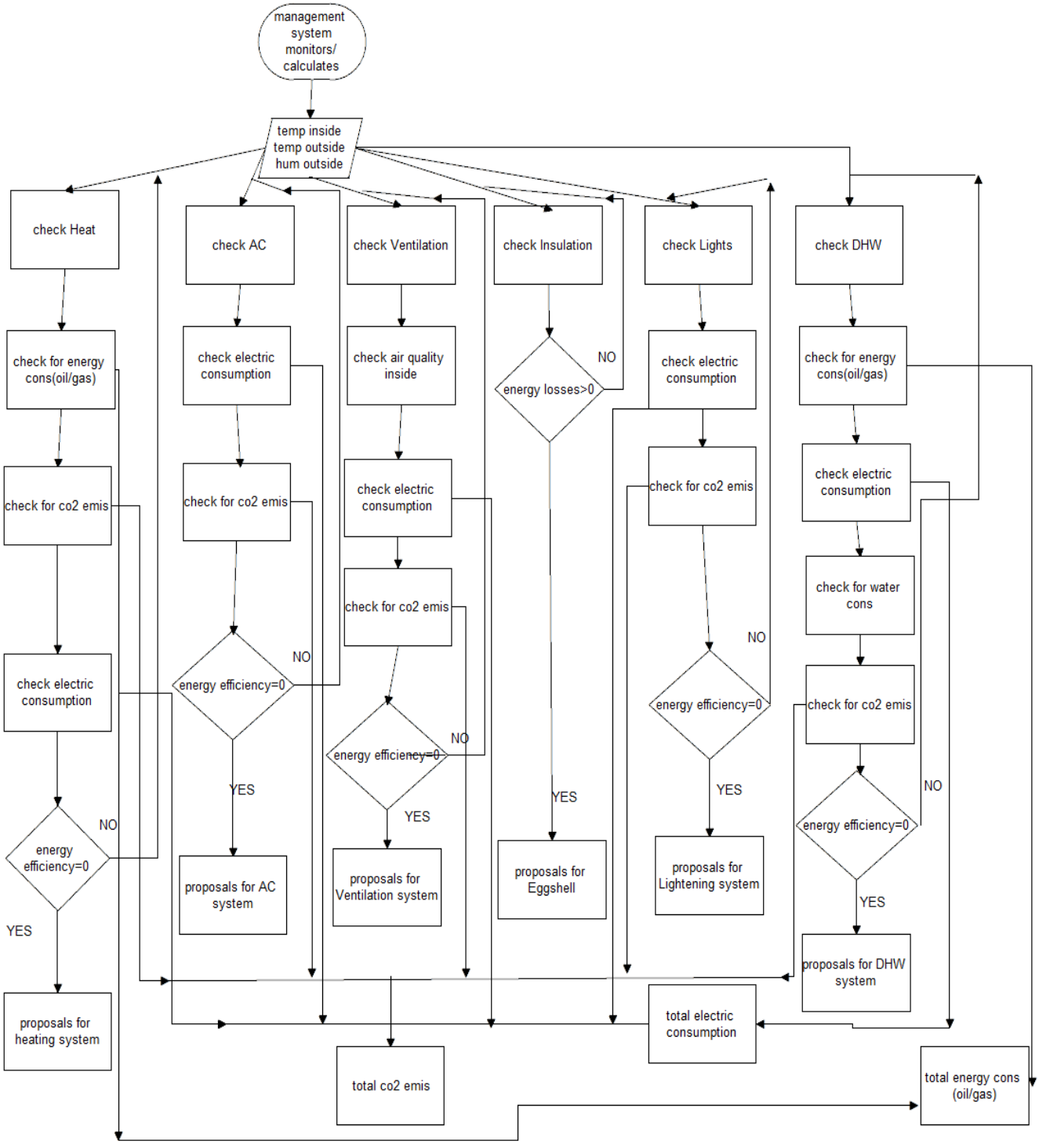


FIGURE 11. Functionality of the management system

Sensors for occupation in every room could be used in order to cut AC operation in unoccupied rooms but predict to preserve a default temperature so as to avoid over-operation for cooling. Solar PV panels could also facilitate the AC system by exploiting energy from the sun, in summer especially when solar energy is in surplus and the heating system does not consume it. This way the consumption of electric power and the polluted emissions are both reduced. In case of energy losses which means that the AC system will over-try to cool every room, waterproofing frames and with low heat permeability are proposed. In the same way, concrete supplement should be mounted in every internal or external wall. Green roofs will be also useful for a building to keep a cool temperature in a natural way.

In case of an inefficient Ventilation system, motor for windows would be a good solution, provided that the weather and the external temperature allow the opening of windows in order to ventilate every room. Sensors for occupation should also be applied in order to cut electric power for ventilation, save energy and avoid pollutant emissions.

As for an inefficient system that provides the building with DHW, PV solar panels would also be useful in order to reduce Co2 emissions. The utility of solar energy will also decrease both consumption of oil for heating water and electric power.

In case of an inefficient lightening system a good proposal is to replace bulbs in lightening system with Led lights. Furthermore, occupation sensors would contribute in this direction, since electric power would be cut off and all lights would be turned off, in case of an unoccupied room. Finally, motors for curtains should be applied in order to benefit from natural light and save electric energy.

Apart from all the proposals which were mentioned before that aim to reduce electric energy consumption, the following solution could be pointed out:

A smart socket system [161] could be used to reduce the consumption of electric energy, achieve energy efficiency and reduce pollutant emissions. This system includes parameter setting and status monitoring.

The resident may enter parameters of each powered device and select different power device priorities. Bluetooth and other wireless communication are used to receive and send data from the building and control electric appliances. The smart socket is

responsible for collecting the power consumption data of all electrical devices and for controlling their power-consumption.

Table VI includes the solutions that the management system would propose both in case of an energy inefficient system and in order to reduce Co2 emissions.

TABLE VI
PROPOSALS TO ACHIEVE ENERGY EFFICIENCY

Increase Energy Efficiency/Decrease	Co2	Heat	Ventilation	AC	Lights	DHW	Electric Energy	Improve Insulation
Green roofs	X			X			X	
Concrete supplement	X	X		X			X	X
Doors/windows frames	X	X		X			X	X
PV solar panels	X	X		X		X	X	
Occupation sensors	X	X	X	X	X	X	X	
LED lights	X				X		X	
Motor for curtains					X		X	
Motor for awnings					X		X	
Motor for windows	X		X				X	
Natural gas	X							
Individual heating system	X	X					X	
Smart thermostats	X	X					X	
Smart sockets	X						X	

4.5 Conclusion

IoE and IoT can serve the planning of transforming the cities of the European Union into smart and sustainable cities. These actions not only would be beneficial for the citizens, but for the environment, too.

In this research, first of all the European legislation regarding smart cities was quoted, in order to show the importance of presenting technology proposals that are legally compatible and applicable to the institution of a smart city. Moreover, an extended literature review was performed, in order to collect all representative technology methods that can be applied, with respect to European legislation as for energy efficiency, to smart buildings. A smart template for the stable short-term and long-term construction of energy efficient buildings, was then presented, by using IoT technology. In addition, it is of great importance to underline the further contribution to the gradually transformation of existing buildings into Nearly Zero energy buildings in European Union, by proposing a management system and solutions for facing and controlling energy inefficiency in existing buildings. The proposed management system may also contribute to the Building Certification and compliance checking of buildings by providing remote and continuous measurements of all building's technical systems.

4.6 Future Work

It is obvious that technological tools and equipment, as well as, financial support are vital in order to simulate both the smart technology building template and the management system that monitors energy consumption in existing buildings.

These facts were a limitation in this research. Therefore a desirable and reasonable future goal of this research is both the implementation and testing of the management system that monitors and controls the smart building template and the implementation and testing of the management system that concludes the energy efficiency of an existing building and proposes solutions to transform the building, according to the current legislation, into environmentally friendly.

4.7 REFERENCES

[116] REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation(EU) No 525/2013, Official Journal of the European Union L156/26, 19.6.2018 [Online]. Available: https://eur-lex.europa.eu/eli/reg/2018/842/oj

[117] DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency, Official Journal of the European Union L156/75, 19.6.2018 [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG

[118] Castellazzi L. ,Zangheri P., Paci D., Economidou M.. Labanca N., Ribeiro Serrenho T., Panev S., Zancanella P., Broc J.-S., "Assessment of second long-term renovation strategies under the Energy Efficiency Directive," Luxembourg: Publications Office of the European Union, 2019[Online].Available: https://ec.europa.eu/jrc/en/publication/assessment-second-long-term-renovation-strategies-under-energy-efficiency-directive

[119] DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2006/32/EC, Official Journal of the European Union L315/1, 14.11.2012 [Online]. Available:https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0027

[120] Andreas P. Plageras, Kostas E. Psannis, Christos Stergiou, Haoxiang Wang, B.B. Gupta, "Efficient IoT-based sensor BIG Data collection–processing and analysis in smart buildings," Future Generation Computer Systems, vol. 82, pp. 349-357, May, 2018. Accessed on: October, 31, 2017, DOI: doi.org/10.1016/j.future.2017.09.082

[121] R. Wegmueller, G. Magnin, J. Robadey and E. Niederhäuser, "Controlled active thermal storage in smart PCM walls for energy independent building applications," 2018 5th International Conference on Renewable Energy: Generation and Applications (ICREGA), Al Ain, 2018, pp. 154-157.DOI: 10.1109/ICREGA.2018.8337575

[122] N. Khan, N. Pathak and N. Roy, "Detecting Common Insulation Problems in Built Environments using Thermal Images," 2019 IEEE International Conference on Smart Computing (SMARTCOMP), Washington, DC, USA, 2019, pp. 454-458.DOI: 10.1109/SMARTCOMP.2019.00087

[123] M. Sophocleous, P. Savva, M. F. Petrou, J. K. Atkinson and J. Georgiou, "A Durable, Screen-Printed Sensor for In Situ and Real-Time Monitoring of Concrete's Electrical Resistivity Suitable for Smart Buildings/Cities and IoT," in IEEE Sens. Lett., vol. 2, no. 4, pp. 1-4, Dec. 2018, Art no. 1501404.DOI: 10.1109/LSENS.2018.2871517

[124] A. Kumar and A. Singh, "Energy efficient and low cost air quality sensor for smart buildings," 2017 3rd International Conference on Computational Intelligence &

Communication Technology (CICT), Ghaziabad, 2017, pp. 1-4.DOI: 10.1109/CIACT.2017.7977310

[125] N. Haidar, N. Tamani, F. Nienaber, M. T. Wesseling, A. Bouju and Y. Ghamri-Doudane, "Data Collection Period and Sensor Selection Method for Smart Building Occupancy Prediction," 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), Kuala Lumpur, Malaysia, 2019, pp. 1-6.DOI: 10.1109/VTCSpring.2019.8746447

[126] S. Antonov, "Smart Solution for Fire Safety in a Large Garage," 2019 International Conference on Creative Business for Smart and Sustainable Growth (CREBUS), Sandanski, Bulgaria, 2019, pp. 1-4.DOI: 10.1109/CREBUS.2019.8840089

[127] G. Cavalera et al., "An Innovative Smart System based on IoT Technologies for Fire and Danger Situations," 2019 4th International Conference on Smart and Sustainable Technologies (SpliTech), Split, Croatia, 2019,pp.1-6.DOI: 10.23919/SpliTech.2019.8783059

[128] P. G. Jeyasheeli and J. V. J. Selva, "An IOT design for smart lighting in green buildings based on environmental factors," 2017 4th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, 2017, pp.1-5.DOI: 10.1109/ICACCS.2017.8014559

[129] A. Pandharipande, M. Zhao and E. Frimout, "Connected Indoor Lighting Based Applications in a Building IoT Ecosystem," in IEEE Internet Things Magazine, vol. 2, no. 1, pp. 22-26, March 2019.DOI: 10.1109/IOTM.2019.1900016

[130] A. Zakharov, A. Romazanov, A. Shirokikh and I. Zakharova, "Intellectual Data Analysis System of Building Temperature Mode Monitoring," 2019 International Russian Automation Conference (RusAutoCon), Sochi, Russia, 2019, pp. 1-6.DOI: 10.1109/RUSAUTOCON.2019.8867611

[131] N. M. Elsayed, R. A. Swief, S. O. Abdellatif and T. S. Abdel-Salam, "Photovoltaic Applications for Lighting Load Energy Saving: Case Studies, Educational Building," 2019 International Conference on Innovative Trends in Computer Engineering (ITCE), Aswan, Egypt, 2019,pp.564-569. DOI: 10.1109/ITCE.2019.8646485

[132] P. D. Leo, F. Spertino, S. Fichera, G. Malgaroli and A. Ratclif, "Improvement of Self-Sufficiency for an Innovative Nearly Zero Energy Building by Photovoltaic Generators," 2019 IEEE Milan PowerTech, Milan, Italy, 2019 ,pp.1-6. DOI: 10.1109/PTC.2019.8810434

[133] K. R. Babu and C. Vyjayanthi, "Implementation of net zero energy building (NZEB) prototype with renewable energy integration," 2017 IEEE Region 10 Symposium (TENSYMP), Cochin, 2017, pp. 1-5.DOI: 10.1109/TENCONSpring.2017.8069994

[134] İ. Ilhan, M. Karaköse and M. Yavaş, "Design and Simulation of Intelligent Central Heating System for Smart Buildings in Smart City," 2019 7th International Istanbul Smart Grids and Cities Congress and Fair (ICSG), Istanbul, Turkey, 2019, pp. 233-237.DOI: 10.1109/SGCF.2019.8782356

[135] T. Sonnekalb and S. Lucia, "Smart Hot Water Control with Learned Human Behavior for Minimal Energy Consumption," 2019 IEEE 5th World Forum on

Internet of Things (WF-IoT), Limerick, Ireland, 2019, pp. 572-577. DOI: 10.1109/WF-IoT.2019.8767171

[136] D. Alulema, M. Zapata and M. A. Zapata, "An IoT-Based Remote Monitoring System for Electrical Power Consumption via Web-Application," 2018 International Conference on Information Systems and Computer Science (INCISCOS), Quito, 2018, pp. 193-197.DOI: 10.1109/INCISCOS.2018.00035

[137] A. M. Ali, S. A. A. Shukor, N. A. Rahim, Z. M. Razlan, Z. A. Z. Jamal and K. Kohlhof, "IoT-Based Smart Air Conditioning Control for Thermal Comfort," 2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS), Selangor, Malaysia, 2019, pp. 289-294.DOI: 10.1109/I2CACIS.2019.8825079

[138] G. Alsuhli and A. Khattab, "A Fog-based IoT Platform for Smart Buildings," 2019 International Conference on Innovative Trends in Computer Engineering (ITCE), Aswan, Egypt, 2019, pp. 174-179.DOI: 10.1109/ITCE.2019.8646480

[139] X. Zhang, M. Pipattanasomporn, T. Chen and S. Rahman, "An IoT-based Thermal Model Learning Framework for Smart Buildings," in IEEE Internet Things J.DOI: 10.1109/JIOT.2019.2951106

[140] J. Aguilar, A. Garcès-Jimènez, N. Gallego-Salvador, J. A. G. De Mesa, J. M. Gomez-Pulido and À. J. Garcìa-Tejedor, "Autonomic Management Architecture for Multi-HVAC Systems in Smart Buildings," in IEEE Access, vol. 7, pp. 123402-123415, 2019.DOI: 10.1109/ACCESS.2019.2937639

[141] S. Rastegarpour, M. Ghaemi and L. Ferrarini, "A predictive control strategy for energy management in buildings with radiant floors and thermal storage," 2018 SICE International Symposium on Control Systems (SICE ISCS), Tokyo, 2018, pp. 67-73.DOI: 10.23919/SICEISCS.2018.8330158

[142] A. Gillespie, T. F. Xulu, S. I. Noubissie Tientcheu and S. Daniel Chowdhury, "Building Design Considerations for an Energy Efficient HVAC System," 2018 IEEE PES/IAS PowerAfrica, Cape Town, 2018, pp. 1-6.DOI: 10.1109/PowerAfrica.2018.8520995

[143] B. Seng, C. Magniont, S. Spagnol and S. Lorente, "Evaluation of Hemp Concrete Thermal Properties," 2016 Intl IEEE Conferences on Ubiquitous Intelligence & Computing, Advanced and Trusted Computing, Scalable Computing and Communications, Cloud and Big Data Computing, Internet of People, and Smart World Congress (UIC/ATC/ScalCom/CBDCom/IoP/SmartWorld), Toulouse, 2016, pp. 984-989.DOI: 10.1109/UIC-ATC-ScalCom-CBDCom-IoP-SmartWorld.2016.0154

[144] J. Patel and A. Goyal, "Smart Materials in Construction Technology," 2018 International Conference on Smart City and Emerging Technology (ICSCET), Mumbai, 2018, pp. 1-9.DOI: 10.1109/ICSCET.2018.8537256

[145] Y. Yuan, X. Li, Z. Liu and X. Guan, "Occupancy Estimation in Buildings Based on Infrared Array Sensors Detection," in IEEE Sensors J.DOI: 10.1109/JSEN.2019.2943157

[146] L. Liu, "A Multi-Functional Smart Socket Design," 2019 International Conference on Communications, Information System and Computer Engineering (CISCE), Haikou, China, 2019, pp. 5-8.DOI: 10.1109/CISCE.2019.00009

[147] G. Karmakar, S. Roy, G. Chattopadhyay and Z. Xiao, "Dynamically controlling exterior and interior window coverings through IoT for environmental friendly smart homes," 2017 IEEE International Conference on Mechatronics (ICM), Churchill, VIC, 2017, pp. 487-491.DOI: 10.1109/ICMECH.2017.7921156
[148] W. Li, K. Thirugnanam, W. Tushar, C. Yuen, K. T. Chew and S. Tai, "Improving the Operation of Solar Water Heating Systems in Green Buildings via Optimized Control Strategies," in IEEE Trans. Ind. Informat., vol. 14, no. 4, pp. 1646-1655, April 2018.DOI: 10.1109/TII.2018.2797018
[149] A. Golla, P. Staudt and C. Weinhardt, "Combining PVT Generation and Air Conditioning: A Cost Analysis of Surplus Heat Utilization," 2019 International Conference on Smart Energy Systems and Technologies (SEST), Porto, Portugal, 2019, pp. 1-6.DOI: 10.1109/SEST.2019.8849048
[150] CEN Standard for Energy Performance of Buildings, EN ISO 13790,2009
[151] CEN Standard for Heating Systems in Buildings, EN 15316-02-01,2008
[152] CEN Standard for Thermal Performance of Buildings, EN ISO 13789,2017
[153] CEN Standard for Thermal performance of windows, doors and shutters, EN ISO 10077-1,2017
[154] CEN Standard for Building Components and Building elements, EN ISO 6946,2017
[155] CEN Standard for Thermal Performance of Buildings, EN ISO 13370,2017
[156] CEN Standard for Heating Systems in Buildings, EN 15316-03-01,2008
[157] CEN Standard for Energy Requirements for Lightening, EN 15193,2008
[158] N. Dinh and Y. Kim, "An Efficient On-Demand Latency Guaranteed Interactive Model for Sensor-Cloud," in IEEE Access, vol. 6, pp. 68596-68611, 2018.DOI: 10.1109/ACCESS.2018.2879811
[159] X. Zhang, M. Pipattanasomporn, T. Chen and S. Rahman, "An IoT-Based Thermal Model Learning Framework for Smart Buildings," in IEEE Internet Things J., vol. 7, no. 1, pp. 518-527, Jan. 2020.DOI: 10.1109/JIOT.2019.2951106
[160] J. Zhang, Y. Tao, J. Qiu and X. Han, "Design of a smart socket for smart home energy management systems," 2019 Chinese Control And Decision Conference (CCDC), Nanchang, China, 2019, pp. 5543-5548.DOI: 10.1109/CCDC.2019.8832486

Conclusions of the doctoral thesis

The recently conditions of the global industry have clarified that the future belongs to the entrepreneur who will consider and promote an innovative product, which will be clearly impressively missing from the consumers, will be characterized by intelligence and practicality[3], and therefore it will create a new market focusing on its distribution. This industrial era we are moving into is characterized by the rapid development of technology and especially artificial intelligence, which is a wide field of smart technology and mainly encompasses computer technology, as well as IoT, achievements in Big data, artificial intelligence techniques and machine learning.

The great challenge of this industrial era is that this smart technology is developing in order to serve global society, which is governed by contracts, Intellectual Property Rights, privacy, freedom of information, and employment. Therefore, legislation should simultaneously evolve so that it enables the protection of those who produce technology, those who apply and adopt it, those who buy or sell it. In this way, technology can be integrated into society by encouraging law and technology representatives to cooperate and contribute in this direction. Accordingly, the protection of such an invention, ,included the software related one's, is necessary for moral reasons and for protecting the inventor's interests, but also for reasons of general social interest and a patent process is established for the legal protection of inventions. A patent is clearly an incentive to develop ideas for inventors, as the economic and commercial exploitation of each idea is a kind of counterweight to the high costs often incurred by the inventor. The exclusive power of industrial exploitation provided to the inventor through a patent is an incentive for the inventor to reveal his industrial idea to the public, which serves the technological prosperity of society.

A patent can protect every original idea of a product or a method of making a product, which would be new, original and would be industrially applicable. In other words, the invention may refer to a product or an industrial application of a method. In the first case, a new product or the improvement of an already known product comes to solve a real technical problem. In the second case, a new method of industrial application is invented, which improves an already known method. In addition, patents motivate

individuals and businesses to engage in research and develop innovative products. The expectation of profitable exploitation of the exclusive rights, encourages individuals and businesses to turn to innovative products, from which, later, the general public, will benefit. In this way, dynamic efficiency is promoted. Also, the safe publication of innovations enhances the level of technological innovation, while ensuring the inventors, who otherwise they would try to keep their inventions as trade secrets, in order to eliminate the possibility of copying from competitors[3].

And as the precondition for a patent grant, is the disclosure and the detailed description of the invention, a trade off phenomenon is created between the inventor and society as a whole: the inventor will reveal his innovation and every country, in which the inventor requested protection, will give him the right to exploit the product of his invention, exclusively, for the next 20 years.

Further, considering the survey which was developed in this thesis, it is concluded that technology students are not consciously aware of the Patent Law, but they are confident about the patent institution. There is a lack of knowledge in the field of patenting technological inventions, but they are willing to patronize their potential invention by granting a patent, as well as, they intend to commercially exploit their potential invention. At the same time, they have a positive attitude and motivation for entrepreneurship and they are willing to establish their own business, which ensures a contribution to the country's future economy. They believe that a nascent technology company can cope with the competition in the industry of technological innovation. They also believe that it is worth to undertake and financially support a patent granting process, in order to protect an innovation from infringement. They regard that an invention should be available to the public earlier than the 20 years that provides the Patent Law, and therefore contribution in society's technological advancement is achieved. So, maybe it is time for the law to be revised and new policies to apply.

Subsequently, since technology industry has already indicated the need for technology professionals who work and take decisions lead by their legal engineering skills, and considering the conclusions of the survey, as future work, a course will be compiled and will be proposed to be included in the curriculum of technical universities.

This under preparation course will regard IP and both legal and managerial issues that concern a technology professional and this thesis lays the foundations for this course's development. Furthermore, this survey will be soon conducted in other countries, as well, in order to draw general and international conclusions. Because the industry of technology needs scientists and technocrats who can protect their Intellectual Property, are able to manage a competitive business and therefore contribute to smart technology industry and society's well being.

In addition, as far as what concerns smart buildings, all member States of Europe should implement the plan, they submitted according to the EED, so as to transform the cities of the European Union into smart and sustainable cities. These actions not only would be beneficial for the citizens, but for the environment, too. In this thesis, regarding the importance of presenting technology proposals that are legally compatible and applicable to the institution of a smart city, a smart template for the stable short-term and long-term construction of energy efficient buildings, by using IoT technology, was developed. Additionally, a further contribution was presented to the gradually transformation of existing buildings into Nearly Zero Energy Buildings in European Union, by proposing a management system and solutions for facing and controlling energy inefficiency in existing buildings. The proposed management system may also contribute to the Building Certification and compliance checking of buildings by providing remote and continuous measurements of all building's technical systems.

Another future goal, of which the foundations are laid by this thesis, is both the implementation and application of the management system that monitors and controls the smart building template in the construction of smart buildings. Furthermore, the implementation and application of the management system, concludes the energy efficiency of an existing building and proposes solutions to transform the building, according to the current legislation, into environmentally friendly.

Eventually, the fact is that technology is evolving at a very fast pace and legal science is really making great efforts to keep up with it. The need for legal protection of technology is imperative, since it concerns business activities and settles in society. Technology concerns all people's communication and transactions, governs every aspect of our daily lives, and provides to the humanity the tools to overcome problems like

environmental problems. This exchange benefits both society and technology, but it also arises negative consequences. Therefore, this thesis focused on future technology professionals, because they need to be equipped not only with technical knowhow and skills but also with legal and managerial skills so as to face problems, to work, to survive in the industry of technology and to contribute in the global society.

Finally, in the context of smart technology and artificial intelligence, technology is called to resolve problems of energy efficiency, energy savings and reduction of polluted emissions. Europe is moving in this direction by following the EED, and this thesis focused on smart and energy buildings, by developing solutions, utilizing IoT, for the transformation of buildings into NZEB and for the management of energy in existing buildings.

Bibliography

01 Αλεξανδροπούλου-Αιγυπτιάδου,Ευγενία.“Πειρατεία Προγραμμάτων Ηλεκτρονικών Υπολογιστών και Προστασία του Δικαιώματος Αναπαραγωγής: Ενόψει και του Πρόσφατου Νόμου 3524/2007.” Ελληνική Δικαιοσύνη 48(2007) : 1315-27.

02 Ε. Αλεξανδροπούλου-Αιγυπτιάδου, *Πνευματική ιδιοκτησία και πληροφορική*. Αθήνα: Εκδόσεις Θέμις, 2012.

03 Μ..-Θ. ΜΑΡΙΝΟΣ, *ΛΟΓΙΣΜΙΚΟ(SOFTWARE) ΝΟΜΙΚΗ ΠΡΟΣΤΑΣΙΑ ΚΑΙ ΣΥΜΒΑΣΕΙΣ ΙΙ*. ΑΘΗΝΑ: ΚΡΙΤΙΚΗ, 1992.

04 Μ.-Θ. Δ. ΜΑΡΙΝΟΣ, *ΛΟΓΙΣΜΙΚΟ(SOFTWARE) ΝΟΜΙΚΗ ΠΡΟΣΤΑΣΙΑ ΚΑΙ ΣΥΜΒΑΣΕΙΣ*. Αθήνα: Κριτική, 1989.

05 Π. Δ. Μποζάνης, *ΔΟΜΕΣ ΔΕΔΟΜΕΝΩΝ*. ΘΕΣΣΑΛΟΝΙΚΗ: Τζιόλας, 2006.

06 A. A. Rumanti, F. Muhammad, A. F. Rizana, I. I. Wiratmadja and C. Adelia, "Competitive Advantage Analysis of Small Medium Industries in Indonesia: An Approach of Management Technology and Strategic Management," 2019 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Macao, Macao, 2019, pp. 109-113, doi: 10.1109/IEEM44572.2019.8978869.

07 A. Ceclan, "Urban Energy Management, from concept to action and results," 2019 8th International Conference on Modern Power Systems (MPS), Cluj Napoca, Romania, 2019, pp. 1-4, doi: 10.1109/MPS.2019.8759679.

08 A. FOUNOUN and A. HAYAR, "Evaluation of the concept of the smart city through local regulation and the importance of local initiative," *2018 IEEE International Smart Cities Conference (ISC2)*, Kansas City, MO, USA, 2018, pp. 1-6, doi: 10.1109/ISC2.2018.8656933.

09 A. Gillespie, T. F. Xulu, S. I. Noubissie Tientcheu and S. Daniel Chowdhury, "Building Design Considerations for an Energy Efficient HVAC System," 2018 IEEE PES/IAS PowerAfrica, Cape Town, 2018, pp. 1-6.DOI: 10.1109/PowerAfrica.2018.8520995

10 A. Golla, P. Staudt and C. Weinhardt, "Combining PVT Generation and Air Conditioning: A Cost Analysis of Surplus Heat Utilization," 2019 International Conference on Smart Energy Systems and Technologies (SEST), Porto, Portugal,

2019, pp. 1-6.DOI: 10.1109/SEST.2019.8849048

11 A. J. C. Trappey, C. V. Trappey, U. H. Govindarajan and J. J. H. Sun, "Patent Value Analysis Using Deep Learning Models—The Case of IoT Technology Mining for the Manufacturing Industry," in *IEEE Transactions on Engineering Management*. doi: 10.1109/TEM.2019.2957842

12 A. Kniazevych, S. Kraichuk and N. Ostapchuk, "The Concept of Management of The Development of National Innovation Systems," 2018 International Conference on High Technology for Sustainable Development (HiTech), Sofia, 2018, pp. 1-3, doi: 10.1109/HiTech.2018.8566321.

13 A. Kumar and A. Singh, "Energy efficient and low cost air quality sensor for smart buildings," 2017 3rd International Conference on Computational Intelligence & Communication Technology (CICT), Ghaziabad, 2017, pp. 1-4.DOI: 10.1109/CIACT.2017.7977310

14 A. M. Ali, S. A. A. Shukor, N. A. Rahim, Z. M. Razlan, Z. A. Z. Jamal and K. Kohlhof, "IoT-Based Smart Air Conditioning Control for Thermal Comfort," 2019 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS), Selangor, Malaysia, 2019, pp. 289-294.DOI: 10.1109/I2CACIS.2019.8825079

15 A. Nitu, C. Stirbu and F. M. Enescu, "Mobile application for a smart city," *2018 10th International Conference on Electronics, Computers and Artificial Intelligence (ECAI)*, Iasi, Romania, 2018, pp. 1-4, doi: 10.1109/ECAI.2018.8679038.

16 A. P. Plageras and K. E. Psannis, "Algorithms for Big Data Delivery over the Internet of Things," *2017 IEEE 19th Conference on Business Informatics (CBI)*, Thessaloniki, 2017, pp. 202-206. doi: 10.1109/CBI.2017.27

17 A. Pandharipande, M. Zhao and E. Frimout, "Connected Indoor Lighting Based Applications in a Building IoT Ecosystem," in IEEE Internet Things Magazine, vol. 2, no. 1, pp. 22-26, March 2019.DOI: 10.1109/IOTM.2019.1900016

18 A. Wilk, "Cyber Security Education and Law," *2016 IEEE International Conference on Software Science, Technology and Engineering (SWSTE)*, Beer-Sheva, 2016, pp. 94-103. doi: 10.1109/SWSTE.2016.21

19 A. Zakharov, A. Romazanov, A. Shirokikh and I. Zakharova, "Intellectual Data Analysis System of Building Temperature Mode Monitoring," 2019 International Russian Automation Conference (RusAutoCon), Sochi, Russia, 2019, pp. 1-6.DOI: 10.1109/RUSAUTOCON.2019.8867611

20 Alice Civera, Michele Meoli, Silvio Vismara,Engagement of academics in university technology transfer: Opportunity and necessity academic entrepreneurship,European Economic Review,Volume 123,2020,103376,ISSN 0014-2921, https://doi.org/10.1016/j.euroecorev.2020.103376.

21 Amy J.C. Trappey, Charles V. Trappey, Jheng-Long Wu, Jack W.C. Wang, Intelligent compilation of patent summaries using machine learning and natural language processing techniques, Advanced Engineering Informatics, Volume 43, 2020,101027, ISSN 1474-0346, https://doi.org/10.1016/j.aei.2019.101027.

22 Andreas P. Plageras, Kostas E. Psannis, Christos Stergiou, Haoxiang Wang, B.B. Gupta, "Efficient IoT-based sensor BIG Data collection–processing and analysis in smart buildings," Future Generation Computer Systems, vol. 82, pp. 349-357, May, 2018. Accessed on: October, 31, 2017, DOI: doi.org/10.1016/j.future.2017.09.082

23 Audretsch, D.B., Link, A.N. & van Hasselt, M. Knowledge begets knowledge: university knowledge spillovers and the output of scientific papers from U.S. Small Business Innovation Research (SBIR) projects. *Scientometrics* **121,** 1367–1383 (2019). https://doi.org/10.1007/s11192-019-03260-3

24 B. M. Brosgol, "How to Succeed in the Software Business While Giving Away the Source Code: The AdaCore Experience," in IEEE Software, vol. 36, no. 6, pp. 17-22, Nov.-Dec. 2019, doi: 10.1109/MS.2019.2934044.

25 B. Seng, C. Magniont, S. Spagnol and S. Lorente, "Evaluation of Hemp Concrete Thermal Properties," 2016 Intl IEEE Conferences on Ubiquitous Intelligence & Computing, Advanced and Trusted Computing, Scalable Computing and Communications, Cloud and Big Data Computing, Internet of People, and Smart World Congress (UIC/ATC/ScalCom/CBDCom/IoP/SmartWorld), Toulouse, 2016, pp. 984-989.DOI: 10.1109/UIC-ATC-ScalCom-CBDCom-IoP-SmartWorld.2016.0154

26 Backs, S., Günther, M. & Stummer, C. Stimulating academic patenting in a university ecosystem: an agent-based simulation approach. *J Technol Transf* **44,** 434–461 (2019). https://doi.org/10.1007/s10961-018-9697-x

27 Bernd Carsten Stahl, Job Timmermans, and Brent Daniel Mittelstadt, “The ethics of computing: A survey of the computing-oriented literature,” ACM Comput. Surv. 48, 4, Article 55, Feb. 2016.

28 C. Amirat and R. Reeps, "Continuous Innovation Through Experimentation," 2018 IEEE Technology and Engineering Management Conference (TEMSCON), Evanston, IL, 2018, pp. 1-6, doi: 10.1109/TEMSCON.2018.8488399.

29 C. Esposito, A. Castiglione, F. Frattini, M. Cinque, Y. Yang and K. R. Choo, "On Data Sovereignty in Cloud-Based Computation Offloading for Smart Cities Applications," in *IEEE Internet of Things Journal*, vol. 6, no. 3, pp. 4521-4535, June 2019, doi: 10.1109/JIOT.2018.2886410.

30 C. Hanewicz, P. Becker and P. Alin, "Maintaining the Relevance of Technology Management Programs in an Entrepreneurial Environment," *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*, Honolulu, HI, 2018, pp. 1-7. doi: 10.23919/PICMET.2018.8481791

31 C. K. Metallidou, K. Psannis E., and E. Alexandropoulou-Egyptiadou, “Survey on the Patent Law awareness and the Entrepreneurial trend of Greece’s graduates of Technology Institutes,” *IEEE Access*, doi: 10.1109/ACCESS.2020.2994099.

32 C. K. Metallidou, K. Psannis E., and E. Alexandropoulou-Egyptiadou, “Energy Efficiency in Smart Buildings: IoT Approaches,” *IEEE Access*, vol. 8, pp. 63679–63699, Mar. 2020, doi: https://doi.org/10.1109/ACCESS.2020.2984461.

33 C. Kampf, "Extended Abstract: Building Understanding for Innovation: A Communication Framework for Innovation Projects That Goes Beyond Technology Transfer," 2018 IEEE International Professional Communication Conference (ProComm), Toronto, ON, 2018, pp. 68-68, doi: 10.1109/ProComm.2018.00024.

34 C. Shin, T. KIM, S. Lee, J. Kim, H. Nam and Y. K. Jeong, "A Study on the Effects of Economic Zero Energy Town according to the Korea’s Renewable Energy Support Policies," 2019 International Conference on Information and Communication Technology Convergence (ICTC), Jeju Island, Korea (South), 2019, pp. 1204-1207, doi: 10.1109/ICTC46691.2019.8939931.

35 C. Stergiou, K. E. Psannis, A. P. Plageras, G. Kokkonis and Y. Ishibashi, "Architecture for security monitoring in IoT environments," *2017 IEEE 26th International Symposium on Industrial*

Electronics (ISIE), Edinburgh, 2017, pp. 1382-1385. doi: 10.1109/ISIE.2017.8001447

36 C. Zhang, K. Tsukioka, D. Yin and K. Motohashi, "Innovation Strategy and Technological Catch-Up of Chinese Internet Giants: Evidence Based on Patent Data," *2019 Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, USA, 2019, pp. 1-14. doi: 10.23919/PICMET.2019.8893774

37 Castellazzi L. ,Zangheri P., Paci D., Economidou M.. Labanca N., Ribeiro Serrenho T., Panev S., Zancanella P., Broc J.-S., "Assessment of second long-term renovation strategies under the Energy Efficiency Directive," Luxembourg: Publications Office of the European Union, 2019[Online].Available: https://ec.europa.eu/jrc/en/publication/assessment-second-long-term-renovation-strategies-under-energy-efficiency-directive

38 CEN Standard for Building Components and Building elements, EN ISO 6946,2017

39 CEN Standard for Energy Performance of Buildings, EN ISO 13790,2009

40 CEN Standard for Energy Requirements for Lightening, EN 15193,2008

41 CEN Standard for Heating Systems in Buildings, EN 15316-02-01,2008

42 CEN Standard for Heating Systems in Buildings, EN 15316-03-01,2008

43 CEN Standard for Thermal Performance of Buildings, EN ISO 13370,2017

44 CEN Standard for Thermal Performance of Buildings, EN ISO 13789,2017

45 CEN Standard for Thermal performance of windows, doors and shutters, EN ISO 10077-1,2017

46 *Conference on Advanced Mechatronic Systems (ICAMechS)*, Kusatsu, Shiga, Japan, 2019, pp. 390-395. doi: 10.1109/ICAMechS.2019.8861622

47 Convention on the Grant of European Patents, EPC,1973, https://www.epo.org/law-practice/legal-texts/epc.html

48 D. Alulema, M. Zapata and M. A. Zapata, "An IoT-Based Remote Monitoring System for Electrical Power Consumption via Web-Application," 2018 International Conference on Information Systems and Computer Science (INCISCOS), Quito, 2018, pp. 193-197.DOI: 10.1109/INCISCOS.2018.00035

49 D. Bainbridge, *Introduction to Computer Law*, 5th ed. UK: Pearson Education Ltd, 2004.

50 D. K. Aagri and A. Bisht, "Export and Import of Renewable energy by Hybrid MicroGrid via IoT," 2018 3rd International Conference On Internet of Things: Smart Innovation and Usages (IoT-SIU), Bhimtal, 2018, pp. 1-4, doi: 10.1109/IoT-SIU.2018.8519873.

51 D. Kappos, "An Examination of Software Patents." Nov. 20, 2012, [Online]. Available: https://www.uspto.gov/about-us/news-updates/examination-software-patents.

52 D. Ktoridou, E. Doukanari, E. Epaminonda and A. Karayiannis, "Case-based learning: Offering a premier targeted learning experience for technology management students," 2018 IEEE Global Engineering Education Conference (EDUCON), Tenerife, 2018, pp. 1781-1786, doi: 10.1109/EDUCON.2018.8363450.

53 D. Ktoridou, E. Doukanari, E. Epaminonda and A. Karayiannis, "Case-based learning: Offering a premier targeted learning experience for technology management students," 2018 IEEE Global Engineering Education Conference (EDUCON), Tenerife, 2018, pp. 1781-1786, doi: 10.1109/EDUCON.2018.8363450.

54 D. Lučié, "Regulatory challenges due to implementation of Internet of Things based on 5G technology," *2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, Opatija, 2018, pp. 0339-0344, doi: 10.23919/MIPRO.2018.8400065.

55 D. Müller, Y. Te and P. Jain, "Predicting business performance through patent applications," *2017 IEEE International Conference on Big Data (Big Data)*, Boston, MA, 2017, pp. 4159-4164.
doi: 10.1109/BigData.2017.8258438

56 D. Zhang, "Study on the Effects of Different Measures in Promoting Renewable Energy Consumption," 2018 2nd IEEE Conference on Energy Internet and Energy System Integration (EI2), Beijing, 2018, pp. 1-5, doi: 10.1109/EI2.2018.8581892.

57 Daniel Gervais, Is Intellectual Property Law Ready for Artificial Intelligence?, GRUR International, Volume 69, Issue 2, February 2020, Pages 117–118, https://doi.org/10.1093/grurint/ikz025

58 de Haan, U., Shwartz, S.C. & Gómez-Baquero, F. A startup postdoc program as a channel for university technology transfer: the case of the Runway Startup Postdoc Program at the Jacobs Technion–Cornell Institute at Cornell Tech. J Technol Transf (2019). https://doi.org/10.1007/s10961-019-09764-7

59 DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency, Official Journal of the European Union L156/75, 19.6.2018 [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG

60 DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2006/32/EC, Official Journal of the European Union L315/1, 14.11.2012 [Online]. Available:https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32012L0027

61 Directorate-General for Energy (European Commission), *Good practice in energy efficiency, For a sustainable, safer and more competitive Europe*. EU publications, 2017.

62 E. Alexandropoulou-Egyptiadou, *The Hellenic framework for computer program copyright protection following the implementation of the relative European Union Directives, in Investigating Cyber Law and Cyber Ethics*. USA, Pennsylvania: IGI GLOBAL, 2012.

63 E. Leonard, I. H. De Kock and W. G. Bam, "Investigating the relationships between health and innovation systems to guide innovation adoption," 2019 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC), Valbonne Sophia-Antipolis, France, 2019, pp. 1-10, doi: 10.1109/ICE.2019.8792677.

64 Elliott, C., Mavriplis, C. & Anis, H. An entrepreneurship education and peer mentoring program for women in STEM: mentors' experiences and perceptions of entrepreneurial self-efficacy and intent. *Int Entrep Manag J* (2020). https://doi.org/10.1007/s11365-019-00624-2

65 G. Aiello *et al*., "A context agnostic air quality service to exploit data in the IoE era," *2019 4th International Conference on Smart and Sustainable Technologies (SpliTech)*, Split, Croatia, 2019, pp. 1-8, doi: 10.23919/SpliTech.2019.8783138.

66 G. Alsuhli and A. Khattab, "A Fog-based IoT Platform for Smart Buildings," 2019 International Conference on Innovative Trends in Computer Engineering (ITCE), Aswan, Egypt, 2019, pp. 174-179.DOI: 10.1109/ITCE.2019.8646480

67 G. Cavalera et al., "An Innovative Smart System based on IoT Technologies for Fire and Danger Situations," 2019 4th International Conference on Smart and Sustainable Technologies (SpliTech), Split, Croatia, 2019,pp.1-6.DOI: 10.23919/SpliTech.2019.8783059

68 G. Karmakar, S. Roy, G. Chattopadhyay and Z. Xiao, "Dynamically controlling exterior and interior window coverings through IoT for environmental friendly smart homes," 2017 IEEE International Conference on Mechatronics (ICM), Churchill, VIC, 2017, pp. 487-491.DOI: 10.1109/ICMECH.2017.7921156

69 G. Muthuselvi and B. Saravanan, "The promise of DSM in smart grid using home energy management system with renewable integration," 2017 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, 2017, pp. 1-4, doi: 10.1109/IPACT.2017.8245102.

70 G. Wan, L. Tang and X. Xiong, "Research on Performance evaluation of Software industry," 2019 16th International Conference on Service Systems and Service Management (ICSSSM), Shenzhen, China, 2019, pp. 1-5, doi: 10.1109/ICSSSM.2019.8887706.

71 H. D. Mohammadian, "IoE – a Solution for Energy Management Challenges," 2019 IEEE Global Engineering Education Conference (EDUCON), Dubai, United Arab Emirates, 2019, pp. 1455-1461, doi: 10.1109/EDUCON.2019.8725281.

72 H. Menouar, I. Guvenc, K. Akkaya, A. S. Uluagac, A. Kadri and A. Tuncer, "UAV-Enabled Intelligent Transportation Systems for the Smart City: Applications and Challenges," in *IEEE Communications Magazine*, vol. 55, no. 3, pp. 22-28, March 2017, doi: 10.1109/MCOM.2017.1600238CM.

73 H. Rockman, *Intellectual Property Law for Engineers and Scientists*. New Jersey: J. Wiley and sons, 2004.

74 Haney, Brian S., AI Patents: A Data Driven Approach (January 28, 2020). Brian S. Haney, AI Patents: A Data Driven Approach, 19 Chi.-Kent J. Intell. Prop. __ (2020)(Forthcoming). Available at SSRN: https://ssrn.com/abstract=3527154 or

http://dx.doi.org/10.2139/ssrn.3527154

75 İ. Ilhan, M. Karaköse and M. Yavaş, "Design and Simulation of Intelligent Central Heating System for Smart Buildings in Smart City," 2019 7th International Istanbul Smart Grids and Cities Congress and Fair (ICSG), Istanbul, Turkey, 2019, pp. 233-237.DOI: 10.1109/SGCF.2019.8782356

76 I. Lima, C. Marques, R. Moraes, V. Sarmentó and Z. Carvalho, "The Public Policy Strategies Fostering Smart Cities," 2017 IEEE First Summer School on Smart Cities (S3C), Natal, 2017, pp. 165-167, doi: 10.1109/S3C.2017.8501409.

77 J. Aguilar, A. Garcès-Jimènez, N. Gallego-Salvador, J. A. G. De Mesa, J. M. Gomez-Pulido and À. J. Garcìa-Tejedor, "Autonomic Management Architecture for Multi-HVAC Systems in Smart Buildings," in IEEE Access, vol. 7, pp. 123402-123415, 2019.DOI: 10.1109/ACCESS.2019.2937639

78 J. Li, "Intellectual property licensing tensions in incorporating open source into formal standard setting context — The case of Apache V.2 in ETSI as a start," *2017 ITU Kaleidoscope: Challenges for a Data-Driven Society (ITU K)*, Nanjing, 2017, pp. 1-8. doi: 10.23919/ITU-WT.2017.8246986

79 J. Patel and A. Goyal, "Smart Materials in Construction Technology," 2018 International Conference on Smart City and Emerging Technology (ICSCET), Mumbai, 2018, pp. 1-9.DOI: 10.1109/ICSCET.2018.8537256

80 J. Patnaik and B. Bhowmick, "Appropriate Technology and Management for Sustainability," 2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Bangkok, 2018, pp. 1289-1292, doi: 10.1109/IEEM.2018.8607424.

81 J. Shim and Y. Deguchi, "Conjoint comparison of support systems for intellectual property activities of university students in science and engineering majors in Korea and Japan," *Proceedings of IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE) 2012*, Hong Kong, 2012, pp. W2D-4-W2D-6. doi: 10.1109/TALE.2012.6360303

82 J. Zhang, Y. Guan, X. Qu, H. B. Liaqat and Y. Li, "Research on Technology Similarity of Enterprises Based on Patent Bibliometrics," *2018 IEEE International Conference on Smart Internet of Things (SmartIoT)*, Xi'an, 2018, pp. 204-209. doi: 10.1109/SmartIoT.2018.00044

83 J. Zhang, Y. Tao, J. Qiu and X. Han, "Design of a smart socket for smart home energy management systems," 2019 Chinese Control And Decision Conference (CCDC), Nanchang, China, 2019, pp. 5543-5548.DOI: 10.1109/CCDC.2019.8832486

84 Jefferson, D.J., Maida, M., Farkas, A. *et al.* Technology transfer in the Americas: common and divergent practices among major research universities and public sector institutions. *J Technol Transf* **42,** 1307–1333 (2017). https://doi.org/10.1007/s10961-016-9516-1

85 K. A. Achmad, L. E. Nugroho, A. Djunaedi and Widyawan, "Smart City for Development: Towards a Conceptual Framework," *2018 4th International Conference on Science and Technology (ICST)*, Yogyakarta, 2018, pp. 1-6, doi: 10.1109/ICSTC.2018.8528677.

86 K. Lemke-Rust and P. Samarin, "Exploring Embedded Software with Side Channels and Fault Analysis," 2018 12th European Workshop on Microelectronics Education (EWME), Braunschweig, Germany, 2018, pp. 67-70, doi: 10.1109/EWME.2018.8629479.

87 K. R. Babu and C. Vyjayanthi, "Implementation of net zero energy building (NZEB) prototype with renewable energy integration," 2017 IEEE Region 10 Symposium (TENSYMP), Cochin, 2017, pp. 1-5.DOI: 10.1109/TENCONSpring.2017.8069994

88 Kadian, T. (2020). An Introduction To Intellectual Property Rights and Their Importance In Indian Context. *Our Heritage*, *68*(1), 6252-6256. Retrieved from https://archives.ourheritagejournal.com/index.php/oh/article/view/1664

89 Kirby, D.A., El Hadidi, H.H. University technology transfer efficiency in a factor driven economy: the need for a coherent policy in Egypt. *J Technol Transf* **44,** 1367–1395 (2019). https://doi.org/10.1007/s10961-019-09737-w

90 L. Liu, "A Multi-Functional Smart Socket Design," 2019 International Conference on Communications, Information System and Computer Engineering (CISCE), Haikou, China, 2019, pp. 5-8.DOI: 10.1109/CISCE.2019.00009

91 L. Manjakkal, F. Nikbakhtnasrabadi and R. Dahiya, "Energy Autonomous Sensors for Water Quality Monitoring," *2018 IEEE SENSORS*, New Delhi, 2018, pp. 1-4, doi: 10.1109/ICSENS.2018.8589564.

92 L. Nazarko and B. Melnikas, "Responsible Research and Innovation in Engineering and Technology Management: Concept, Metrics and Assessment," 2019 IEEE

Technology & Engineering Management Conference (TEMSCON), Atlanta, GA, USA, 2019, pp. 1-5, doi: 10.1109/TEMSCON.2019.8813596.

93 L. Y. Y. Lu and J. S. Liu, "A survey of intellectual property rights literature from 1971 to 2012: The main path analysis," *Proceedings of PICMET '14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration*, Kanazawa, 2014, pp. 1274-1280.

94 Lisa Larrimore Ouellette, Andrew Tutt, How do patent incentives affect university researchers?, International Review of Law and Economics,Volume 61,2020,105883 ,ISSN 0144-8188, https://doi.org/10.1016/j.irle.2019.105883.

95 M. Boban and M. Weber, "Internet of Things, legal and regulatory framework in digital transformation from smart to intelligent cities," *2018 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, Opatija, 2018, pp. 1359-1364, doi: 10.23919/MIPRO.2018.8400245.

96 M. Eastwood, A. Konios, B. Tan, Y. Jing and A. Hamid, "Conditional Random Field Feature Generation of Smart Home Sensor Data using Random Forests," *2019 IEEE MTT-S International Microwave Biomedical Conference (IMBioC)*, Nanjing, China, 2019, pp. 1-4, doi: 10.1109/IMBIOC.2019.8777764.

97 M. H. Alsharif, A. H. Kelechi, S. Kim, I. Khan, J. Kim and J. H. Kim, "Enabling Hardware Green Internet of Things: A review of Substantial Issues," in IEEE Access, doi: 10.1109/ACCESS.2019.2926800.

98 M. Herman, "Evolving Technologies and Intellectual Property Landscapes: Developing IPR Policies to Avoid Confusion and Chaos Within Development Communities," in IEEE Communications Standards Magazine, vol. 3, no. 2, pp. 62-67, June 2019, doi: 10.1109/MCOMSTD.2019.1900012.

99 M. J. du Plessis and M. W. Pretorius, "Does My Organization Need an Innovation Management Function?: Towards a Model for Evaluation," 2018 Portland International Conference on Management of Engineering and Technology (PICMET), Honolulu, HI, 2018, pp. 1-10, doi: 10.23919/PICMET.2018.8481890.

100 M. Jovanović, V. Obradović and M. Todorović, "ICT Development as A Key Innovation Driver: The Project Management Approach," 2019 IEEE 14th International Conference on Computer Sciences and Information Technologies (CSIT), Lviv,

Ukraine, 2019, pp. 148-151, doi: 10.1109/STC-CSIT.2019.8929768.

101 M. Leisenberg and M. Stepponat, "Internet of Things Remote Labs: Experiences with Data Analysis Experiments for Students Education," *2019 IEEE Global Engineering Education Conference (EDUCON)*, Dubai, United Arab Emirates, 2019, pp. 22-27, doi: 10.1109/EDUCON.2019.8725070.

102 M. Sako and K. Kato, "Research on the harmonization of intellectual property systems from the point of view of Japanese inventors," *2017 IEEE Technology & Engineering Management Conference (TEMSCON)*, Santa Clara, CA, 2017, pp. 245-251. doi: 10.1109/TEMSCON.2017.7998384

103 M. Shibata, Y. Ohtsuka, M. Takahashi and K. Okamoto, "Advanced FPGA technology trend based on patent analysis with link mining," *2018 International Conference on Electronics Packaging and iMAPS All Asia Conference (ICEP-IAAC)*, Mie, 2018, pp. 147-151. doi: 10.23919/ICEP.2018.8374691

104 M. Sophocleous, P. Savva, M. F. Petrou, J. K. Atkinson and J. Georgiou, "A Durable, Screen-Printed Sensor for In Situ and Real-Time Monitoring of Concrete's Electrical Resistivity Suitable for Smart Buildings/Cities and IoT," in IEEE Sens. Lett., vol. 2, no. 4, pp. 1-4, Dec. 2018, Art no. 1501404.DOI: 10.1109/LSENS.2018.2871517

105 M. Vasiliev, M. Nur-E-Alam and K. Alameh, "Highly Stable Thin-Film Multilayers For Thermal Regulation and Energy Savings In Smart Cities," *2019 IEEE 16th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT and AI (HONET-ICT)*, Charlotte, NC, USA, 2019, pp. 229-231, doi: 10.1109/HONET.2019.8908086.

106 N. Dinh and Y. Kim, "An Efficient On-Demand Latency Guaranteed Interactive Model for Sensor-Cloud," in IEEE Access, vol. 6, pp. 68596-68611, 2018.DOI: 10.1109/ACCESS.2018.2879811

107 N. Haidar, N. Tamani, F. Nienaber, M. T. Wesseling, A. Bouju and Y. Ghamri-Doudane, "Data Collection Period and Sensor Selection Method for Smart Building Occupancy Prediction," 2019 IEEE 89th Vehicular Technology Conference (VTC2019-Spring), Kuala Lumpur, Malaysia, 2019, pp. 1-6.DOI: 10.1109/VTCSpring.2019.8746447

108 N. Khan, N. Pathak and N. Roy, "Detecting Common Insulation Problems in Built Environments using Thermal Images," 2019 IEEE International Conference on Smart Computing (SMARTCOMP), Washington, DC, USA, 2019, pp. 454-458.DOI:

10.1109/SMARTCOMP.2019.00087

109 N. Koshizuka, S. Haller and K. Sakamura, "CPaaS.io: An EU-Japan Collaboration on Open Smart-City Platforms," in *Computer*, vol. 51, no. 12, pp. 50-58, Dec. 2018, doi: 10.1109/MC.2018.2880019.

110 N. M. Elsayed, R. A. Swief, S. O. Abdellatif and T. S. Abdel-Salam, "Photovoltaic Applications for Lighting Load Energy Saving: Case Studies, Educational Building," 2019 International Conference on Innovative Trends in Computer Engineering (ITCE), Aswan, Egypt, 2019,pp.564-569. DOI: 10.1109/ITCE.2019.8646485

111 N. T. Anh Van, "Technology Innovation and Firm Performace in Vietnam's SME Sector," 2019 International Conference on System Science and Engineering (ICSSE), Dong Hoi, Vietnam, 2019, pp. 401-404, doi: 10.1109/ICSSE.2019.8823136.

112 Ν. Ρόκας, *Βιομηχανική Ιδιοκτησία*, Αντ. Ν. Σάκκουλα. Αθήνα-Κομοτηνή, 2004.

113 P. A. Nylund, X. Ferras-Hernandez and A. Brem, "Strategies for Activating Innovation Ecosystems: Introduction of a Taxonomy," in IEEE Engineering Management Review, vol. 47, no. 4, pp. 60-66, 1 Fourthquarter,Dec. 2019, doi: 10.1109/EMR.2019.2931696.

114 P. Burgstaller, "Awareness of Privacy and Intellectual Property Rights under the Economic Partnership Agreement between EU and Japan," 2019 IEEE 10th International Conference on Awareness Science and Technology (iCAST), Morioka, Japan, 2019, pp. 1-4, doi: 10.1109/ICAwST.2019.8923131.

115 P. D. Leo, F. Spertino, S. Fichera, G. Malgaroli and A. Ratclif, "Improvement of Self-Sufficiency for an Innovative Nearly Zero Energy Building by Photovoltaic Generators," 2019 IEEE Milan PowerTech, Milan, Italy, 2019 ,pp.1-6. DOI: 10.1109/PTC.2019.8810434

116 P. G. Jeyasheeli and J. V. J. Selva, "An IOT design for smart lighting in green buildings based on environmental factors," 2017 4th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, 2017, pp.1-5.DOI: 10.1109/ICACCS.2017.8014559

117 P. Matoušek, O. Ryšavý, J. I. James and Y. Jake Jang, "Interconnecting Education and Research Through International Partnership: IoT Case Study," *2018 28th EAEEIE Annual Conference (EAEEIE)*, Hafnarfjordur, 2018, pp. 1-6, doi: 10.1109/EAEEIE.2018.8534248.

118 P. Zhai, "Design and Implementation of Intelligent International Law Online Consultation System," *2018 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*, Xiamen, 2018, pp. 476-479, doi: 10.1109/ICITBS.2018.00126.

119 P. Zhai, "Design and Implementation of Intelligent International Law Online Consultation System," *2018 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*, Xiamen, 2018, pp. 476-479, doi: 10.1109/ICITBS.2018.00126.

120 Q. Lin and Z. Lian, "A study of the innovation and protection mechanisms for the cultural and creative industries," *2017 International Conference on Applied System Innovation (ICASI)*, Sapporo, 2017, pp. 133-135. doi: 10.1109/ICASI.2017.7988603

121 R. Garg, S. Varadi and A. Kertesz, "Legal Considerations of IoT Applications in Fog and Cloud Environments," *2019 27th Euromicro International Conference on Parallel, Distributed and Network-Based Processing (PDP)*, Pavia, Italy, 2019, pp. 193-198, doi: 10.1109/EMPDP.2019.8671620.

122 R. Setyowati, Sutoto, S. N. Asih, A. Ishlahuddin, M. R. Shihab and B. Ranti, "Improving Capabilities and Creating Values in Public Services Through Extended Organization Concept: Case Study of Jakarta Smart City," *2019 International Conference on Information Management and Technology (ICIMTech)*, Jakarta/Bali, Indonesia, 2019, pp. 192-197, doi: 10.1109/ICIMTech.2019.8843819.

123 R. Wegmueller, G. Magnin, J. Robadey and E. Niederhäuser, "Controlled active thermal storage in smart PCM walls for energy independent building applications," 2018 5th International Conference on Renewable Energy: Generation and Applications (ICREGA), Al Ain, 2018, pp. 154-157.DOI: 10.1109/ICREGA.2018.8337575

124 REGULATION (EU) 2018/842 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation(EU) No 525/2013, Official Journal of the European Union L156/26, 19.6.2018 [Online]. Available: https://eur-lex.europa.eu/eli/reg/2018/842/oj

125 S. Antonov, "Smart Solution for Fire Safety in a Large Garage," 2019 International Conference on Creative Business for Smart and Sustainable Growth (CREBUS), Sandanski, Bulgaria, 2019, pp. 1-4.DOI: 10.1109/CREBUS.2019.8840089

126 S. Cha, T. Hsu, Y. Xiang and K. Yeh, "Privacy Enhancing Technologies in the Internet of Things: Perspectives and Challenges," in *IEEE Internet of Things Journal*, vol. 6, no. 2, pp. 2159-2187, April 2019, doi: 10.1109/JIOT.2018.2878658.

127 S. Ghosh, "Smart homes: Architectural and engineering design imperatives for smart city building codes," *2018 Technologies for Smart-City Energy Security and Power (ICSESP)*, Bhubaneswar, 2018, pp. 1-4, doi: 10.1109/ICSESP.2018.8376676.

128 S. Hu and T. Jiang, "Artificial Intelligence Technology Challenges Patent Laws," *2019 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*, Changsha, China, 2019, pp. 241-244. doi: 10.1109/ICITBS.2019.00064

129 S. Hu and T. Jiang, "Artificial Intelligence Technology Challenges Patent Laws," *2019 Int. Conf. Intell. Transp. Big Data Smart City*, pp. 241–244, 2019, doi: 10.1109/ICITBS.2019.00064.

130 S. Hu, "Patent Protection for Artificial Intelligence in China," *2019 International Conference on Virtual Reality and Intelligent Systems (ICVRIS)*, Jishou, China, 2019, pp. 295-298. doi: 10.1109/ICVRIS.2019.00078

131 S. Hu, "The Influence of Artificial Intelligence Development on Patent Legislation," *2019 International Conference on Robots & Intelligent System (ICRIS)*, Haikou, China, 2019, pp. 110-113. doi: 10.1109/ICRIS.2019.00036

132 S. Khairy and A. G. Hossam, "Building Energy Management Systems (BEMS)," 2018, doi: 10.1002/9781119422099.

133 S. Kim, J. Ahn and D. Chung, "A Design of Energy Demand / Supply Prediction Model Using Deep Learning for Zero Energy Town Based on Measured Data," 2019 International Conference on Information and Communication Technology Convergence (ICTC), Jeju Island, Korea (South), 2019, pp. 1215-1217, doi: 10.1109/ICTC46691.2019.8939786.

134 S. L. S. Worthington, "Innovation, Entrepreneurial Orientation, and the Survival of the 21st Century Tech Organization," in IEEE Engineering Management Review, vol. 46, no. 4, pp. 19-21, Fourthquarter,Dec. 2018, doi: 10.1109/EMR.2018.2879320.

135 S. M. Fu and C. M. Chou, "A Case Study of Intellectual Property Rights Management with Capability Maturity Model," 2019 IEEE International Conference on Industrial

Engineering and Engineering Management (IEEM), Macao, Macao, 2019, pp. 134-138, doi: 10.1109/IEEM44572.2019.8978645.

136 S. Marzal, R. González-Medina, R. Salas-Puente, G. Garcerá and E. Figueres, "An Embedded Internet of Energy Communication Platform for the Future Smart Microgrids Management," in IEEE Internet of Things Journal, vol. 6, no. 4, pp. 7241-7252, Aug. 2019, doi: 10.1109/JIOT.2019.2915389.

137 S. Nemet, M. Barić, F. Bencić and D. Kukolj, "Comparative Technology Assessment using Patent Evaluation," *2018 Zooming Innovation in Consumer Technologies Conference (ZINC)*, Novi Sad, 2018,pp.162-165. doi: 10.1109/ZINC.2018.8448935

138 S. Okara, S. Broering and N. Sick, "Anticipating Industry Convergence in the Context of Industry 4.0," *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*, Honolulu, HI, 2018, pp. 1-8. doi: 10.23919/PICMET.2018.8481794

139 S. Park and B. Kim, "4th Industrial Revolution and Open Access Network for Smart City," *2018 Portland International Conference on Management of Engineering and Technology (PICMET)*, Honolulu, HI, 2018, pp. 1-10, doi: 10.23919/PICMET.2018.8481779.

140 S. Rastegarpour, M. Ghaemi and L. Ferrarini, "A predictive control strategy for energy management in buildings with radiant floors and thermal storage," 2018 SICE International Symposium on Control Systems (SICE ISCS), Tokyo, 2018, pp. 67-73.DOI: 10.23919/SICEISCS.2018.8330158

141 S. Shamim, S. Cang, H. Yu, Y. Li, L. Y. Chen and X. Yao, "How firms in emerging economies can learn industry 4.0 by extracting knowledge from their foreign partners? A view point from strategic management perspective," *2019 International*

142 S. Sholla, R. Naaz and M. A. Chishti, "Ethics Aware Object Oriented Smart City Architecture," in *China Communications*, vol. 14, no. 5, pp. 160-173, May 2017, doi: 10.1109/CC.2017.7942323.

143 Select Committee, "An Enhanced European Patent System." [Online]. Available: www.unified-patent-court.org.

144 Sohn, S.Y., Han, E.J. Engineering graduate students' views on the effective ownership of academic patents. *J Technol Transf* **44,** 132–154 (2019). https://doi.org/10.1007/s10961-017-9598-4

145 Sun, X., Zhou, X., Wang, Q. et al. Understanding attitudes towards intellectual property from the perspective of design professionals. Electron Commer Res (2019). https://doi.org/10.1007/s10660-019-09378-z

146 Sun, Y., Zhang, C. & Kok, R.A.W. The role of research outcome quality in the relationship between university research collaboration and technology transfer: empirical results from China. *Scientometrics* **122,** 1003–1026 (2020). https://doi.org/10.1007/s11192-019-03330-6

147 T. Akakura, T. Kawamata and K. Kato, "Development and Use of a Video On Demand e-Learning System with Logic Circuit Exercises for Teaching Intellectual Property Law," *2018 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, Wollongong, NSW, 2018, pp. 883-886. doi: 10.1109/TALE.2018.8615187

148 T. Jiang and S. Hu, "Intellectual Property Protection for AI-Related Inventions in Japan," *2019 International Conference on Virtual Reality and Intelligent Systems (ICVRIS)*, Jishou, China, 2019, pp. 286-289. doi: 10.1109/ICVRIS.2019.00076

149 T. Jiang and S. Hu, "Intellectual Property Protection for AI-Related Inventions in Japan," 2019 International Conference on Virtual Reality and Intelligent Systems (ICVRIS), Jishou, China, 2019, pp. 286-289, doi: 10.1109/ICVRIS.2019.00076.

150 T. Kose, H. Yamano and I. Sakata, "Detecting Emerging Complex Technological Fields in Robotics," *2019 Portland International Conference on Management of Engineering and Technology (PICMET)*, Portland, OR, USA, 2019, pp. 1-12. doi: 10.23919/PICMET.2019.8893969

151 T. Ku, W. Park and H. Choi, "Energy Big Data Life Cycle Mechanism for Renewable Energy System," IEEE INFOCOM 2019 - IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS), Paris, France, 2019, pp. 1067-1068, doi: 10.1109/INFCOMW.2019.8845036.

152 T. Ku, W. Park and H. Choi, "Virtual Simulation Mechanism for Distributed Energy Resources Based on Home Energy System Facilities," 2019 IEEE International Conference on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2019, pp. 1-2, doi: 10.1109/ICCE.2019.8661834.

153 T. R. Andel, L. N. Whitehurst, J. T. McDonald and W. Al-Assadi, "Enhancing Security Against Software Attacks with Reprogrammable Hardware," 2018 1st International Conference on Data Intelligence and Security (ICDIS), South Padre Island, TX, 2018, pp. 258-266, doi: 10.1109/ICDIS.2018.00049.

154 T. Saiki, "Patent survey to Japanese R&D-directed firms," *Proceedings of PICMET '14 Conference: Portland International Center for Management of Engineering and Technology; Infrastructure and Service Integration*, Kanazawa, 2014, pp. 1431-1436.

155 T. Sonnekalb and S. Lucia, "Smart Hot Water Control with Learned Human Behavior for Minimal Energy Consumption," 2019 IEEE 5th World Forum on Internet of Things (WF-IoT), Limerick, Ireland, 2019, pp. 572-577. DOI: 10.1109/WF-IoT.2019.8767171

156 V. Dattana, K. Gupta and A. Kush, "A Probability based Model for Big Data Security in Smart City," *2019 4th MEC International Conference on Big Data and Smart City (ICBDSC)*, Muscat, Oman, 2019, pp. 1-6, doi: 10.1109/ICBDSC.2019.8645607.

157 V. H. M. Garcia, E. Y. F. Rodriguez and L. M. M. Estrada, "Knowledge management model and measurement of intellectual capital in the financial sector," 2018 13th Iberian Conference on Information Systems and Technologies (CISTI), Caceres, 2018, pp. 1-7, doi: 10.23919/CISTI.2018.8399196.

158 W. Li, K. Thirugnanam, W. Tushar, C. Yuen, K. T. Chew and S. Tai, "Improving the Operation of Solar Water Heating Systems in Green Buildings via Optimized Control Strategies," in IEEE Trans. Ind. Informat., vol. 14, no. 4, pp. 1646-1655, April 2018.DOI: 10.1109/TII.2018.2797018

159 W. Liu and X. Yu, "Cultivating Intellectual Property Education in the Electronics Engineering Curriculum: A Case Study in Integrated Circuit Design," in *IEEE Access*, vol. 7, pp. 101401-101414, 2019. doi: 10.1109/ACCESS.2019.2931343

160 W. Saksilapachai, T. Mayakul, S. Wattanasirichaigoon and S. Kiattisin, "Communication Process Management within Virtual Work for Startup Entrepreneur," 2019 4th Technology Innovation Management and Engineering Science International Conference (TIMES-iCON), Bangkok, Thailand, 2019, pp. 1-4, doi: 10.1109/TIMES-iCON47539.2019.9024502.

161 W. Scacchi, "Winning and Losing in Large-Scale Software Development: A Multi-Decade Perspective," in Computer, vol. 51, no. 10, pp. 58-65, October 2018, doi:

10.1109/MC.2018.3971348.

162 Wang Y., Zhang L. (2020) Research on Intellectual Property Protection of Industrial Innovation Under the Background of Big Data. In: Huang C., Chan YW., Yen N. (eds) Data Processing Techniques and Applications for Cyber-Physical Systems (DPTA 2019). Advances in Intelligent Systems and Computing, vol 1088. Springer, Singapore, DOI https://doi.org/10.1007/978-981-15-1468-5_210

163 X. Zhang, M. Pipattanasomporn, T. Chen and S. Rahman, "An IoT-based Thermal Model Learning Framework for Smart Buildings," in IEEE Internet Things J.DOI: 10.1109/JIOT.2019.2951106

164 X. Zhang, M. Pipattanasomporn, T. Chen and S. Rahman, "An IoT-Based Thermal Model Learning Framework for Smart Buildings," in IEEE Internet Things J., vol. 7, no. 1, pp. 518-527, Jan. 2020.DOI: 10.1109/JIOT.2019.2951106

165 Xiang Li, Chanil Pak & Kexin Bi (2020) Analysis of the development trends and innovation characteristics of Internet of Things technology – based on patentometrics and bibliometrics, Technology Analysis & Strategic Management, 32:1, 104-118, DOI: 10.1080/09537325.2019.1636960

166 Y. Su and B. Liu, "Synergetics of Enterprise Innovation Systems Based on a Three-Variable Oscillation Reaction," in IEEE Access, vol. 7, pp. 150598-150608, 2019, doi: 10.1109/ACCESS.2019.2948103.

167 Y. Yuan, X. Li, Z. Liu and X. Guan, "Occupancy Estimation in Buildings Based on Infrared Array Sensors Detection," in IEEE Sensors J.DOI: 10.1109/JSEN.2019.2943157

168 "The 3rd Technology Innovation Management and Engineering Science International Conference," 2018 3rd Technology Innovation Management and Engineering Science International Conference (TIMES-iCON), Bangkok, Thailand, 2018, pp. i-xii, doi: 10.1109/TIMES-iCON.2018.8621740.

169 “1733/87.” [Online]. Available: https://www.e-nomothesia.gr/epheureseis-euresitekhnies/n-1733-1987.html.

170 “2121/1993.” [Online]. Available: https://www.opi.gr/vivliothiki/2121-1993.

171 “2290/1995.” [Online]. Available: http://legislation.di.uoa.gr/eli/law/1995/2290?language=en.

172 “A study on inventorship in inventions involving AI activity.” the European Patent Office, Feb. 2019, [Online]. Available: https://www.epo.org/service-support/updates/2019/20190614.html.

173 “Agreement on a Unified Patent Court OJ C 175,2013/C 175/01.” Official Journal of the European Union, Jun. 20, 2013, [Online]. Available: https://eur-lex.europa.eu/legal content/EN/TXT/?qid=1588861962627&uri=CELEX:42013A0620(01).

174 “algorithm.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/algorithm).

175 “Berne Convention for the Protection of Literary and Artistic Works.” Jul. 24, 1971, [Online]. Available: http://www.wipo.int/wipolex/en/treaties/text.jsp?file_id=283693.

176 “COMMISSION RECOMMENDATION (EU) 2019/1019 of 7 June 2019 on building modernisation.” [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588932366308&uri=CELEX:32019H1019.

177 “COMMISSION RECOMMENDATION (EU) 2019/786 of 8 May 2019 on building renovation (notified under document C(2019) 3352).” [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588932281603&uri=CELEX:32019H0786.

178 “computer program.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/computer-program).

179 “computer programming.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/computer-programming.

180 “Contracting States of the PCT.” [Online]. Available: https://www.wipo.int/pct/en/pct_contracting_states.html.

181 “Council Regulation (EU) No 1260/2012 of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection with regard to the applicable translation arrangements, OJ L 361.” Official Journal of the European Union, Dec. 31, 2012, [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R1260.

182 “DIRECTIVE (EU) 2018/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 amending Directive 2012/27/EU on energy efficiency.”

[Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L2002&qid=1588931253613.

183 "DIRECTIVE (EU) 2018/844 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L0844.

184 "DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588932634472&uri=CELEX:32010L0031.

185 "DIRECTIVE 2012/27/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC." [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32012L0027.

186 "energy efficient." [Online]. Available: (https://dictionary.cambridge.org/dictionary/english/energy-efficient).

187 "Environmental and Energy Study Institute, building efficiency." [Online]. Available: https://www.eesi.org/topics/energy-efficiency/description.

188 "Environmental and Energy Study Institute, energy efficiency." [Online]. Available: https://www.eesi.org/topics/energy-efficiency/description.

189 "EU buildings database." [Online]. Available: https://ec.europa.eu/energy/eu-buildings-database_en.

190 "EU buildings Datamapper." [Online]. Available: https://ec.europa.eu/energy/eu-buildings-datamapper_en.

191 "European Patent Office , Guidelines for Examination." [Online]. Available: https://www.epo.org/law-practice/legal-texts/html/guidelines/e/f_iia1.htm.

192 "European Patent Office." [Online]. Available: https://www.epo.org/index.html.

193 "Eurostat Statistics Explained site, Renewable energy sources." [Online]. Available: https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Renewable_energy_sources.

194 “Fees schedule.” [Online]. Available: https://my.epoline.org/epoline-portal/classic/epoline.Scheduleoffees.

195 “hardware.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/hardware).

196 “Hellenic Industrial Property Organisation.” [Online]. Available: http://www.obi.gr/el/.

197 “IP5 Statistics Report,2018 Edition.” Oct. 2019, [Online]. Available: www.fiveipoffices.org.

198 “Nearly Zero Energy Buildings.” [Online]. Available: https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en.

199 “Patent Cooperation Treaty.” [Online]. Available: https://www.wipo.int/pct/en/texts/index.html.

200 “patent.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/patent.

201 “PCT patent applications in 2018.” [Online]. Available: https://www.wipo.int/edocs/infogdocs/en/ipfactsandfigures2019/.

202 “Proposal for a Council Regulation on the Community patent COM/2000/0412.” Jan. 08, 2000, [Online]. Available: http://www.epo.org/service-support/faq/procedure-law/faq.html.

203 “Regulation (EU) No 1257/2012 of the European Parliament and of the Council of 17 December 2012 implementing enhanced cooperation in the area of the creation of unitary patent protection, OJ L 361, 31.12.2012.” [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R1257.

204 “renewable energy.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/renewable-energy.

205 “smart building.” [Online]. Available: https://ec.europa.eu/growth/tools-databases/dem/monitor/tags/smart-building.

206 “smart.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/smart.

207 “software.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/software.

208 “source code.” [Online]. Available: https://dictionary.cambridge.org/dictionary/english/source-code.

209 “The annual fees for European patent and for Unitary patent.” [Online]. Available: https://www.epo.org/law-practice/unitary/unitary-patent/cost.html.

210 “the energy performance of buildings standards” (EPB standards).” [Online]. Available: https://epb.center/epb-standards/energy-performance-buildings-directive-epbd/.

211 “The EPO’s 2018 annual report.” [Online]. Available: https://www.epo.org/about-us/annual-reports-statistics/annual-report/2018.html.

212 “the European Commission, a smart city.” [Online]. Available: https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban- development/city-initiatives/smart-cities_en.

213 “the European Commission, Building Energy Management Systems (BEMS).” [Online]. Available: https://setis.ec.europa.eu/publications/setis-magazine/energy-efficiency-buildings/smart-buildings-and-role-of-digitalisation.

214 “The European Commission: The Energy Efficiency Directive (2012/27/EU).” [Online]. Available: https://ec.europa.eu/energy/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive_en.

215 “The European Patent Convention.” 1973, [Online]. Available: http://www.epo.org/law-practice/legal-texts/html/epc/2016/e/ma1.html.

216 “The most important provisions and requirements of Greece’s national law, under the EPC.” [Online]. Available: https://www.epo.org/law-practice/legal-texts/national-law.html.

217 “The Paris Convention.” 1883, [Online]. Available: https://www.wipo.int/treaties/en/ip/paris/.

218 “The PCT system.” [Online]. Available: https://www.wipo.int/pct/en/faqs/faqs.html.

219 “the Unitary Patent Guide, "Obtaining, maintaining and managing Unitary Patents.” European Patent Office, 2017, [Online]. Available: https://www.epo.org/law-practice/unitary/unitary-

patent/unitary-patent-guide.html.

220 “The Unitary Patent.” The European Commission, [Online]. Available: https://ec.europa.eu/growth/industry/policy/intellectual-property/patents/unitary-patent_en.

221 “The World Intellectual Property Organization (WIPO).” [Online]. Available: https://www.wipo.int/portal/en/index.html.

222 “The World Trade Organization.” [Online]. Available: https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm7_e.htm.

223 “Unified Patent Court, UPC.” the EPO, [Online]. Available: https://www.epo.org/law-practice/unitary/upc.html.

224 “Uruguay Round Agreement: TRIPS Trade-Related Aspects of Intellectual Property Rights.” Apr. 15, 1994, [Online]. Available: http://www.wipo.int/treaties/en/text.jsp?file_id=305907.

225 “wipo.” https://www.wipo.int/pct/en/faqs/faqs.html.

APPENDIX

European Patent Office on behalf of WIPO

Fees for international applications (applicable as of 1 April 2020)

Fees payable to the EPO for international applications in the international phase (applicable as of 1 April 2020).

Code	EPO receiving Office	EUR
019	Transmittal fee **R. 14 PCT**; **R. 157(4) EPC**	**135.00**
003	Search fee **R. 16 PCT**	**1 775.00**
225	International filing fee **R. 15.2 PCT**	**1 217.00**
222	Supplement for each sheet in excess of 30 sheets	**14.00**
316 318 319	PCT reduction for filing in electronic form - web-form filing - request in character-coded format + PDF application - request, description, claims and abstract in character-coded format	**92.00** **183.00** **275.00**
029	Issue of a certified copy of a European patent application or an international application (priority document) **R. 17.1(b) PCT**; **R. 54 EPC**	**105.00**
063	Late payment fee **R. 16*bis*.2 PCT** **50**% of the unpaid fee(s) but not to exceed EUR **608.50**	

013	Fee for requesting restoration of right of priority **R. 26*bis*.3(d) PCT**	**665.00**
Code	EPO International Searching Authority; Supplementary International Searching Authority	EUR
003	Additional search fee **R. 40.2(a) PCT**; **R. 158(1) EPC**	**1 775.00**
	Fee for a supplementary international search **R. 45*bis*.3(a) PCT**	**1 775.00** [4]
066	Fee for the late furnishing of sequence listings **R. 13*ter*.1(c)** and **R. 13*ter*.2 PCT**	**240.00**
062	Protest fee (**R. 158(3) EPC**, **R. 40.2(e)** and **68.3(e) PCT**) relating to an additional international search	**910.00**
069	Review fee (**R. 45*bis*.6(c) PCT**) relating to a supplementary international search	**910.00**
	Supplementary search handling fee (**R. 45*bis*.2 PCT**)	**CHF 200.00** [4]
	Late payment fee relating to a supplementary international search (**R. 45*bis*.4(c) PCT**) **50%** of the supplementary search handling fee	
Code	EPO International Preliminary Examining Authority	EUR
224	Handling fee	**183.00**

	R. 57 PCT	
021	Fee for preliminary examination **R. 58 PCT**; **R. 158(2) EPC**	**1 830.00**
064	Late payment fee [5] **R. 58*bis*.2 PCT** **50%** of the unpaid fee(s) but not to exceed EUR **366.00**	
066	Fee for the late furnishing of sequence listings **R. 13*ter*.1(c)** and **R. 13*ter*.2 PCT**	**240.00**
062	Protest fee (**R. 158(3) EPC**, **R. 40.2(e)** and **68.3(e) PCT**) relating to an additional international search	**910.00**

Fees payable to the EPO for international applications upon entry into the "regional phase" (Euro-PCT applications), applicable as of 1 April 2020.

Code	EPO European phase	EUR
	Filing fee	
020	online filings of EPO Form 1200	**125.00**
020	other filing methods	**260.00**
520	Additional fee for a European patent application comprising more than 35 pages (not counting pages forming part of a sequence listing) for the 36th and each subsequent page	**16.00**
005	Designation fee	**610.00**

408(BA) 410(ME)	Extension fee for each "extension state"	**102.00**
420(MA) 421(MD) 422(TN) 423(KH)	Validation fee for Morocco (MA) Validation fee for the Republic of Moldova (MD) Validation fee for Tunisia (TN) Validation fee for Cambodia (KH)	**240.00** **200.00** **180.00** **180.00**
	Claims fee Search fee Examination fee Flat-rate fee for an additional copy of the documents cited in the supplementary European search report *Amounts and fee codes are the same as for European patent applications*	
033	Renewal fee for the 3rd year, calculated from the date of filing	**490.00**
013	Fee for requesting restoration of right of priority **R. 49ter.2(d) PCT**	**665.00**
013	Fee for reinstatement of rights **R. 49.6(d) PCT**	**665.00**

Tables available: https://www.epo.org/applying/fees/international-fees/important-fees.html