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Review of the latest challenges and prospects for smart cities

Litsi, Georgia

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SCHOOL OF NEAPOLIS UNIVERSITY PAFOS

"REVIEW OF THE LATEST CHALLENGES AND PROSPECTS FOR SMART CITIES"

GEORGIA LITSI

January 2022

SCHOOL OF NEAPOLIS UNIVERSITY PAFOS

"REVIEW OF THE LATEST CHALLENGES AND PROSPECTS FOR SMART CITIES"

This thesis was submitted for distance acquisition of a postgraduate degree in Information Systems and Digital Innovation at Neapolis University

GEORGIA LITSI

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Abstract

The concept of a Smart City has been theorized and envisioned in the 1990s, but it was in the last decade where the concept became a reality. The European Union with its Horizon 2020 innovation and research program made the creation of Smart Cities a reality. In this study the Lighthouse projects that stemmed from the Horizon 2020 are examined to see the issues they tackled and the course of the actions taken by the participating cities in Europe. To achieve this, all the Lighthouse projects and the participating cities that have either been completed, or are still ongoing from the year 2014 onwards, were examined with regards to their objectives that they had set. For the completed projects the results that they had published were used to investigate if they had achieved what they had set out to do. The results illustrate that over time the focus of the projects shifted from a holistic approach towards the Positive Energy District concept. In addition, in this study, we discuss how the Lighthouse projects and their results helped change and affect different industries (energy sector, automation, and construction industry), the European Union's goals and the current EU legislation (Green Deal).

Περίληψη

Η έννοια της έξυπνης πόλης εμφανίστηκε σαν όραμα από τη δεκαετία του 1990, παρόλα αυτά πραγματοποιήθηκε και εφαρμόστηκε στην καθημερινότητα μας την τελευταία δεκαετία. Το πρόγραμμα Horizon 2020 είναι ένα καινοτόμο, ερευνητικό πρόγραμμα της Ευρωπαϊκής Ένωσης το οποίο δημιουργήθηκε με σκοπό την υλοποίηση των «Έξυπνων Πόλεων». Στην παρούσα έρευνα θα μελετηθούν τα Lighthouse Projects που συμμετείχαν στο Horizon 2020 με στόχο την ανάδειξη των κυριότερων σημείων ενδιαφέροντος όσον αφορά τις παρεμβάσεις και την πορεία τους στην πάροδο των χρόνων. Για να υλοποιηθεί, χρειάστηκε να μελετηθούν όλες οι Lighthouse πόλεις και οι αντικειμενικοί στόχοι που τέθηκαν σε αυτές από το 2014. Τα δεδομένα που προέκυψαν από τα προγράμματα που έχουν ολοκληρωθεί μελετώνται ως προς το βαθμό επίτευξης των στόχων που είχαν τεθεί αρχικά. Από τη μελέτη προκύπτει ότι υπήρξε μετατόπιση του ενδιαφέροντος από την ευρεία εισαγωγή έξυπνων παρεμβάσεων στον περιορισμό των παρεμβάσεων στον τομέα της Ενέργειας. Επιπλέον, στην παρούσα Διπλωματική διατριβή συζητείται τόσο η επιρροή και οι αλλαγές που επήλθαν από τα Lighthouse Projects στους στόχους και τη νομοθεσία της Ευρωπαϊκής Ένωσης όσο και σε διάφορες Βιομηχανίες όπως της Ενέργειας, του Αυτοματισμού.

Chapter 1. Introduction

Over the past few decades, there has been an increase in people moving towards the cities. According to the UN, more than half of the world's population resides in metropolitan cities (United Nations, 2019). That number is predicted to further increase in the future, as cities provide better jobs, educational and cultural opportunities, and living conditions. (Brenner, 2013; Henderson, 2010; Wang et al., 2012). Urbanization has both positive and negative aspects; it helps cities become economically prosperous and as a result the cities become social hubσ. On the other hand, it has a negative effect in the environment that surrounds the cities. (Shen, Peng, Zhang, & Wu, 2012).

1.1 Smart City

The acknowledgment of the environmental issues created by urbanization has led researchers towards investigating possible solutions for these effects, such as public air pollution, public transport issues, and financial issues such as unemployment (Albino, Berardi, & Dangelico, 2015). The concept of a Smart City is a new way of evaluating cities and leads the way on how to better optimize the resources and technology available for potential investments that are yet to come (Lazaroiu & Roscia, 2012). Furthermore, as modern life becomes more digitalized, it is easier to turn cities into smart cities (Parviainen, Tihinen, Kääriäinen, & Teppola, 2017) but more importantly to incorporate sustainable living in urbanization (Bibri, 2018). The Smart City approach is a revolutionary concept that has many different sub-research areas each dedicated to a different aspect of this new city concept.

Smart cities rely on current and future technologies such as Information Communication Technology (ICT), (Albino et al., 2015). The Covid-19 pandemic has illustrated the importance of information, data, and technologies such as Internet to help the society continue functioning during the lockdowns (Wirsbinna, 2021). This pushed towards converting certain aspects of society from the physical environment to a digital one (Lyons, Mokhtarian, Dijst, & Böcker, 2018). This has manifested as increased digitalization and numerous innovations within the cities (Balogun et al., 2020; Cheshmehzangi, 2021; De Dutta & Prasad 2020).

1.2 Smart City Definition

There are many different definitions that can be found in the literature regarding Smart Cities, since each academic has their own perspective of what a Smart City should be. However, there are certain aspects of Smart City that are most commonly found such as an intelligent city, a city with knowledge, a sustainable city, a digital city, ubiquitous city etc. (Paola & Rosenthal-Sabroux, 2014). The main outcome from researching these different definitions is that there seems to be a confusion on what a Smart City is and the differences are not clear (Albino et al., 2015; Ruhlandt, 2018; Townsend, 2017; Wirsbinna, 2021)

Most definitions of Smart cities in the literature tend to describe this concept as multidimensional and complex, and therefore can affect -as was stated previously- every aspect of a city's life (Gil-Garcia, Pardo, & Nam, 2015; Wirsbinna, 2021). Giffinger et al. (2007) characterized Smart City as a city that performs well, using six "smart" characteristics while focusing on the "smart" combination of activities and endowments of self-decisive, independent and aware citizens. Those six characteristics are mobility, living identifiers, people, economy and environment (Ismagilova, Hughes, Dwivedi, & Raman, 2019; Moustaka, Vakali, & Anthopoulos, 2019; Ruhlandt, 2018; Zheng, Yuan, Zhu, Zhang, & Shao, 2020).

Smart city has been defined by Odendaal (2003) in a technical approach that links to "smart" applications of ICT and the opportunities presented by ICT that enable cities to capitalize and promote its prosperity. In addition, the use of computer services to create important infrastructure and services can span from education, administration, healthcare, transportation, public safety, real estate, and utilities, which can be connected together, and become more efficient (Washburn et al., 2010).

Bakici et al., (2012) created an inclusive definition that aligns the concept of what a smart city is with the goals the European Union's smart cities have had over the years is considered to be the most suited for the needs of this project and will be adopted. The definition defines a smart city as a high-tech intensive and advanced city, which connects information, people, and city elements while using new technologies. The purpose is to create a greener, more sustainable, competitive and innovative city, which will increase people's life quality.

1.3 Beyond Definitions

The communication infrastructure is an aspect of great value for every definition on what a Smart City should be. The definitions and expectations concerning Smart Cities were created from 1990 to 2000 (Angelidou, 2015). Amsterdam was the first city to pioneer and move towards a digitalized society. More specifically, in 1994 the gates to the virtual city, which was commonly known as Digital City of Amsterdam, attracted both visitors and local residents towards buying Internet modems. It was a first step to what later would become the idea of a smart city, a concept that flourished within the European Countries in the past few years (Caragliu, Del Bo, & Nijkamp, 2011). The development of the Internet was an important contribution in urbanization, increasing its significance by making the data access possible.

Despite the research carried out, the concept of a Smart City remains elusive. As society is transforming, the needs of the Smart City should change accordingly (Molinillo, AnayaSánchez, Morrison, & Coca-Stefaniak, 2019). Social reality provides the ability to describe how people behave in the city, while urban reality is used to describe the infrastructure within the city confines such as streets buildings etc. When urban and social reality are combined, they conclude to the core of what a traditional city is (Erokhina, Mukhametov, & Sheremetiev, 2019). Both social and digital reality are now intertwined as social media, mobile devices and e-commerce, becoming, globally, an indispensable part of people's everyday life (Okhrimenko, Sovik, 2019).

1.4 Lighthouse Projects

Despite the fact that the introduction of the Smart City concept is a global phenomenon, only a part could be examined for the purposes of this research, in order to conclude to specific outcomes of future use, regarding the challenges and the prospect that arise. Smart City approach is a revolutionary concept that has many different sub-research areas each dedicated to a different aspect of this new city concept. Therefore, Europe is considered a suitable candidate for this study, as it consists of a union of countries that share the same political, economical and environmental perspective concerning the Smart City initiative. The smart city project gained momentum and grown expediently in the European Union, over the past few years. More specially, the Smart city project in Europe is now a governance focused project, by the European Union. The government of every participating country in collaboration with the local councils, create social infrastructures such as transportation and better ICT communication systems. These two aspects can help create better quality of life and upgraded management of natural resources for the people that live in the city (Caragliu, Del Bo, & Nijkamp, 2011; Wirsbinna, 2020). The growth of smart cities and the innovations they introduce to city life can be attributed to the Horizon 2020 program.

The European Union created the Horizon 2020 project, among other programs, which was a financial instrument implementing the Innovation project within the EU. It was Europe's flagship initiative that aimed to secure Europe's global competitiveness. It was considered as a way to promote economic growth and create more jobs. Horizon 2020 had political support of both Europe's leaders and the Members of the European Parliament. This research was an investment in Europe's future and its citizen, it was a blueprint for sustainable, smart, and inclusive growth and jobs.

Horizon 2020 combined innovation with research. In order to achieve this, emphasis was given on industrial leadership, excellent science, and tackling societal challenges. The goal was to ensure that Europe removed barriers to innovation, produces world-class science by uniting public and private sectors. Horizon 2020 was the biggest Research and Innovation program to ever been created in the EU, with the total amount of €80 billion funding being distributed to European countries during the span of 7 years (2014 to 2020).

The Lighthouse projects were the first and prototype cities of the countries involved in the Horizon innovation and research project, that were funded by the European Union to create smart municipalities and cities. The Smart City Initiatives were designed to help create and develop business models and solutions that later could be replicated on a larger scale, so as to benefit European cities and provide outcomes of global usage (European Commission, 2020). An example of a well-known Smart City that has been funded by the EU-Lighthouse Project, is the city of Stockholm which became a leading European Smart city through the "GROW SMARTER" Program.

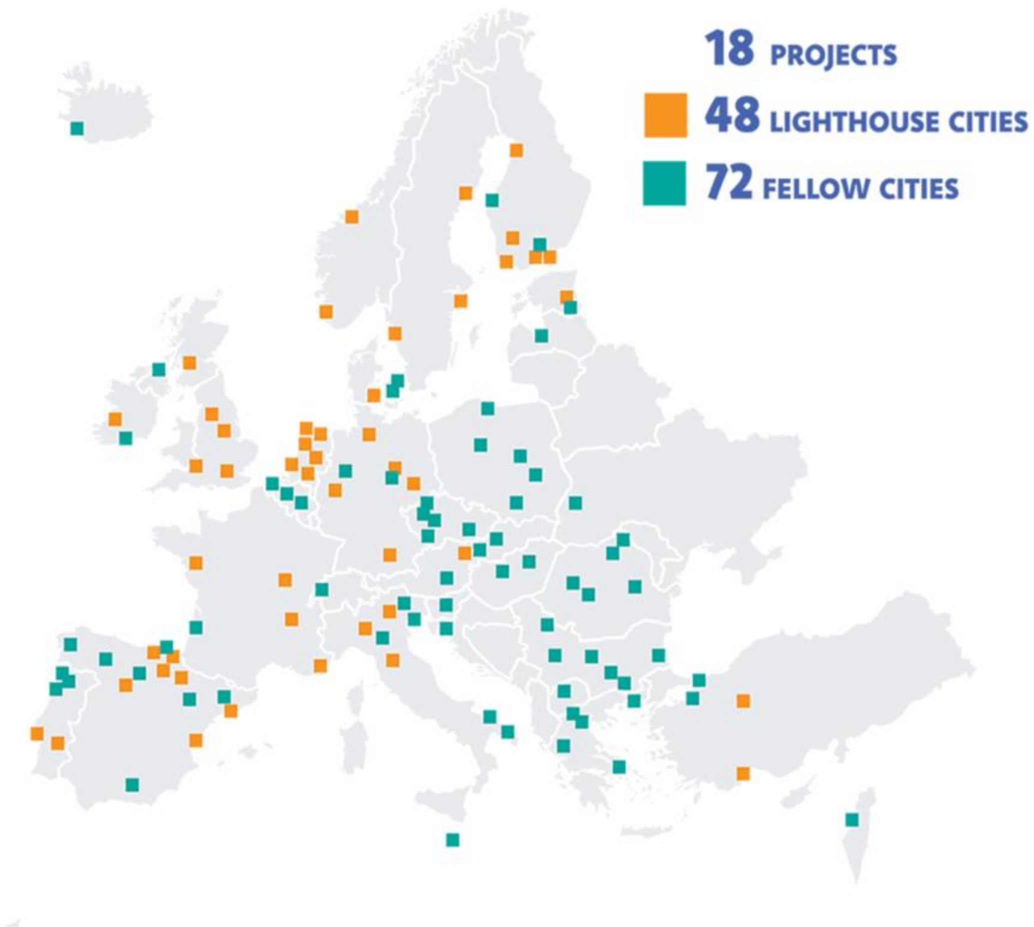

Image 1 - Map of the Lightouse cities and follower cities - Source: https://smart-cities-marketplace.ec.europa.eu/scale

Projects facts and figures

82 Total projects	18 Lighthouse Projects	345 Total Cities
48 Lighthouse Cities	72 Fellow Cities	3 Observer cities
€ 1.285.868.759 Total combined budget of projects	€ 808.136.541 Total EU contribution	

Image 2 - Lighthouse projects fact and figure - Source: https://smart-cities-marketplace.ec.europa.eu/

1.5 Current Research and Objectives

For a comprehensive overview of the subject, the background of the cities included in the Lighthouse Projects will be examined given that characteristics determine the final implementation of the projects. There are detailed project instructions assigned to each city and there are specific initiatives taken for digital innovations. There is a free access to the information included on each program, but there is a gap in the literature of combined data regarding the total sum of the Lighthouse cities included in the Horizon project. The aim of this research is to collect this information and vertically categorize it according to the smart interventions of the different thematic fields that have been implemented since 2014 in 46 European cities. Emphasis will be given on their critical evaluation, in order to make useful correlations and conclusions.
Upon completion of the work, the clear separation of the interventions that arise from the basic needs of each European city and the applications that are created out to cover those needs, will be visible. Similarly, a clear separation of innovations that enhance the expansion of the resources that will be available, in addition to meeting the standard needs will be made. It is of great importance to shift the interest from technological progress to improving the quality of life of citizens. Furthermore, it is important to identify projects that have the potential to carry out interventions that develop the overall vision of the digital union of cities, of industries and citizens.

The aim of this research is to examine the latest developments in the field of Smart Sustainable Cities. The data that will be collected will be critically evaluated to examine what useful information can be found with regards to the prospects and challenges of Smart Cities in the modern era. The present study is going to examine the gaps that have been identified in the literature. This will be established by critically presenting the correlations and comparisons of the latest Lighthouse Projects and the patterns that characterize them in the implementation of the projects specifically in European cities.

The research questions that will be investigated in this study are the following:

- What are the interventions observed through surveying countries that have joined the Lighthouse Projects and are funded by the Horizon 2020 program?

- How interventions are categorized according to their scope in vertical sectors (eg transport, energy, etc.)

- What factors determine the interventions (climatic conditions, current legislation, Government decisions, etc.)
- What are the application patterns observed in cities with common features (Nordic countries, Balkan countries, etc.)
- How these are divided into projects to meet standard needs and additional applications to upgrade the quality of life of citizens.
- What are some innovations that has been created by the utilization of resources?
- Are there new opportunities, prospects or challenges that have arisen from the implementation of Lighthouse Projects?

1.6 Methodology

The European Commission has funded 17 projects from the year 2014 onwards and these projects were designed to generate Smart cities in the EU. The amount of funding which these cities had and will receive from 2015 to 2024 is €360 million (European Commission, 2020). The 17 cities can be found in Table 1.

The goal of the Horizon 2020 SSC program, was to make sure not only that these cities are functional but also can also that they could be financially viable in the long run. These projects were not restricted to cities within the Lighthouse project, but to other cities as well, by working in unison to illustrate the processes, business models, and technologies that can transform their ecosystems into to more sustainable and smarter places (European Commission, 2016).

The Lighthouse cities participating, were also pilot cities that demonstrate whether the concept of Smart City Initiatives (SCI) could be successful in the future. In addition, the issues faced by Lighthouse cities became the template for future SCI cities to learn from. Due to the fact that public financing was being used to fund these projects an overall review and reports on the projects progress was written and sent to the European Commission. The European Commission used the Community Research and Development Information Service (CORDIS) as a source to examine the results for all EU funded projects that were for innovation and research (European Commision, 2020).

For transparency reasons the CORDIS had a public database where people could find information on all of the projects the European Commission has funded.

These information spans from reports, fact sheets, results participants and useful links that were freely accessible and contain publications. These links to the next part of the chapter and the importance of creating available data from the sources above to facilitate future projects. Using as a basis the results of project like Lighthouse can help develop the next generation of Smart Sustainable Cities (SSC). This SSC can expand beyond European Cities to other metropolitan areas in the world to develop their own successful project (Engelbert, van Zoonen, & Hirzalla, 2019). In this study the results from the changes that were implemented in the 17 smart cities will be examined further to investigate the aim and the objectives that were set.

This research will be conducted by collecting all the information mentioned above and vertically categorizing it according to the smart interventions of the different thematic fields. There will be an evaluation process, in order to answer the research questions and make useful correlations and conclusions as far as the prospects and challenges of Smart Cities in the modern era are concerned.

More specifically, the research will begin by focusing on one of the Lighthouse projects of the first call. This program is called Grow Smarter and it is considered to be a template for all the projects that followed. The purpose of the analysis is to document the interventions observed in the three Lighthouse Cities and simultaneously acknowledge the implementations and thematic fields that took part in all of the subsequent Lighthouse projects. A further outcome of the Grow Smarter analysis will be to present the application patterns observed in the cities analyzed – Barcelona, Stockholm and Cologne - according to features such as climate conditions. Moreover, the presentation of the interventions will provide the opportunity to categorize interventions into basic vertical sectors, according to their scope.

In the next chapter, there will be a short analysis of each Lighthouse project that run developed from 2014 to 2019. The brief mention of the Lighthouse projects is necessary in order to be familiar with the projects and their current goals depending on legislation and government decisions that affected their implementations.

Consequently, a table of clear vertical sectors will be created, that will consist of the combination of the sources of information that are mentioned above:

- all of the Lighthouse Projects
- all the implementations
- categorization into thematic fields

The outcomes that derive from the table will be discussed, concerning the evolution of the Smart Cities scope of standard needs and additional applications. Finally, the access to the information required by EU funding, about the challenges that Horizon 2020 faced, can be detrimental to all innovative projects initiated due to the published results of Smart City Lighthouse Projects. Having access to such data, about the successes and the failures can help create Smart City Initiatives (SCI) for Smart cities that can then be presented to investments groups. These investment proposals can concern infrastructure and innovation development for other EU initiatives in the future, such as Green Deal etc.

Year	**Project Name**	**Lighthouse City**
2014	Grow Smarter	Stockholm
		Cologne
		Barcelona
	Triangulum	Eindhoven
		Manchester
		Stavanger
	REMO	Valladoid
		Nottingham
		Tepebasi
2015	SMARTER TOGETHER	Vienna
		Munich
		Lyon
	REPLICATE	San Sebastian
		Florence
		Bristol
	SmartEnCity	Vitoria-Gasteiz
		Tartu
		Sonderborg
	Sharing Cities - SHAR-LLM	Lisbon

		London
		Milan
2016	mySMARTLife	Nantes
		Hamburg
		Helsinki
	RUGGEDISED	Rotterdam
		Glasgow
		Umea
2017	MatchUP	Valencia
		Dresen
		Antalya
	IRIS	Utrecht
		Nice
		Gothenburg
	Stardust	Pamblona
		Tambere
		Trento
2018	MAKING-CITY	Groningen
		Oulu
	+CityChange	Trondheim
		Limerick
2019	POCITYF	Alkmaar
		Evora
	Atelier	Amsterdam
		Bilbao
	Sparcs	Espoo
		Leipzig

Table 1 - Smart City participants

Chapter 2. A Lighthouse Prototype

In this chapter, one of the first Lighthouse projects will be presented. The program is called Grow Smarter and is considered to be a prototype for the Lighthouse projects in the Horizon 2020, and a template for projects that followed. In addition, the microscopic review of the project, cities and interventions may allow us to provide patterns about the implementations regarding the climate conditions etc.

2.1 The Importance of Grow Smarter

Grow Smarter was one of the first projects of its kind in the EU, bringing together the cities of Stockholm, Barcelona, and Cologne with the contribution of 12 smart and integrated solutions for city services (Dirks, & Keeling, 2010). The services included were heating, renovation, mobility, and waste management and were meant to prepare the cities for a wider market rollout. Grow Smarter was the most influential lighthouse project of its generation (2014) which also included REMO and Triangulum. The last two projects, did not have the same impact as Grown Smarter did. To be more precise, Stockholm won an award for the world's smartest city in 2019 (Landahl, 2020). The smart solutions that were implemented in this project followed the "Lighthouse Cities" strategic development plans. As a result, the "Follower cities" that followed, were parallel to the initial plans that the three original cities set.

The solutions of this project were replicated afterward by the five "Follower cities" and also presented to other international and European study groups. The project began in 2015 and ended in 2019, the total cost was calculated to €35,794,300 with the EU contribution being €24,820,974. The project found certain solutions for the challenges that are faced by urban areas (García et al., 2017). The project implemented certain changes such as district heating, smart grids, new street lighting, integrating infrastructure for ICT, and smarter waste handling. All of the aforementioned will be explored further in this section. The consortium included both research and industrial partners that presented the findings and the solutions of the project. These findings were later implemented in other smart cities and business plans throughout Europe.

The three Lighthouse Cities will be presented in the following sections, along with the thematic fields and their implementations.

2.1.1 Barcelona

Barcelona was a city that was voted as the European Capital of Innovation 2014. It was a metropolitan hub that was vast, with long tradition in both entrepreneurship and industrial sector (Bakıcı, Almirall, & Wareham, 2013). It had been a prominent part of Barcelona City Council, to encourage strategic initiatives that aimed to generate international collaboration and promote a more futuristic and global vision for public bodies and businesses alike. This also included the promotion and development of technological and scientific centers in Barcelona.

The city of Barcelona started its Smart City program in 2015, and the program's goal was to install fiber optic cables to make the connection between two municipal buildings (Capdevila, & Zarlenga, 2015). The City Council is currently promoting and combining both public and private partnerships in order to encourage more innovation projects in fields such as commerce, street lighting, transportation and environmental monitoring. Barcelona converted from a normal to a modern city and urban laboratory. The city pilots several services to create an efficient, friendly and open environment. For the purposes of the Smart City project, the zone that was chosen to participate in this innovation was the 22nd District. This area was multi-purpose as it combined industrial, academic, and residential buildings and the area was vibrant and lively as it bordered the Mediterranean Sea. The implementations of Barcelona refer to low energy district, integrated infrastructure and sustainable urban mobility that will be now presented.

- <u>Refurbishment changes</u>. The changes implemented in Barcelona from this project were refurbishments that would be efficient and also help towards battling climate change. For example, this project introduced ventilated facades, connection to district heating and cooling networks, smart energy management and energy generation (Gascó-Hernandez, 2018). More specifically, a number of different measures were established such as LEDs with photosensors, floor heating and cooling systems, photovoltaics, district heating and cooling, and variable speed fans.

The project also included implementations of other passive measures such as roof insulation, façade insulation, new windows that have less air leakage and blind installation. Furthermore, active measures were suggested to be implemented such as connection to district heating and installation of efficient taps for water to add a smart

Home Energy Management System in building, by replacing old boilers (Grimaldi, & Fernandez, 2017).
The next phase of the project included additional refurbishment changes for buildings that included façades and roofs that were covered by PV, creating electricity. The PVs were placed in educative and sports centers creating significant savings in energy bills for heating (Bibri, & Krogstie, 2020). Once again replacing windows was of high priority, for better insulation. Sport center pools were also refurbished by insulation and dehumidifiers installation, LED lights, and photovoltaic and aerothermal heat.

- Smart energy-saving tenants. Individual tenants were also approached to make changes in their homes in this project moving towards a greener way of living. The first part of the project included 450 citizens and their homes'. The project included a mobile app and a web platform tool name "Visual Energy Advisor" electricity that would monitor the total consumption (March, & Ribera-Fumaz, 2016). This helped people visualize and customize their energy data, have alerts for real-time prices for their consumption, control the indoor temperature of their house and their appliances and get personalized recommendations. To achieve this several devices were used to communicate to the central hub using WiFi. The devices used to disaggregate consumption for the aforementioned project were smart plugs, thermostats, and current clamps.

- Smart electricity management. This project included the development of a cloud-based platform named "EcoStruxure Resource Advisor", which would monitor the incoming data from the buildings that took part in the project. The tool was able to illustrate the KPIs (Key Performance Indicator) from all the retrofitted works conducted and show the energy consumption after usage completion. It also showed the process and impact of the project in progress to citizens. Furthermore, the installation of Photovoltaic units and electrical storage in both residential and tertiary buildings, which was mentioned earlier, were enriched with PV pergolas and innovative PV cells such as half-cells (Smith, & Martín, 2021). All of the PVs installation were also equipped with smart energy management software. The software was able not only to gather important information but to use the energy flow in optimal ways as well, providing tenants the ability to make decisions based on building consumption forecasts, real-time operations, the electricity prices of the grid and the weather forecast.

- Smart street lighting. Smart street lighting, traffic ports and lampposts used as hubs for communication, were some of the important changes made in the streets of Barcelona. This street infrastructure gave wireless access networks to support the growing need for mobile connectivity throughout the city and IoT services. The street lighting poles, that became a small telecom site, were named Smart Towers (March, & Ribera-Fumaz, 2018). The towers provide connectivity to the citizens and visitors of Barcelona. Moreover, the cloud-based data collection provided a detailed analysis of the infrastructure and the energy consumption of the tenants' private property and the public infrastructure associated with the project.

- Waste heat recovery. This implementation included a photovoltaic plant, placed on building rooftops that would feed the building with cooling and heating energy straight from the local District Heating and Cooling (DHC) network (Noori, Hoppe, & de Jong, 2020).

- Big data management. As far as open data is concerned, the development of the platform mentioned earlier, enabled individuals to examine the success of the project. The platform selected data from many different aspects of the Grow Smarter project. For example, some of the sources were smart taxis, freight information, Smart Towers and all of the retrofitting that was conducted in Barcelona. This dataset helped to give solutions to different problems, provided real-life support to make appropriate decisions and offered the opportunity to have interoperability but also standardized management (Mancebo, 2020).

- Sustainable delivery and traffic management. The project contributed to sustainable delivery. One of the contributions is the usage of e-cargo bikes for deliveries in the last mile. E-cargo bikes can be found in a micro-consolidation center which is located in the city. All data from traffic lights were required to introduce this model (Gascó, 2016). The direction flow of the city streets and the number of lanes consisted important information about the model. Finally, MDF (Main Distribution Frame) was used to divide central equipment lines between the areas of interest as an initiative for research and not for empirical demonstration, for traffic management.

- Alternative fuel driven vehicles. This next part of the project was about creating appropriate infrastructure for e-vehicles to use as alternative vehicles. E-vehicles could contribute to lower harmful emissions and create better air quality within the city limits. Charging points free of charge were installed for these vehicles, located in land owned by the municipality, called "fast-charging stations" (Madakam, & Ramachandran, 2015). The charges that were installed were the V2X chargers in addition to an energy storage system and a photovoltaic (PV) plant. This implementation endorsed the reduction of CO2 emissions, energy costs and better autonomy.

- Smart mobility solutions. The final phase of the project was the creation of smart mobility solutions to create a new system for taxis. New smart taxis stands were implemented, informing drivers and users in real-time, about the amount of taxis that are currently located and waiting in the taxi stands. The program uses sensors to monitor the number of taxis that are spotted in each location to reduce pending time and traffic (Ferrer, 2017).

2.1.2 Stockholm

Stockholm is the Swedish capital city. Stockholm is one of the cities that worked since the 1990s to battle climate change mitigation by adopting a more sustainable way of life (Landahl, 2020). This city is a frontrunner in climate change and has implemented plans of action by pioneering many different policies to make sure that it meets the ambitious targets set for the environment. Stockholm was a leading city of the GrowSmarter project and has won the 2019 World Smart City Award. The city grows rapidly and therefore had to face certain challenges such as maintaining its unique character while continuing its development. The main priority of Stockholm except for being sustainable was to offer its citizens an inspiring and attractive way of living and working.

- Efficient and smart climate shell refurbishment. Similar to Barcelona, one of Stockholm's priorities in the project was to refurbish its buildings by adopting a control system for the heating, creating a smart ventilation control for garages, installing indoor temperature meters in all the apartments, electricity meters and water saving equipment (Helm, Forsberg, & Johannsen, 2019). Furthermore, Stockholm also installed infrastructure for the wider community such as district heating metes, photovoltaic installations and battery storage for the energy created by the photovoltaic installations.

An EnergyHUB installation contributed to supervising the amount of electricity used and overall, all the solutions added in the city were monitored by the L&T's Energy Saving Center. The changes created heating savings (11%), electricity savings (19%) and an overall energy saving of 14%. During the refurbishment period, tenants were asked to leave the premises to have a home energy management system installed into their property. Most of the buildings that underwent these types of refurbishments were listed as buildings that were valuable both historically and culturally.

- Smart building logistics. The materials that were removed during the refurbishment process were grouped so they could be delivered at the same time to the construction site, at the appropriate moment. In addition, the material removed from the sites were also transported in vehicles that used alternative fuels (Eriksson, 2010). In these new active houses, it was possible to control and monitor all the lights and the thermostats from a specific tool that could provide the ability to check the energy consumption of hot water, heating and electricity in real-time. The tenants could also monitor the prices of these utilities in real-time and adjust their consumption accordingly.

The building energy management system (BEMS) was the tool that tenants used to monitor their energy consumption. The building's existing control systems as well as the new ones that were installed for the project were connected to ESC. Simultaneously, all the other meters such as the temperature, smart meters, moisture meters, and CO2 sensors were connected to create a platform for a smart building. The data was not only collected from the participating buildings but also from water sensors, the district heating network, and the electrical sensors (Harrison, et al., 2010). Everything was done by using automatic meter readings, which gave the users the ability to read their data live and to respond by will. This type of analysis and comparison becomes a regulated consumption 24/7.

- Smart electricity management. EnergyHUB, is local renewable production of energy that was created to manage and store the energy that was produced by photovoltaics and within Stockholm. The project implemented photovoltaic and electrical units along with smart energy management software to be used for both residential and tertiary buildings. This management software gathers information that is relative to energy and then optimizes the necessary energy flow among the different solar panels. In addition, this energy flow is also used for energy storage to maximize battery usage and to perform important saving strategies (Bouzarovski, Frankowski, & Tirado Herrero, 2018).

- Smart street lighting. The lighting that would be installed for this project was separated into three different categories: the motion sensor, the self-controlled and the remote lighting (Tyni, & Wikberg, 2019). The Motion sensor is LED lighting, controlled lighting for bicycle paths and pedestrians which can provide lighter, specifically 100% more light and lamps ahead for anyone that approaches them. The manually controlled street LED lights are dimmed down later on in the night. Finally, the remote-controlled LED lights can be set on different levels which change throughout the nighttime.

Combining these different functionalities in the public infrastructure- traffic lights, street lighting poles and traffic signs- provides a connection to walkable urban areas with sensors. The data created from these lights/sensors is used to feed the IOT platform and create visualizations. Furthermore, the data is used for communication with the citizens and also steering and preprogramming the city's infrastructure such as streetlights (Haarstad, & Wathne, 2018). Another mini-project within the overall project was the installation of four traffic measuring sensors in a bridge used by pedestrians and that run over a street that had another four sensors. This helped the local authorities make measurements on both normal traffic and pedestrian traffic.

- Waste heat recovery. A new business model was created for the district of cooling and heating to recover any surplus heat. The heating and cooling system was integrated with existing district heating (DH) networks in order to meet the demands of the local populations, with regards to their heating demands within that urban environment (Sandström, 2020). An innovative business model was created but its full potential remains unknown. In order to reduce the waste produced in the facilities, the model has installed plugs in the heat pumps that recovers energy and sends it back into DH network. This new technological innovation can produce hot water using a heat pump at a temperature of 85°C instead of the usual temperature of 68ºC.

- Smart waste collection. A waste collection program was created named AWCS that stands for automated waste collection system (AWCS) (Heilert, 2019). It requires different colored bags to sort out the waste efficiently and reduce the amount of effort needed for the task. The waste is weighed during the time being disposed and the system registers the type of waste being thrown away depending on the color of the bag used.

- Big data management. Similar to Barcelona, the Stockholm City Data Platform was used to analyze the movements and the flow of both people and vehicles within the project designated areas. The platform retrieves data on the emissions that were released into the atmosphere and calculates the impact that the emissions had on the environment. In a small area, more than 30 Wi-Fi and camera-based sensors were installed to track the pedestrians and bicycles movements in an effort to minimize potential emission impacts due to congestions vehicle flows & emission impacts. City Data Platform helps calculate statistically different paths between sensors (blind spots) and offers different routes for people and vehicles whenever that is possible so they can avoid congestions (Wathne, & Haarstad, 2020).

- Sustainable delivery. Another implementation this project had was the creation of a parcel delivery room that is located on the bottom floor of any multistorey apartment complex. This room allows residents to order different items online. The items are delivered to the home with a "c/o" address. The parcels arrive in a specific central terminal and are transported to the allocated delivery room, by using bikes e-cargo. The only individuals that would be permitted access to the delivery room would be the residents and the couriers, using an app on their smartphone 24/ 7 (Luterek, 2019).

- Smart traffic management. Another smartphone app designed for the Stockholm project to help its users plan journeys that could minimize or reduce environmental impact (Sola, Sanmarti, & Corchero, 2020). Simultaneously, it would help drivers to locate charging points for their electrical vehicles or alternative fuel stations. The data gathered using this app would also help the local and the government authorities understand the changes in their citizen behavior with regards to their traveling or usage of more eco-friendly vehicles.

This app would also help foresee the potential problems in traffic so that government could act quickly and effectively, without the need for travel surveys. The smartphone app, could also provide invaluable data on how to synchronize traffic signals to prioritize the distribution of vehicles that use renewable energy or alternative types of fuel, by using the information collected by the sensors. Using the data, can improve the traffic flow and also reduce the number of times a vehicle needs to start and stop (Andersson, Ödlund, & Westling, 2019).

- Alternative fuel driven vehicles. The use of alternative powered vehicles or vehicles that use alternative fuel creates the need for new facilities to charge cars. In addition, new rapid charging points or stations in residential areas need to be created in both public and private land (Pozdniakova, 2018). A fast charger that included a fee needs to be offered for couriers and taxis. There were other options made available such as multiple user groups that includes car-sharing services, taxis or private vehicles.

New alternative fueling stations need to be available not only for private-owned vehicles and heavy-duty vehicles and buses but, as stated previously, for a potential car-sharing service for an electric vehicle (EV) as well, that would be available to the public (Bastian, & Börjesson, 2018). An example of this, is the Valla Torg residents that do not have to pay membership fees when using the car-sharing services until the residents understood the new scheme. This would also reduce the number of cars within the city of Stockholm.

- Smart mobility solutions. In Stockholm, electric cargo bikes are used differently than in Barcelona as it was the transportation for families that did not own a vehicle to transport their shopping to their houses or to carry large purchases (Corradini, 2020).

2.1.3 Cologne

Cologne is a German city that is located on the banks of the river Rhine, and is the fourth largest German city. It is a city that has important and key factors in both the industrial and the business section. The city had a clear commitment to achieving its ambitious goals to reduce greenhouse gas emissions, increase energy efficiency and also to increase its renewable energy capabilities. Cologne had worked closely with local industries to make these goals come to fruition. Its areas of focus were to create energy efficiency of buildings, sustainable mobility, low-emission heating facilities and to ensure that these changes were integrated into the new infrastructure as the city expanded over the years. The area of Stegerwaldsiedlung which is the district in Cologne that took part in the project in 2018 won an award for being one of 100 Climate Protection Housing Estates in North Rhine-Westphalia (Leitheiser, & Follmann, 2020).

- Efficient and smart climate shell refurbishment. Similar to the two previous cities of Barcelona and Stockholm the first thing the project tackled was to refurbish the buildings of the city using efficient LED lighting in common areas,_triple glazed windows, photovoltaics, and energy lifts. In addition, efficient heating pumps and monitored equipment were installed and connected to the district heating network (DATA, 2007). The buildings that participated in the scheme were also fitted with a smart management system. The tenants of the residential buildings were offered window sensors that delivered information about the windows state (open or closed), heating thermostats, humidity sensors, indoor temperature sensors, and smart plugs. All of the above could be accessed remotely from a phone app and gave the users' the ability to manually control them.

The local infrastructure was also upgraded to manage these changes so a virtual power plant (intelligent management system) was created to connect the local photovoltaic production, the batteries, and the heat pumps to an external energy production system. The system can operate on a neighborhood level and can manage heat consumption and optimize energy levels by contacting both the external energy producers (district heat) and the internal producers (heat pump, battery storage, and photovoltaic). This allows the system to maximize its self-efficiency. Moreover, charging stations for different types of electric vehicles such as pedelecs and cars were installed in the neighborhood. Finally, smart meters that help predict and measure the patterns of energy consumption were installed in each apartment (Goess, de Jong, & Meijers, 2016).

- Integrated Infrastructure. In the streets of the Cologne hotspots, named "Humble Lampposts", were implemented using smart lighting, traffic posts and lampposts that were turned into communication hubs (Borda, & Bowen, 2017). These "Humble Lampposts" became WiFi hotspots and electrical charging points as well. Another cloud-based data collection hub was created to analyze all the data collected by this project to understand how the tenants consume energy. Similar to the other two cities, a website was created so the tenants could access their energy consumption both in real-time but also retroactive by the information of their energy consumption history.

- Big data management. The platform that hosted all the data collected by the different services associated with the project is an open data platform and consists of different focus areas such as the traffic situation and the environment. The platforms' name is 'Urban Pulse' and it is used by the utility partners, the City of Cologne, and private partners (Leitheiser, & Follmann, 2020).

- Sustainable Urban Mobility. Cologne's last implementations concerned Mobility. The city installed rapid charging points for electrical vehicles to improve air quality and reduce the CO_2 levels in the atmosphere. Cologne also implemented some different measures such as chargers free for everyone to use, mobility stations for car-sharing and users registering for service. These mobilities stations were different and may vary in size according to the location (Dulisch, 2017). Other transportation alternatives used in this project were car sharing with both conventional and e-cars, and public transport. Another new implementation was timesharing parking spots both private and public, sharing bikes, and e-bikes. In both sharing schemes, cars and bikes are integrated into the mobility stations.

2.2 Conclusion

In conclusion it is evident in this chapter that the original three cities of the Grow Smarter Horizon2020 project, Barcelona, Stockholm, and Cologne implemented the changes the project deemed necessary to reduce the energy consumption but also the CO_2 emissions within the city bounds. Overall, there were some similarities and differences that were identified in each project. The differences were due to the needs each city and its citizens had to improve their way of living. In Stockholm and Cologne more funds were used on car sharing schemes and heating projects as they are both countries that experience colder winters. In Barcelona the element of hot summers pushed them to add fans for example in the building that were refurbished. These three cities and the results of the projects would become the base for the next Horizon projects that would be funded by the EU their successes and the failures would help the next cities become even better.

Chapter 3. Lighthouse Projects Beyond Grow Smarter

3.1 Lighthouse Projects Overview

After the successful implementation of the first Lighthouse projects particularly Grown Smarter that was described in detail in the previous section and the other three projects as well (REMO, Triangulum and Haring Cities), the European Union expanded the Lighthouse projects in other European countries and cities. The successful results of Grow Smarter were used as a starting base to focus on similar issues such as mobility, heating, sustainability, green energy etc. in the following projects. These issues were tackled by both the participating Lighthouse Cities and Follower Cities in the newer projects. In this chapter there will be a brief description of new lighthouse projects that followed spanning from 2015 (SmartEnCity) with the last one beginning in 2019 (POCITYF), along with the main objectives for each. The description of the objectives for each project will also illustrate that over time the focus of the projects slowly started to shift towards three vertical sectors - energy, mobility and ICT.

3.1.1 Smartencity

The SmartEnCity project is the first to follow the Grow Smarter and began in 2015. The three Lighthouse cities that were selected for this project were Vitoria-Gasteiz in Spain, Tartu in Estonia, and Sonderborg in Denmark (Matskevits, 2020). The approach to this project was to define in detail, plan the project and finally implement it. The project same to the Grow Smarter project was funded by the European Union's Horizon 2020 research and innovation program. The project was also coordinated by the TECNALIA Research & Innovation, which included 35 partners from six different countries that were all joining forces to make the Smart Zero Carbon Cities feasible in the Europe Union.

SmartEnCity has as a main objective to develop an approach that could be replicated but also be highly adaptable in the needs of each new city that wanted to implement it. This was done in order to transform cities in Europe into smart, sustainable and make urban environments that are resource efficient. To achieve this aforementioned goal two things needed to be achieved one to implement measures to improve energy efficiency and two plan these measures. The outcome would be to create a more efficient energy system for the main consuming sector in the city, while creating more renewable energy sources and showing the benefits these sources have to the environment.

The Smart Zero Carbon City concept, has the underlying concept to ensure that the carbon footprint the city has, and the energy demand can both be set and kept at a minimum. To achieve this demand, controlled technologies should be used to save energy and promote conscious awareness on energy consumption. Simultaneously, the energy supplied in the city should come from clean renewable sources (solar, wind, hydro, geothermal, biomass, wave, and tide) that can be produced locally. These energy sources should then be managed by either private and public stakeholders or aware citizens. According to the European Union's smart cities marketplace the project is still ongoing (Smart Cities Marketplace, 2021).

The objectives that were set for this lighthouse project for the three medium-sized cities are the following:

- To achieve an important/ significant reduction in the demand of existing residential building stock, through a cost-effective low energy retrofitting actions that will take place at district scale.
- To increase the Renewable Energy Sources' share of the energy supply, by using local available sources.
- To improve and increase the usage of clean energy in city mobility and transportation for both people and goods. To make this feasible there was a need to deploy green vehicles throughout the city and also have intelligent infrastructure for these vehicles.

3.1.2 Replicate

The next Lighthouse project to begin was REPLICATE which stands for Renaissance of PLaces with Innovative Citizenship And Technologies (Lopes Azevedo, Stöffler, & Fernandez, 2020). This project began in 2015 and is another European Union research and development funded project that had three main aims to deploy mobility**,** energy efficiency**,** and ICT solutions **i**n city districts. In this project the three cities that were chosen to become the lead cities were Florence in Italy**,** San Sebastian in Spain, and Bristol in Great Britain. Overall, this Lighthouse project had a Consortium that consisted of 38 different partners**.**

The REPLICATE team work focused on accelerating the deployment of innovative technologies, improving the sustainability of urban transport, and providing organizational and economic solutions to significantly increase resource, energy efficiency and to drastically reduce greenhouse gas emissions that are released in urban areas. The aim of the project was to make the transition process from a "normal" city to a smart city in three specific areas.

The areas affected were sustainable mobility, energy efficiency and ICT infrastructure. The city's goal was to become more energy efficient by reducing its energy consumption 56% with regards to its existing situation in retrofitting buildings and by 35% when it comes to district heating. These two areas alone can reduce the city's energy consumption significantly. The next area that needs addressing is sustainable mobility, where more Electric vehicles will be integrated into the city, a new information mobility system will be introduced alongside more recharging systems. More specifically more than 200 electric vehicles will become available, and 228 charging points will be created. Finally, by integrating ICT infrastructure into the participating cities would develop cost effective services which would also be sustainable for the citizens. Simultaneously, a number of public services would be updated for example introducing new high speed mobile wireless network that is based on postWIMAX technology. A new lighting system developed based on LED technology and an ICT model for Open Data Management based on the FI-WARE.

3.1.3 Smarter Together

The next lighthouse project to begin was the Smarter Together program in 2015. Its aim was sustainable development that are inclusive and integrated in societies (Gaiddon, et al., 2016). Furthermore, these societies can be developed in a partnership that also fosters a productive dialogue among all parties, so that leads to being 'smarter together'. Moreover, it was based equally on constant innovation and modern technologies, as the important ingredients that were available to serving people, promote economic transformation and societal development.

Smarter together as a project shared the philosophy and fundamental values that was built upon this project. Its aim was not only to improve the citizen's lives in each city but to also transform them into something new. To achieve this balance, there was a necessity for engagement between citizens, the ICT technologies and the institutional governance so that inclusive and smart solutions could be delivered for these citizens.

For this program to be implemented into reality six neighborhoods were chosen in three different European countries. The experiment is a unique opportunity to make innovative smart city components, include a co-creation process and high-quality refurbishment measures to explore new methods and add value in urban societies. The three European countries participating in this program was Lyon, Vienna, and Munich. The objectives for each were the following:

- Data management platform & smart services
- Citizen & Stakeholder Engagement
- Electric-Renewable Energy Sources
- E-Mobility
- Holistic Refurbishment

3.1.4 My Smartlife

The lighthouse projects continued to develop throughout Europe and another one was created in 2016, which was name mySMARTLife (Lange, & Knieling, 2020). The aim of the mySMARTLife was to make the three participating Lighthouse Cities of Hamburg, Nantes, and Helsinki environmentally friendly. To achieve this the cities aimed to reduce their CO_2 emissions they released into the atmosphere every year and also increase the use of more renewable sources that produce energy.

The projects activities were focused on "Inclusive Cities" that aimed to offer their citizens a high quality of life. Furthermore, the next important concept of the project was "Smart People", where the citizens have an important role within the city development. Another concept was that of the "Smart Economy", the city should have a dynamic and an innovative economic concept that aims to guarantee that its citizens were not only employed but also that the employment offered them an adequate income. The result was to attract talented individuals in all sectors and be provided services and goods that meet their needs and their requirements.

As with the previous lighthouse projects this one focused on some key interventions that were planned to be carried out in each the three participating Lighthouse Cities. These innovations include some technological solutions that are connected with the usage of renewable energies, clean transportation, refurbished buildings in the participating neighborhoods, and supported ICT solutions. There was also an integrated planning process in the project design. More specifically, citizens could actively be involved in the decision making for aspects of the project, to link certain actions in different fields (e.g. sustainable energy, mobility, ICT). Following this structured city business model, would lead towards a more integrated urban transformation strategy that could later be transferred with ease to other European cities.

3.1.5 Ruggediced

The RUGGEDISED program is another lighthouse project that began in 2016. This smart city project was funded once again by the European Union's Horizon 2020 research and innovation program (Bagheri, Brandt, & van Oosterhout, 2021). The participating cities for this program are Glasgow, Rotterdam, and Umeå. As with any lighthouse project it also had followers' cities, but the focus will remain in the three main lighthouse cities, as their results were the ones that would later be implemented in the follower cities.

The cities would be working in partnership with both research centers in all the six cities (three main cities and the three follower cities) and local businesses. This path was chosen to demonstrate that it was possible to combine the different objectives of the project which were e-mobility, ICT, and energy solutions affectively. The aim was to design a city that would reduce its environmental impact from its everyday activities, to create an environment that would be stimulating, and to develop an economy that was sustainable.

3.1.6 Matchup

The MAtchUP lighthouse project is another EU-funded Smart City project that involves three lighthouse cities and those are Valencia (Spain), Dresden (Germany) and Antalya (Turkey) (Rodríguez et al., 2019). The MAtchUP cities come together to solve their economic, social, and environmental problems and help promote livability, social inclusion, and prosperity of their citizens. The MAtchUP implemented and designed a variety of innovative solutions in mobility, energy, and ICT sectors that would become a model for other European cities to transform themselves.

MAtchUP's objectives were to develop and adopt solutions that can convert the problems that cities face into smart opportunities by using them to improve citizen's lives while boosting the local economy. The final aim was to develop a more livable and prosperous urban environment.

MAtchUP was built on three main objectives:

1. The planning of a sustainable urban transformation in mobility energy, and ICT fields.
2. The effective replication and upscaling of smart city solutions.

3. The implementation of solutions to repaint and reshape.

3.1.7 Stardust

Another project that was implemented with the EU Horizon 2020 Smart Cities project was the STARDUST project in 2017 (Astrain et al., 2021). The projects aim was to bring together advanced European cities and form a constellation of "innovation islands". More specifically, cities/models that were highly efficient, smart, intelligent, and citizen oriented. Furthermore, in these cities' innovative, non-technical solutions and technical green solutions would be implanted and later on validated so they could become bankable for other cities to replicate them.

STARDUST had the opportunity to lead the way for other cities to incorporate a more sustainable way of life by intertwine imagination and innovation. The objectives STARDUST had was to create a highly efficient, intelligent city with low carbon, and citizen-oriented cities. To achieve this innovative business models and green technical solutions would be presented to address the challenges faced by the urban cities taking part in this project. The challenges are focused on society, mobility, environment, economy, economy, and the cities' visibility.

The targets set for the STARDUST project include:

- To create several "innovation islands", that illustrate cost-effective, scalable, and bankable solutions that can be urban scaled
- To create smart ecosystems that will use the new economic paradigm in European cities based on market competitiveness, eco-innovation, low carbon usage, and promotion of a circular economy
- To create and deploy open city information platforms. More specifically, an ICT platform that provide the opportunity for both the lighthouse and the follower cities to actively engage together and effectively address the issues they face with their technical partners
- To organize and foster the lighthouse cities' solutions, that will then be transferred and replicated to the other participating cities (Follower)

3.1.8 Iris

The next Lighthouse project was the IRIS project which started in 2017. The participating lighthouse cities were those of Utrecht (NL), Göteborg (SE) and Nice Côte d'Azur (FR) (Calzada, 2019). The aim was to deliver better, accessible, cheaper, and reliable energy and mobility services to create a sustainable urban city with a better quality of life for the citizens of the city. To make this happen IRIS brought together many different stakeholders so they could design, illustrate and quantify the value of an innovative business model that develops when solutions concerning sectors such as mobility, energy, and ICT domains, are integrated.

The project brought together five transition tracks and provided sixteen integrated solutions. These solutions showed that cities can mix and match depending on the specific needs of each city. The first three tracks that were created were focused on grid flexibility and energy efficiency. They included measures such as vehicle-to-grid storage, second life battery, supply, and dynamic balance. These measures focused on increasing renewable energy production and rolling-out e-buses and e-cars.

The fourth track focuses on data sharing, standardization of the common ICT architecture, and governance practices accelerating innovation. Track five is a measure that integrates co-creation and interdisciplinary citizen engagement by connecting the needs of end-users with the needs of stakeholders to support innovative business models.

3.1.9 Making City

The MAKING-CITY project began in 2018 and was coordinated by the CARTIF Technology Centre, to once again illustrate the advantages that derive from the use of Positive Energy District (PED) (Späth, & Knieling, 2020). PED is defined by the European Strategic Energy Technology Plan (SET Plan) as a district that has a goal to achieve a net zero energy import and a net zero carbon emissions every year. In addition, its main focus was to work towards creating a local surplus production of renewable energy annually. The objectives of the MAKING- CITY project were the following:

1. To demonstrate the PED concept in the two Lighthouse cities Groningen and Oulu.
2. To establish a validated procedure that supports PED definition (calculation procedures, assessed technical, social, identified barriers, and regulatory framework conditions).

3. To replicate the PED concept developed in MAKING-CITY in the follower cities.
4. To support and promote the City Vision 2050.
5. To develop a rigorous monitoring and evaluation program.
6. To create business models that can integrate the PED deployment and to help create a business ecosystem using the PED concept which would be created during the MAKING-CITY project.
7. To raise business opportunities in the cities and to organize social innovation activities by integrating the PED concept. By involving SMEs, industrials, NGOs.
8. To deploy an exploitation and market strategy so that results and technologies can be identified.
9. To create a beneficial communication and dissemination strategy in order to raise awareness to promote the PED concept that was developed during the MAKING-CITY project.
10. To foster strong cooperation with other related projects and relevant clusters of projects.

3.1.10 +Cityxchange

The +CityxChange *(Positive City ExChange)* was the next smart city project. The European Union's Horizon 2020 funded this project (Gohari, et al., 2020). The projects responsibility was to host and lead the project carried out by the Norwegian University of Science and Technology (NTNU) in collaboration with other Lighthouse Cities of Limerick City and Trondheim Kommune. Its three main objectives were:

- Citizen driven approach,
- Replication Technology
- Business model

3.1.11 Sparcs

The SPARCS project was developed to help the two participating lighthouse cities to produce a network of Sustainable energy Positive & zero cARbon CommunitieS (Uspenskaia, et al., 2021) by creating broad planning, management processes and models. The aim of the SPARCS project was to show and validate solutions that will be innovational for integrated and smart energy systems. These systems will change the participating cities into ecosystems that are zero carbon and sustainable. Simultaneously it will help improve the citizen's quality of life. The two lighthouse cities were Leipzig and Espoo. The main aims of SPARCS were to:

- To establish a circular economic framework that is also dynamic.
- To engage in innovation-oriented investors, professionals, and companies
- To enable an urban transformation that is based on the successful partnership between private and public entities.

3.1.12 Atelier

The most recent Lighthouse project was the ATELIER the following project that was funded by the EU's Horizon 2020 Smart City. The project's aim was to develop and effectively replicate the Positive Energy Districts (PEDs) in the two lighthouse cities that were chosen which were the city of Bilbao and the city of Amsterdam (Calzada, 2020). The focus of this project was to create a Positive Energy Districts for the participating cities with a goal to save 1,7 kton of CO_2 emissions. This would demonstrate the importance of integrating smart urban solutions that support the deployment of PEDs.

The aforementioned objective was set on three principles:

1. To reduce CO_2 emissions.
2. Secure, sustainable, and affordable energy systems for citizens.
3. Collaboration and knowledge sharing.

3.1.13 Pocityf

The final lighthouse project is that of POCITYF which is also EU-funded smart city project (Leitão et al., 2020). The project was focused on helping cities that of historical value and transform them into greener, smarter, and more livable cities while respecting the city's cultural heritage. The Positive Energy District can be become a reality after being tested and implemented in the participating cities. In addition, POCITYF supports Europe goal of becoming the first Carbon Neutral Continent by the year 2050. These two Lighthouse cities are Alkmaar and Evora.

The objectives are:

- To create solutions, reduce energy consumption in building and district level. To create P2P energy management and storage solutions in an effort to support the grid to become more flexible and to help curtailment reduction.

- To integrate electro-mobility solutions as a way to enable the grid to become more flexible.
- To integrate the newest generation of ICT solutions in the city platforms that already exist.
- To get citizen engagement so they participate in co-creation, planning, decision making, and problem solving.

3.2 Conclusion Beyond Grow Smarter

Now that the sum of the Lighthouse projects is presented, it is crucial for the purposes of this research, to illustrate the areas of interest in which the projects focused on according to the implementation they performed. The areas have been categorized according to their scope in vertical sectors. The most significant sectors are:

- Energy, that includes Refurbishments and Buildings, Energy Providers, Energy System and Mobility
- ICT and it’s aspects
- and Other Thematic Fields Types that include variant implementations

In order to comprehend *table 2* there will be a brief overview on the meaning of the sectors.

- ❖ ReBuilding/ Refurbishments refer to the buildings and the passive implementations carried in order to achieve the standards of each project, for example PVs. Several of the implementations are leaning towards “Smart” and relates to ICT sector such as Home Energy Management System in buildings.
- ❖ Energy Providers are associated to alternative sources of energy such as electrical charging stations.
- ❖ Energy System Types are mainly the grids. The action of creating renewable energy and maintaining energy for when we need it e.g. waste heat recovery
- ❖ Mobility refers to the changes of infrastructure in order to promote the changes mentioned above for example about e-vehicles
- ❖ ICT aspects are associated with the implementations of the information and communication technology, data transfer and current technology that is constantly evolving.

❖ Finally, Other Thematic Fields, that represent the section in which the implementations of all kinds that are considered to differ from the above are included. An example of such an implementation should be traffic measuring sensors for pedestrians (Stockholm).

C= Project completed, O=Project Ongoing, F = Projected Future Outcome

YEAR	**PROJECT**	**CITY**	**ENERGY**				**ICT**	**OTHER**
			Building/ Refurbis hments	Energy Providers	Energy System Types	Mobility	ICT aspects	Other Thematic Field
2019	POCITYF	Alkmaar	F	F	F	F		
		Evora	F	F	F	F		
	Atelier	Amsterdam	F	F	F		F	
		Bilbao		F	F		F	
	Sparcs	Espo	F	F	F	F		
		Leipzig	F	F	F	F		
2018	MAKING-CITY	Groningen	F	F	F	F	F	
		Oulu	F	F	F	F	F	
	+CityChange	Trondheim	F	F	F		F	
		Limerick	F	F	F		F	
2017	MatchUP	Valencia	O	O			O	O
		Dresen	O	O			O	O
		Antalya	O	O			O	O
	IRIS	Utrecht		F	F	F	F	
		Nice		F	F	F	F	
		Gothenburg		F	F	F	F	
	Stardust	Pamblona		F	F	F	F	
		Tambere		F	F	F	F	
		Trento		F	F	F	F	

2016	mySMARTLife	Nantes	O	O	O	O		O
		Hamburg	O	O	O	O		O
		Helsinki	O	O	O	O		O
	RUGGEDISED	Rotterdam	O	O	O	O		O
		Glasgow	O	O	O	O		O
		Umea	O	O	O	O		O
2015	SMARTER TOGETHER	Vienna	C	C		C		C
		Munich	C	C		C		C
		Lyon	C	C		C		C
	REPLICATE	San Sebastian	C	C	C	C	C	C
		Florence	C	C	C	C	C	C
		Bristol	C	C	C	C	C	C
	SmartEnCity	Vitoria-Gasteiz		O	O	O	O	
		Tartu		O	O	O	O	
		Sonderborg		O	O	O	O	
2014	Sharing Cities	Lisbon	C			C	C	C
		London	C			C	C	C
		Milan	C			C	C	C
	Grow Smarter	Stockholm	C	C	C	C	C	C
		Cologne	C	C	C	C	C	C
		Barcelona	C	C	C	C	C	C
	Triangulum	Eindhoven	C	C	C	C	C	C
		Manchester	C	C	C	C	C	C
		Stavanger	C	C	C	C	C	C
	REMO	Valladoid	C	C	C	C	C	C
		Nottingham	C	C	C	C	C	C

		Tepebasi	C	C	C	C	C	C

Table 2 - Lighthouse Projects and their areas of focus

Table 2 illustrates all projects illustrated in the Horizon 2020 project. It was created based on the categories created by the European Union and specifically the Smart Cities Marketplace website. As we can see, the projects initiated in 2014 and 2015 have already completed and published their results, while the projects since 2016 are whether still ongoing or published future outcomes. More specifically, from the first few generations of lighthouse projects only SmartEnCity is still ongoing, and the results of this project are still not clear according to the European Union (Smart Cities Marketplace, 2021).

The table presents the areas in which the projects focused on and the changes that occurred over time when the lighthouse projects slowly moved away from covering many different areas to focusing on more specific ones mainly energy and ICT projects. As we can observe the implementations carried out until 2016 included Energy, ICT and Other Thematic Fields as well. That means that the projects were still experimenting on the interventions and included a wider variety. Since 2016 it is evident that the focus of the European Union projects moved over time from a holistic approach towards the Positive Energy District and ICT. Only one area in the aforementioned table has been a main focus point for all but one project (Sharing Cities) is the Energy providers' category. It's the category that focuses on renewable energy and how to help the electricity grid of each city to become more efficient over time to cover the requirements of the city's citizens.

For the newer projects the amount of available information beyond the initial objectives of the projects is limited due to the Covid pandemic since the initiatives that could be carried out during the pandemic were restricted. Despite the fact that some projects should have ended by now, they have not, while others have yet to publish the final results and the outcomes of the initiatives carried out (Smart Cities Marketplace, 2021). A more comprehensive outcome of the overall effect the Horizon 2020 program had in these cities should be available in the following years when the final projects have also been completed.

The following chapter will present the prospects that derived from the information already gathered by the Horizon 2020 project and the Lighthouse Cities research, and the realization of the tendency towards Energy related Projects.

Chapter 4. Discussion

For the final chapter, after documenting the course of Horizon 2020 until today, there will be a discussion about the outcomes deriving from the Projects and the impact has to future actions and projects In the European Union.

4.1 Evolution of Smart City Projects within H2020

As can been seen by the Image 1 (Methodology section) the Lighthouse projects have been a monumental task that has been carried out throughout Europe with 17 projects conducted, 46 lighthouse cities and 72 follower cities including cities from both North and South of Europe. (Delsing, 2021). These projects were the following GrowSmarter, Remourban, Triangulum, Replicate, Sharing Cities, SmartenCity, Sharing Cities, Smarter Together, My Smart Life, Ruggedised, IRIS, Matchup, Stardust, Making City, City Exchange, Atelier, Pocityf, and Sparcs. All of the above projects have been funded by the Horizon 2020 program and stakeholders were involved in every aspect (Lange, & Knieling, 2020). The funding for this project has been more than 1.2 billion Euros but the outcomes of these projects have been significant. The above table (Table 2) illustrates the different lighthouse projects that have been carried out in Europe since the project began, in 2014. Some of these projects have ended and their results are published while other projects are still ongoing. The ongoing projects are separated into two separate categories, those who have published some of their results and some that have not published any results at all.

One of the first frameworks that the Horizon 2020 program endorsed is the collaborative effort of the cities to achieve the best results possible. The participants of lighthouse projects are able to exchange the technological knowledge required to complete the projects, and can divide amongst each other the potential risk, while reducing the total cost through this joined effort. If the project successfully completes then the technological advantages occurring can be shared and implemented throughout Europe on a larger scale (e.g Smart Meters) (Škultéty, Beňová, & Gnap, 2021). The Smart Meters were first introduced in the original lighthouse projects and have now become a prominent part of what energy suppliers offer their customers for their homes.

The research carried out in these projects have also shown that the savings that derive from the projects are massive, proving that the embracing of the cities' collaboration is effective. Furthermore, by combining cities in the North and the South of Europe in each project they can tackle many different aspects of the same issue at the same time. For example, in the

Grow Smarter program Barcelona focused on cooling the buildings down in the renovation process but they also implemented the heating of those building, that Stockholm and Cologne predominantly focused on. The outcome showed that having a building prepared for both types of weather can be more beneficial in the long run especially with the extreme weather conditions which have been seen in recent years due to climate change (Varró, & Szalai, 2021).

Examining the projects has illustrated that there are different types of compositions, budget allocations and city networks for each city and each program. The main focus that this program has is that the follower cities must follow the path that the original cities have set. They do not have the chance to make their own active decision-making choices.

The main difference that was identified between the newer projects and the older projects was that the older project tried to encompass many different aspects and complete tasks in all the different categories that the EU had set such as building refurbishment, energy systems, reduction of pollution, creation of ICT systems, incorporating renewable sources in the electrical grid and greener mobility. The new projects are now focusing more on energy reduction, renewable energy sources, creating a viable grid and ICT systems (Vandercruysse, Buts, & Dooms, 2020). The reason behind this shift could be because the world is moving towards a new direction focusing more and more on saving energy and getting it from sources that are renewable to help reduce the CO2 emissions that are realized in the atmosphere from the old existing grids.

Furthermore, some of the building aspects that were tackled by the older projects such as the building having appropriate insulation or a better heating system or windows that do not "lose" as much energy are now being tackled on a larger scale. The success that these original projects had has shown governments throughout the EU that by spending more money on helping their citizens improve their homes could benefit them in the long run. Reducing the energy bills and the stress on the grid especially in the winter months will benefit both the citizens and the electrical grid (Späth, & Knieling, 2020).

Moreover, new buildings that are now being built focus on being energy efficient or "smart buildings" in every way possible which was not the case almost a decade ago. The construction industry has shifted their focus in recent years which has also helped them reduce costs when they are using more energy efficient tactics and methods throughout the construction of the buildings. In addition, there is a general shift in society due to climate change to be more energy efficient in every aspect of someone's life (Ahlers et al., 2019). To reduce the harmful emissions released into the atmosphere but also help combat climate change.

An aspect which all the lighthouse projects have aimed to tackle is to reduce the cities carbon emissions and help them improve their air quality for the citizens of each city (Losavio, et al., 2018). The reduction of carbon emissions has been achieved by earlier projects and preliminary reports of the following projects have also shown that it is feasible goal for the projects that follow. There are some cities that can be seen in the above table (Table 2) that have not published any data or results yet. This could be a direct effect of the Covid-19 pandemic which prevented cities from completing the project on time. Perhaps due to the aforementioned reasons certain tasks or measures could not take place in the current climate. The only project from the original group of projects (2014) that is still ongoing is the Smartencity project, which followed the pattern of the first smart cities framework and that is tackling many different projects all at once. From 2016 onwards a shift is visible the slowing of the lighthouse projects, the main thing that was identified is that the majority have not completed their run and they are still ongoing. The shift towards focusing on sustainable mobility, energy efficiency and ICT infrastructure can be seen in the latest projects (Fernandez-Anez, Fernández-Güell & Giffinger, 2018).

More specifically, the two projects that solely focus on the aforementioned areas - mobility, energy efficiency and ICT infrastructure - were Stardust and IRIS. Both of them are considered to be the first generation of lighthouse projects to shift towards a different type of investment projects. Previous projects did focus on these areas too, but not exclusively. This shift could be a direct link to the preparation and later on signing of the Paris Climate Agreement, which turned the world towards focusing on the importance of combating climate change and its negative consequences (Riva Sanseverino, Riva Sanseverino, & Anello, 2018). The Agreement stated that the world needs to work together to reduce the harmful emissions by 2050. Perhaps that gave the necessary push for the lighthouse projects to move towards more efficient projects focusing on energy supply and electricity grid among the cities of the European Union. Furthermore, actions were made for reducing the current energy consumption of these cities more drastically in the coming years.

All projects after the year 2016 followed the same pattern on refurbishments in order to help reduce the energy consumption of those buildings. Overall, the main focus has also shifted in helping introduced more charging stations to help citizen of these cities charge their e-vehicles or use more ecofriendly vehicles such as hybrid. Perhaps the goal of EU to become a carbon neutral continent by 2050 is also shaping the future of these lighthouse projects and pushing them towards a new direction. A direction that has been set by the Green Deal and the goals it has set for all the EU members (Mora, et al., 2019). The lighthouse projects can become a beacon of positivity and illustrate that different directions and different things that have been implemented in these cities are shaping them to become more livable for their citizens, more ecofriendly and more sustainable in the future.

4.2 The Future of Smart City Projects in Horizon Europe

The future of the lighthouse project and smart cities is SCALE or the European Smart and Lighthouse Cities Amplified. It is an initiative that each city is led to and focuses on engaging different groups to an effort of effective collaboration. These different groups can be policy makers, stakeholders, researchers, universities, industries, and citizens. The purpose of SCALE is to create a new environment for the current and the future smart cities with a joined initiative. Simultaneously, the necessary inclusions for smart cities will be created in order to be more resilient in the future (Cirillo, et al., 2020).

Resilience is important as the world dynamic is progressing, and climate change is is predicted to cause multiple problems in the near future. This shift towards a sustainable future and practices, using technological solutions that are innovative and carbon neutral is a pioneer coordinated action of the original smart cities (Collins, Cox, & Torrisi, 2021). Using the sustainable practices that were created in the original projects and the ones that followed will help implement more green policies for the cities included and even more cities throughout Europe. These actions will create a new structure of society that will be more friendly for city residents and create territory that is more livable for everyone.

SCALE will partner with both the CINEA (European Climate, Infrastructure and Environment Executive Agency) and the European Commission to continue supporting the current cities of the 18 Lighthouse projects which are 120 cities throughout Europe that have been involved over the years in Communities Lighthouse Group and the Horizon 2020 Smart Cities (Mutule et al., 2021). The support will be long term until after the project has concluded and the final reports have been submitted, and not just during the development of the project. This agency was created to establish an element of unification that will connect all of the projects, and also be used as a networking tool and a guide for smart city replication. SCALE will be used as a mean to improve and enhance not only the performance of the Smart cities but also the significance they have in the European community.

Currently SCALE is working closely with the 48 original Lighthouse cities and 72 follower cities. Creating and organizing a consortium with the cities partners such as consultants, industrial partners, associations, and academics in order to bring together the 550 demonstrations of technological creation types, social smart innovations that have helped revolutionize multiple aspects of the city. The creation of smart infrastructure, smart buildings, mobility, the increase of citizen engagement, the creation of big data platforms and a tendency towards city governance. All of the aforementioned are available due to the European Commission funding that has invested in the project more than 420 million € to accomplish their goals (Csukás, & Szabó, 2021).

SCALE's support framework will provide a support system, consultations, design, co-operation, logistical support, communication, application, and access to financiers and to business models (Komninos, et al., 2021). Furthermore, it will help establish an application stable government support to ensure exact replication of the smart cities that have proven functional and provide viable solutions. Some future goals have been set to support Communities Group and Smart Cities not only to achieve each city's individual goals but also provide the necessary tools for other replications in the future.

The goals are the following:

- Support for the SCC (Smart City Concept) Projects – SCALE will offer knowledge, sharing opportunities and support to all the members of the ongoing and finalized of SCC Projects (see table 2). There needs to be consistent communication and the solutions concerning the best practices, solutions, and any general information that can be used to create a successful smart city need to be disseminated (Paskaleva, Evans, & Watson, 2021). This will become the key path to a successful replication of the solutions by follower and other cities. The ultimate goal is to create a positive effect that will snowball through Europe.
- Access to Financing- SCALE will be responsible to enable projects to have access in additional funding if they deem it necessary to continue the project through the SCALE Grant. Furthermore, they will create a space for new lighthouse projects presenting high return smart city investments, the most bankable choices, access to financiers and financing using collaborative activities. The actions will be based on the success on lighthouse pilot projects that have been already completed (Bundgaard, & Borrás, 2021).
- Foster Replication- the scheme SCALE Grant will be launch in the beginning of 2022, it will be a collaboration between the CINEA and the European Commission with SCALE. This new partnership will include more partnerships and activities that are currently not considered or not covered by the SCC Grant Agreements to have access to the appropriate funding, organize and implement them.

- Enhance the Common Brand for Smart Cities- SCALE will focus on the amplification of a united smart city brand. The reason behind this it to position the brand in a place where the smart cities experts would relate topics such as urban transition to a more sustainable, inclusive, greener, and livable city (Paalosmaa, 2021).
- Bridge the SCC Community- SCALE will aim to bring together both the Communities Group and the Smart Cities, and the stakeholders for each project and their activities. SCALE will create groups for workshops, knowledge sharing seminars, events, potential networking possibilities and matchmaking activities. The Community will come together and share their knowledge, technological solutions and best practices among the other partners and the citizens (Yigitcanlar, Kankanamge, & Vella, 2021).
- Finally, to create an Online Collaborative Space- SCALE will develop a smart city platform where the stakeholders will be able to create, discuss, and apply new approaches and collaborations that relate to the implementation and adoption of the new frameworks of legislation created by urban leaders and public policy makers (Razmjoo, et al., 2021).

4.3 The EU Green Deal

The European Green Deal was developed by the European Commission as a set of policy initiatives with an overall aim to make the European Union (EU) become climate neutral by the year 2050 (Elkerbout et al. 2020). The first plan of impact will be assessed and presented in an attempt to reduce the EU's greenhouse gas emission by the year 2030. The necessary reduction will need to be at least 50% and 55% in comparison to the 1990 levels. The current plan of the Green Deal is to review all existing legislation with regards to climate change and create appropriate new legislation on building renovation, circular economy, farming, biodiversity, and innovation. Similar to what has been seen in the Horizon 2020 and the Lighthouse projects all aspects of the city that will be successfully implemented, will be followed by other cities of EU. As the projects tackle the main issues the Lighthouse Cities faced, EU will tackle the same issues on a larger scale following the results of the Lighthouse projects.

The importance of carbon neutrality by the 2050 has become the prominent goal of the European Union through the Green Deal. This is also obvious in Horizon 2020 as the number of Lighthouse projects has steadily risen over the years. Each sector will be look into to see what necessary changes can occur achieve net-zero greenhouse gas emissions (Claeys, Tagliapietra, & Zachmann, 2019). All the current regulations for each industry will be examined thoroughly and adjustments will be made. All the member states by 2023 must create new climate and energy plans for their national grid in order to adhere to the climate goal the EU has set. The newer lighthouse project from 2016 onwards as can be seen in the table follow this trend as the focus has shifted towards energy trends, reducing energy, and better ICT aspects.

The key principles of the Green Deal are the following:

- Prioritization of energy efficiency
- A power sector which has been developed and based on renewable resources
- A secure and affordable energy supply for the EU
- The creation an interconnected digitalized and integrated EU energy market

The EU has created the Strategy for Energy System Integration, a framework to achieve an energy transition to more renewable sources and was also seen in all the lighthouse projects (completed and still ongoing), to achieve a circular system that creates direct electrification and helps develop clean fuel such as hydrogen (Montanarella, & Panagos, 2021).

4.4 3.3.1 Sustainable industry

One of the targets for the EU climate goals is to develop the Circular Economy Industrial policy. The EU announced in March 2020 their new industrial strategy that was focused on empowering the EU citizens, to revitalize all regions and provide access to advanced technologies for the citizens. All of the above were the main aims of the original lighthouse projects to help these cities improve the life quality of citizens (Aggestam, & Giurca, 2021). The key aspects or points of this policy will be to boost modern industries and to promote more climate neutral aspects of the economy such as friendly-goods markets. Industries which are extremely energy intensive such as the cement or the steel industry will slowly be decreasing their activities (Hafner, & Raimondi, 2020). A turn towards sustainable products is something that will be implemented significantly over the next few years as a measure to reduce waste of important materials. The products that will be created will be recycled multiple times. Similarly in all the smart cities projects of Horizon 2020, especially the initial ones there was an enfaces on recycling and reducing waste significantly in each of the participating cities.

The materials recycled are not only household waste but also materials such as batteries, textiles, electronics, vehicles, and plastics. Another issue that will be addressed through the Green Deal is the exportation of waste to other countries outside of EU. Each city/country will use the findings of the lighthouse projects as a template to deal with their own waste effectively (Siddi, 2020). Furthermore, the Commission will also reconsider the existing rules about what is considered as the end-of-life vehicles in an attempt for the circular business model to be promoted.

4.5 3.3.2 Building and renovation

Another aspect of the Green Deal which was also researched and examined on the effectiveness, was building renovations. All of the original projects focused on building renovations and most of the recent ones have also followed this pattern (Bonfante, Basile, & Bouma, 2020). There are a few of the newer Lighthouse projects of the Horizon 2020 that have chosen not to follow this pattern (see table 2). The Green Deal will focus on the building processes and renovations that are no longer sustainable. It will tackle the use on non- renewable resources that are currently being used in the construction industry.
In addition, the Green Deal will promote the creation of buildings that are energy efficient that the lighthouse projects have shown that can be achieved. Furthermore, digitalization of the buildings has also been tested in the lighthouse projects and showed promising results in enforcing specific rules with regards to buildings energy performance (Kemfert, 2019). The importance of renovating social housing will not be overlooked in the deal, as the EU believes every citizen should have equal access to building renovations. The main aim for the building renovations is to reduce the pollution that these buildings emit into the atmosphere on a daily basis.

4.6 Farm to Fork

The next aspect of the Green Deal, is an aspect that the lighthouse projects have not tackled as of yet, the farm to fork strategy. The production from fishermen or farmers will be directly send to the nearby cities, as new methods of fishing and farming which are friendly to the environment will be implemented throughout the EU. The price and quality of these goods will eventually reduce, as these new methods will be commonly adopted. Furthermore, the chemicals and pesticides harmful to the environment will no longer be available in the market. The products will also be of better quality and the packaging will become sustainable. The allocate budgets for this plan will be €10 billion (Pietzcker, Osorio, & Rodrigues, 2021). This is an aspect that none of the lighthouse projects have chosen to tackle directly until now.

4.7 Elimination of Pollution

Another aspect of the Green Deal that Lighthouse projects have worked over the years, is the reduction and hopefully elimination of the pollution. The 'Zero Pollution Action Plan' focused on eliminating the pollution from all current sources by cleaning water, air, and soil by 2050 (Kettunen, et al, 2020). In the Lighthouse projects a significant amount of attention was paid in the original ones - REMO, Triangulum and Grow Smarter - to reduce the air pollution in these cities and according to the results that these three projects presented, the reduction of the air pollution was achieved successfully(Leonard, et al. 2021). On a larger scale each industry must reduce their activities which can cause toxins to be released into the atmosphere. Similarly, agriculture and urban industries that are considered pollutant for the soil and water supply, with micro-plastics and different types of chemicals, will no longer be allowed.

4.8 Sustainable Mobility

The Green Deal will also focus on different transporting methods which will also help reduce CO2 emissions into the atmosphere (Sikora, 2021). The use of sustainable fuels for the different types of transports such as airplanes, trains, ships, and cars will be encouraged. The public will also benefit, as more charging ports for new electric vehicles will be available in public spaces. This measure was pioneered in the first three lighthouse projects, and it has now been implemented on each of the projects that has followed since those original ones.

It is evident that certain aspects of the Green Deal which the EU has set forward, derive from on the original Lighthouse projects and the multiple aspects they tackled. Their success showed to EU Commission that they can be implanted on a larger scale. The only part considered as new investigation is the farm to fork suggestion, the main focus of which is to reduce their emissions and help citizen to embrace a new way of life. A Life where citizens live in low emission buildings, have grid that is mostly powered by sustainable sources, less pollution is emitted in the air and more public charging stations are available for e-vehicles. The lighthouse projects and Horizon 2020 were the steppingstone for the Green Deal and their impressive results are what created the path that the EU Commission is now using to make the Europe Union carbon neutral by 2050 (Haines, & Scheelbeek, 2020).

Conclusion

Overall, the outcomes that the Lighthouse projects highlighted cannot be overlooked. The findings lead the way for the future of the European Union in a meaningful and positive way. They have upgraded thousands of peoples' lives and are currently shaping the EU legislation (i.e Green Deal). The main conclusion is that the older projects tried to encompass many different aspects and complete tasks in all the different categories that the EU had set such as building refurbishment, energy systems, reduction of pollution, creation of ICT systems, incorporating renewable sources in the electrical grid and greener mobility. The new projects are now focusing more on energy reduction, renewable energy sources, creating a viable grid and ICT systems (Vandercruysse, Buts, & Dooms, 2020). The reason behind this shift could be because the world is moving towards a new direction focusing more and more on saving energy and getting it from sources that are renewable to help reduce the CO2 emissions that are realized in the atmosphere from the old existing grids. Many different industries have been reformatted such as the energy sector and the automotive industry by making electric vehicle more accessible to everyone. In addition, the construction industry is being reformed by the refurbishments introduced by the Lighthouse projects that are now being used as guidelines for newer building. Perhaps the goal of EU to become a carbon neutral continent by 2050 is also shaping the future of these lighthouse projects and pushing them towards a new direction.

Finally, the creation of SCALE platform and Green Deal legislation is promising for more achievements, by both the ongoing projects and their results and outcomes. The above combination will empower the Europe Union to step into a new and exciting future where becoming carbon neutral will be achievable in the timeline set.

Bibliography

1. Aggestam, F., & Giurca, A. (2021). The art of the "green" deal: Policy pathways for the EU Forest Strategy. Forest Policy and Economics, 128, 102456. **doi.org/10.1016/j.forpol.2021.102456**
2. Ahlers, D., Wienhofen, L. W., Petersen, S. A., & Anvaari, M. (2019, June). A Smart City ecosystem enabling open innovation. In International Conference on Innovations for Community Services (pp. 109-122). Springer, Cham. DOI: 10.1007/978-3-030-22482-0_9
3. Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: definitions, dimensions, and performance. Journal in Urban Technology,. **https://doi.org/10.1080/10630732.2014.942092**.
4. Andersson, M., Ödlund, L., & Westling, H. (2019). The role of the Swedish municipalities in the transition towards sustainable energy systems. In WEENTECH Proceedings in Energy (Vol. 5, No. 1, pp. 124-135). WEENTECH. **https://doi.org/10.32438/WPE.3319**
5. Angelidou, M. (2015). Smart cities: A conjuncture of four forces. *Cities*, *47,* 95-106. https://doi.org/10.1016/j.cities.2015.05.004
6. Anthopoulos, L., Fitsilis, P., & Ziozias, C. (2016). What is the source of smart city value? A business model analysis. International Journal of Electronic Government Research, 12(2), 56–76. **https://doi.org/10.4018/IJEGR.2016040104**
7. Astrain, J. J., Falcone, F., Lopez-Martin, A. J., Sanchis, P., Villadangos, J., & Matias, I. R. (2021). Monitoring of Electric Buses within an Urban Smart City Environment. IEEE Sensors Journal. doi: 10.1109/JSEN.2021.3077846.
8. Bagheri, S., Brandt, T., & van Oosterhout, M. (2021). Digital City Rotterdam: Open Urban Platform. Retrieved from http://hdl.handle.net/1765/135667
9. Bakıcı, T., Almirall, E., & Wareham, J. (2013). A smart city initiative: the case of Barcelona. Journal of the knowledge economy, 4(2), 135-148. **https://doi.org/10.1007/s13132-012-0084-9**
10. Balogun, A. L., Marks, D., Sharma, R., Shekhar, H., Balmes, C., Maheng, D., … Salehi, P. (2020). Assessing the Potentials of Digitalization as a Tool for Climate Change Adaptation and Sustainable Development in Urban Centres. Sustainable Cities and Society, 53, 101888. **https://doi.org/10.1016/j.scs.2019.101888**
11. Bastian, A., & Börjesson, M. (2018). The city as a driver of new mobility patterns, cycling and gender equality: Travel behaviour trends in Stockholm 1985–2015. Travel behaviour and society, 13, 71-87. **https://doi.org/10.1016/j.tbs.2018.06.003**
12. Bibri, S. E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. Sustainable Cities and Society, 38, 758–794. **https://doi.org/10.1016/j.scs.2017.12.032**
13. Bibri, S. E., & Krogstie, J. (2020). The emerging data–driven Smart City and its innovative applied solutions for sustainability: The cases of London and Barcelona. Energy Informatics, 3(1), 1-42. https://doi.org/10.1186/s42162-020-00108-6
14. Bonfante, A., Basile, A., & Bouma, J. (2020). Targeting the soil quality and soil health concepts when aiming for the United Nations Sustainable Development Goals and the EU Green Deal. Soil, 6(2), 453-466. https://doi.org/10.5194/soil-6-453-2020
15. Borda, A., & Bowen, J. (2017, July). Smart cities and cultural heritage-A review of developments and future opportunities. In EVA. BCS. DOI: 10.14236/ewic/EVA2017.2

16. Bouzarovski, S., Frankowski, J., & Tirado Herrero, S. (2018). Low-carbon gentrification: When climate change encounters residential displacement. International Journal of Urban and Regional Research, 42(5), 845-863. https://doi.org/10.1111/1468-2427.12634
17. Brenner, N. (2013). Theses on urbanization. Public Culture, 25(1), 85–114. **https://doi.org/10.1215/08992363-1890477**
18. Bundgaard, L., & Borrás, S. (2021). City-wide scale-up of smart city pilot projects: Governance conditions. Technological Forecasting and Social Change, 172, 121014. **https://doi.org/10.1016/j.techfore.2021.121014**
19. Calzada, I. (2019). Report on the City-to-City-Learning Programme: the replication strategy in replicate EU-H2020-Smart Cities and Communities (SCC) Lighthouse Project (www. replicate-project. eu/city2citylearning). **http://orca.cardiff.ac.uk/id/eprint/139147**
20. Calzada, I. (2020). Replicating smart cities: The city-to-City learning programme in the replicate EC-H2020-SCC project. Smart Cities, 3(3), 978-1003. https://doi.org/10.3390/smartcities3030049
21. Capdevila, I., & Zarlenga, M. I. (2015). Smart city or smart citizens? The Barcelona case. Journal of Strategy and Management. **https://doi.org/10.1108/JSMA-03-2015-0030**
22. Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. Journal of Urban Technology, 65–82. **https://doi.org/10.1080/10630732.2011.601117**
23. Cheshmehzangi, A. (2021). From Transitions to Transformation: A Brief Review of the Potential Impacts of COVID-19 on Boosting Digitization, Digitalization, and Systems Thinking in the Built Environment. Journal of Building Construction and Planning Research, 09(01), 26–39. **https://doi.org/10.4236/jbcpr.2021.91003**
24. Cirillo, F., Gómez, D., Diez, L., Maestro, I. E., Gilbert, T. B. J., & Akhavan, R. (2020). Smart city IoT services creation through large-scale collaboration. IEEE Internet of Things Journal, 7(6), 5267-5275. doi: 10.1109/JIOT.2020.2978770.
25. Claeys, G., Tagliapietra, S., & Zachmann, G. (2019). How to make the European Green Deal work. Bruegel. **http://aei.pitt.edu/id/eprint/100978**
26. Collins, A., Cox, A., & Torrisi, G. (2021). Searching for a Smart City: A Bibliographic Analysis of 'Public Facing'EU Smart City Projects. Tijdschrift voor economische en sociale geografie. https://doi.org/10.1111/tesg.12476
27. Corradini, A. (2020). What makes a city smart? A new concept of city based on sustainability and innovation. **https://tesi.luiss.it/id/eprint/29409**
28. Csukás, M. S., & Szabó, R. Z. (2021). The many faces of the smart city: Differing value propositions in the activity portfolios of nine cities. Cities, 112, 103116. **https://doi.org/10.1016/j.cities.2021.103116**
29. DATA, B. (2007). Urban ENVIRONMENT.
30. De Dutta, S., & Prasad, R. (2020). Digitalization of Global Cities and the Smart Grid. Wireless Personal Communications, 113(3), 1385–1395. **https://doi.org/10.1007/s11277-020-07478-w**
31. Delsing, J. (2021). Smart City Solution Engineering. Smart Cities, 4(2), 643-661. https://www.mdpi.com/2624-6511/4/2/33#:~:text=2)%2C%20643%2D661%3B-,https%3A//doi.org/10.3390/smartcities4020033,-Received%3A%2024%20March
32. Dirks, S., & Keeling, M. (2010). A Vision of Smarter Cities: How cities can lead the way into. Ministry of Science, Technology and Innovation Aras 1-7, Blok C4 & C5, Kompleks C, Pusat Pentadbiran Kerajaan Persekutuan, 62662 Putrajaya, Wilayah Persekutuan. T+:(603) 8885 8000.
33. Dulisch, L. (2017). Smart City projects and Energy Transition. A comparative case study of the Smart City projects in Amsterdam and Cologne.

34. Elkerbout, M., Egenhofer, C., Núñez Ferrer, J., Catuti, M., Kustova, I., & Rizos, V. (2020). The European Green Deal after Corona: Implications for EU climate policy. CEPS Policy Insights, (2020/06), 1-12. **http://aei.pitt.edu/id/eprint/102671**

35. Engelbert, J., van Zoonen, L., & Hirzalla, F. (2019). Excluding citizens from the European smart city: The discourse practices of pursuing and granting smartness. *Technological Forecasting and Social Change*, *142*, 347-353. **https://doi.org/10.1016/j.techfore.2018.08.020**

36. Eriksson, M. (2010). "People in Stockholm are smarter than countryside folks"–Reproducing urban and rural imaginaries in film and life. Journal of Rural Studies, 26(2), 95-104. **https://doi.org/10.1016/j.jrurstud.2009.09.005**

37. Erokhina, O. V., Mukhametov, D. R., & Sheremetiev, A. V. (2019). New Social Reality: Digital Society and Smart City. 2019 Wave Electronics and Its Application in Information and Telecommunication Systems, WECONF 2019. **https://doi.org/10.1109/WECONF.2019.8840644**

38. European Commission. (2016). The Marketplace of the European Innovation Partnership on Smart Cities and Communities (EIP-SCC). Retrieved September 20, 2020, from Website website: **https://eusmartcities.eu/**

39. European Commission. (2019). Horizon 2020 GROWSMARTER Project 646456. Retrieved from CORDIS DATABASE website: **https://cordis.europa.eu/project/id/646456**

40. European Commission. (2020). Smart Cities Marketplace. Retrieved October 10, 2020, from Website website: **https://eu-smartcities.eu/**

41. European Commission. (2020j). The Economic Impact of Open Data Opportunities for value creation in Europe. **https://doi.org/10.2830/63132**

42. Fernandez-Anez, V., Fernández-Güell, J. M., & Giffinger, R. (2018). Smart City implementation and discourses: An integrated conceptual model. The case of Vienna. Cities, 78, 4-16. **https://doi.org/10.1016/j.cities.2017.12.004**

43. Ferrer, J. R. (2017). Barcelona's Smart City vision: an opportunity for transformation. Field Actions Science Reports. The journal of field actions, (Special Issue 16), 70-75. ISSN 1867-8521

44. Gaiddon, B., Girardi, J., Neumann, H. M., Thielen, K., Etienne, V., & Wendt, W. (2016, June). Three Cities–Lyon, Munich, Vienna–will be SMARTER TOGETHER. In REAL CORP 2016–SMART ME UP! How to become and how to stay a Smart City, and does this improve quality of life? Proceedings of 21st International Conference on Urban Planning, Regional Development and Information Society (pp. 965-975). CORP–Competence Center of Urban and Regional Planning. ISBN 978-3-9504173-0-2

45. García, J. M., Fernandez, P., Ruiz-Cortes, A., Dustdar, S., & Toro, M. (2017). Edge and cloud pricing for the sharing economy. IEEE Internet Computing, 21(2), 78-84. doi: 10.1109/MIC.2017.24.

46. Gascó, M. (2016, January). What makes a city smart? Lessons from Barcelona. In 2016 49th Hawaii International Conference on System Sciences (HICSS) (pp. 2983-2989). IEEE. doi: 10.1109/HICSS.2016.373.

47. Gascó-Hernandez, M. (2018). Building a smart city: Lessons from Barcelona. Communications of the ACM, 61(4), 50-57. **https://doi.org/10.1145/3117800**

48. Giffinger, R. ;, Fertner, C. ;, Kramar, H. ;, Kalasek, R. ;, Pichler-Milanovic, N. ;, & Meijers. (2007). Smart Cities: Ranking of European Medium-Sized Cities. Centre of Regional Science (SRF), Vienna University of Technology

49. Gil-Garcia, J. R., Pardo, T. A., & Nam, T. (2015). What makes a city smart? Identifying core components and proposing an integrative and comprehensive conceptualization. Information Polity, 20(1), 61–87. **https://doi.org/10.3233/IP-150354**

50. Goess, S., de Jong, M., & Meijers, E. (2016). City branding in polycentric urban regions: identification, profiling and transformation in the Randstad and Rhine-Ruhr. European Planning Studies, 24(11), 2036-2056. https://doi.org/10.1080/09654313.2016.1228832
51. Gohari, S., Baer, D., Nielsen, B. F., Gilcher, E., & Situmorang, W. Z. (2020). Prevailing approaches and practices of citizen participation in smart city projects: lessons from Trondheim, Norway. Infrastructures, 5(4), 36. https://doi.org/10.3390/infrastructures5040036
52. Grimaldi, D., & Fernandez, V. (2017). The alignment of University curricula with the building of a Smart City: A case study from Barcelona. Technological Forecasting and Social Change, 123, 298-306. https://doi.org/10.1016/j.techfore.2016.03.011
53. Haarstad, H., & Wathne, M. W. (2018). SMART CITIES AS STRATEGIC ACTORS. Inside Smart Cities: Place, Politics and Urban Innovation.
54. Hafner, M., & Raimondi, P. P. (2020). Priorities and challenges of the EU energy transition: From the European Green Package to the new Green Deal. Russian Journal of Economics, 6, 374. https://doi.org/10.32609/j.ruje.6.55375
55. Haines, A., & Scheelbeek, P. (2020). European Green Deal: a major opportunity for health improvement. The Lancet, 395(10233), 1327-1329.
56. Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). Foundations for smarter cities. IBM Journal of research and development, 54(4), 1-16. DOI: 10.1147/JRD.2010.2048257
57. Heilert, F. (2019). Investigating 'Improved quality of life'-Assessing social dimensions of GrowSmarter-asmart city project in Stockholm. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:oru:diva-76323
58. Helm, A., Forsberg, N., & Johannsen, C. (2019). Stockholm: Where sustainability meets technology. In Capital Cities and Urban Sustainability (pp. 87-106). Routledge. ISBN9780429426049
59. Henderson, J. V. (2010). Cities and development. Journal of Regional Science, 50(1), 515–540. **https://doi.org/10.1111/j.1467- 9787.2009.00636.x**
60. Ismagilova, E., Hughes, L., Dwivedi, Y. K., & Raman, K. R. (2019, August 1). Smart cities: Advances in research—An information systems perspective. International Journal of Information Management, Vol. 47, pp. 88–100. **https://doi.org/10.1016/j.ijinfomgt.2019.01.004**
61. Kemfert, C. (2019). Green deal for Europe: More climate protection and fewer fossil fuel wars. Intereconomics, 54(6), 353-358. **https://doi.org/10.1007/s10272-019-0853-9**
62. Kettunen, M., Bodin, E., Davey, E., Gionfra, S., & Charveriat, C. (2020). An EU Green Deal for trade policy and the environment. London: IEEP. Retrieved at: https://www.sipotra.it/wp-content/uploads/2020/03/An-EU-Green-Deal-for-trade-policy-and-the-environment-Aligning-trade-with-climate-and-sustainable-development-objectives.pdf
63. Komninos, N., Kakderi, C., Mora, L., Panori, A., & Sefertzi, E. (2021). Towards High Impact Smart Cities: A Universal Architecture Based on Connected Intelligence Spaces. Journal of the Knowledge Economy, 1-29. https://doi.org/10.1007/s13132-021-00767-0
64. Landahl, G. (2020). Stockholm: Smart City. Handbook of Smart Cities, 1-18. https://doi.org/10.4324/9781003021919
65. Lange, K., & Knieling, J. (2020). EU smart city lighthouse projects between top-down strategies and local legitimation: The case of Hamburg. Urban Planning, 5(1), 107-115. https://doi.org/10.17645/up.v5i1.2531

66. Lazaroiu, G. C., & Roscia, M. (2012). Definition methodology for the smart cities model. Energy, 47(1), 326–332. **https://doi.org/10.1016/j.energy.2012.09.028**

67. Leitão, D., Kourtzanidis, K., Giourka, P., Kort, J., Koning, N., Maas, N., ... & Barroso, R. (2021, October). Stakeholders' perspectives on energy related Smart City technologies: POCITYF's standpoint. In IOP Conference Series: Earth and Environmental Science (Vol. 863, No. 1, p. 012012). IOP Publishing.

68. Leitheiser, S., & Follmann, A. (2020). The social innovation–(re) politicisation nexus: Unlocking the political in actually existing smart city campaigns? The case of SmartCity Cologne, Germany. Urban Studies, 57(4), 894-915. **https://doi.org/10.1177/0042098019869820**

69. Leonard, M., Pisani-Ferry, J., Shapiro, J., Tagliapietra, S., & Wolff, G. B. (2021). The geopolitics of the European green deal. Bruegel.

70. Lopes Azevedo, A., Stöffler, S., & Fernandez, T. (2020, September). Following the Smartness: Leipzig as a Follower City in a Horizon 2020 Smart Cities and Communities Lighthouse Project. In SHAPING URBAN CHANGE–Livable City Regions for the 21st Century. Proceedings of REAL CORP 2020, 25th International Conference on Urban Development, Regional Planning and Information Society (pp. 335-343). CORP–Competence Center of Urban and Regional Planning. ISSN 2521-3938

71. Losavio, M. M., Chow, K. P., Koltay, A., & James, J. (2018). The Internet of Things and the Smart City: Legal challenges with digital forensics, privacy, and security. Security and Privacy, 1(3), e23. https://doi.org/10.1002/spy2.23

72. Luterek, M. (2019, December). Smart Cities and Citizen Orientation: The Growing Importance of" Smart People" in Developing Modern Cities. In EMCIS (pp. 209-222). ISBN: 978-3-030-44322-1

73. Lyons, G., Mokhtarian, P., Dijst, M., & Böcker, L. (2018). The dynamics of urban metabolism in the face of digitalization and changing lifestyles: Understanding and influencing our cities. Resources, Conservation and Recycling, 132, 246–257. **https://doi.org/10.1016/j.resconrec.2017.07.032**

74. Madakam, S., & Ramachandran, R. (2015). Barcelona smart city: the Heaven on Earth (internet of things: technological God). ZTE Communications, 13(4), 3-9. http://www.cnki.net/kcms/detail/34.1294.TN.20151208.1455.002.html

75. Mancebo, F. (2020). Smart city strategies: time to involve people. Comparing Amsterdam, Barcelona and Paris. Journal of Urbanism: International Research on Placemaking and Urban Sustainability, 13(2), 133-152. **https://doi.org/10.1080/17549175.2019.1649711**

76. March, H., & Ribera-Fumaz, R. (2016). Smart contradictions: The politics of making Barcelona a Self-sufficient city. European urban and regional studies, 23(4), 816-830. **https://doi.org/10.1177/0969776414554488**

77. March, H., & Ribera-Fumaz, R. (2018). Barcelona: From corporate smart city to technological sovereignty. In Inside smart cities (pp. 227-242). Routledge.

78. Matskevits, D. (2020). Energy efficient Renovation Strategies: Estonia and European Sustainability Project. https://urn.fi/URN:NBN:fi:amk-2020120426194

79. Molinillo, S., Anaya-Sánchez, R., Morrison, A. M., & Coca-Stefaniak, J. A. (2019). Smart city communication via social media: Analysing residents' and visitors' engagement. Cities, 94, 247–255. **https://doi.org/10.1016/j.cities.2019.06.003**

80. Montanarella, L., & Panagos, P. (2021). The relevance of sustainable soil management within the European Green Deal. Land Use Policy, 100, 104950. https://doi.org/10.1016/j.landusepol.2020.104950

81. Mora, L., Deakin, M., Reid, A., & Angelidou, M. (2019). How to overcome the dichotomous nature of smart city research: Proposed methodology and results of a pilot study. Journal of Urban Technology, 26(2), 89-128. https://doi.org/10.1080/10630732.2018.1525265

82. Moustaka, V., Vakali, A., & Anthopoulos, L. G. (2019, January 1). A systematic review for smart city data analytics. ACM Computing Surveys, Vol. 51, pp. 1–41. **https://doi.org/10.1145/3239566**

83. Mutule, A., Domingues, M., Ulloa-Vásquez, F., Carrizo, D., García-Santander, L., Dumitrescu, A. M., ... & Melo, L. (2021). Implementing Smart City Technologies to Inspire Change in Consumer Energy Behaviour. Energies, 14(14), 4310. https://doi.org/10.3390/en14144310

84. Noori, N., Hoppe, T., & de Jong, M. (2020). Classifying pathways for smart city development: comparing design, governance and implementation in Amsterdam, Barcelona, Dubai, and Abu Dhabi. Sustainability, 12(10), 4030. https://doi.org/10.3390/su12104030

85. Odendaal, N. (2003). Information and communication technology and local governance: Understanding the difference between cities in developed and emerging economies. Computers, Environment and Urban Systems, 27(6), 585–607. **https://doi.org/10.1016/S0198-9715(03)00016-4**

86. Okhrimenko, Sovik, P. & L. (2019). Digital transformation of the socioeconomic system: prospects for digitalization in society. Revista ESPACIOS, Vol.40(38) Retrieved at: https://www.revistaespacios.com/a19v40n38/19403826.html

87. Paalosmaa, T. M. (2021). Feasibility of Innovative Smart Mobility Solutions for Vaasa–A Case Study of EU Horizon 2020 IRIS Project. https://urn.fi/URN:NBN:fi-fe202103016267

88. Paola, D. R., & Rosenthal-Sabroux, C. (2014). Smart City How to Create Public and Economic Value with High Technology in Urban Space. Smart City How to Create Public and Economic Value with High Technology in Urban Space, (June 2014), VIII, 238. **https://doi.org/10.1007/978-3-319- 06160-3**

89. Parviainen, P., Tihinen, M., Kääriäinen, J., & Teppola, S. (2017). Tackling the digitalization challenge: how to benefit from digitalization in practice. International Journal of Information Systems and Project Management, 5(1), 63–77. **https://doi.org/10.12821/ijispm050104**

90. Paskaleva, K., Evans, J., & Watson, K. (2021). Co-producing smart cities: A Quadruple Helix approach to assessment. European Urban and Regional Studies, https://doi.org/10.1177/09697764211016037

91. Pietzcker, R. C., Osorio, S., & Rodrigues, R. (2021). Tightening EU ETS targets in line with the European Green Deal: Impacts on the decarbonization of the EU power sector. Applied Energy, 293, 116914.

92. Pozdniakova, A. M. (2018). SMART CITY STRATEGIES "LONDON-STOCKHOLM-VIENNA-KYIV". Acta innovations, (27), 31-45

93. Razmjoo, A., Østergaard, P. A., Denai, M., Nezhad, M. M., & Mirjalili, S. (2021). Effective policies to overcome barriers in the development of smart cities. Energy Research & Social Science, 79, 102175. https://doi.org/10.1016/j.erss.2021.102175

94. Riva Sanseverino, E., Riva Sanseverino, R., & Anello, E. (2018). A cross-reading approach to smart city: A european perspective of chinese smart cities. Smart Cities, 1(1), 26-52. https://doi.org/10.3390/smartcities1010003

95. Rodríguez, C., Sanz-Montalvillo, C., Vallejo, E., & Quijano, A. (2019, December). City-Level Evaluation: Categories, Application Fields and Indicators for Advanced Planning Processes for Urban Transformation. In International conference on Smart and Sustainable Planning for Cities and Regions (pp. 17-35). Springer, Cham. DOI: 10.1007/978-3-030-57332-4_2

96. Ruhlandt, R. W. S. (2018). The governance of smart cities: A systematic literature review. Cities, 81, 1–23. **https://doi.org/https://doi.org/10.1080/10630732.2011.601117**
97. Ruhlandt, R. W. S. (2018). The governance of smart cities: A systematic literature review. Cities, 81, 1–23. **https://doi.org/https://doi.org/10.1080/10630732.2011.601117**
98. Sandström, J. (2020). Global Stockholm: Ambitions beyond the state.
99. Shen, L., Peng, Y., Zhang, X., & Wu, Y. (2012). An alternative model for evaluating sustainable urbanization. Cities, 29(1), 32–39. **https://doi.org/10.1016/j.cities.2011.06.008**
100. Siddi, M. (2020). The European Green Deal: Assessing its current state and future implementation.
101. Sikora, A. (2021, January). European Green Deal–legal and financial challenges of the climate change. In ERA Forum (Vol. 21, No. 4, pp. 681-697). Springer Berlin Heidelberg. https://doi.org/10.1007/s12027-020-00637-3
102. Škultéty, F., Beňová, D., & Gnap, J. (2021). City Logistics as an Imperative Smart City Mechanism: Scrutiny of Clustered EU27 Capitals. Sustainability, 13(7), 3641. https://doi.org/10.3390/su13073641
103. Smith, A., & Martín, P. P. (2021). Going beyond the smart city? Implementing technopolitical platforms for urban democracy in Madrid and Barcelona. Journal of Urban Technology, 28(1-2), 311-330. https://doi.org/10.1080/10630732.2020.1786337
104. Sola, A., Sanmarti, M., & Corchero, C. (2020). Concluding remarks from the implementation of smart low-energy districts in the GrowSmarter project. International Journal of Environmental Impacts, 3(2), 112-119. DOI: 10.2495/EI-V3-N2-112-119
105. Späth, P., & Knieling, J. (2020). How EU-funded Smart City experiments influence modes of planning for mobility: Observations from Hamburg. Urban Transformations, 2(1), 1-17. https://doi.org/10.1186/s42854-020-0006-2
106. Townsend, A. (2017). Smart Cities Book Summary. Futures Group Presentations. **https://doi.org/10.7256/2313-0539.2014.3.12545**
107. Tyni, E., & Wikberg, J. (2019). Classification of Wi-Fi Sensor Data for a Smarter City: Probabilistic Classification using Bayesian Statistics.
108. Uspenskaia, D., Specht, K., Kondziella, H., & Bruckner, T. (2021). Challenges and Barriers for Net-Zero/Positive Energy Buildings and Districts—Empirical Evidence from the Smart City Project SPARCS. Buildings, 11(2), 78. https://doi.org/10.3390/buildings11020078
109. Vandercruysse, L., Buts, C., & Dooms, M. (2020). A typology of smart city services: the case of data protection impact assessment. Cities, 104, 102731. https://doi.org/10.1016/j.cities.2020.102731
110. Varró, K., & Szalai, Á. (2021). Discourses and practices of the smart city in Central Eastern Europe: insights from Hungary's 'big'cities. Urban Research & Practice, 1-25. https://doi.org/10.1080/17535069.2021.1904276
111. Wang, H., He, Q., Liu, X., Zhuang, Y., & Hong, S. (2012, March 15). Global urbanization research from 1991 to 2009: A systematic research review. Landscape and Urban Planning, Vol. 104, pp. 299–309. **https://doi.org/10.1016/j.landurbplan.2011.11.006**
112. Washburn, D., Sindhu, U., Balaouras, S., Dines, R., Hayes, N., & Nelson, L. (2010). Helping CIOs understand "smart city" initiatives. In Forrester Research. Cambridge.
113. Wathne, M. W., & Haarstad, H. (2020). The smart city as mobile policy: Insights on contemporary urbanism. Geoforum, 108, 130-138. https://doi.org/10.1016/j.geoforum.2019.12.003

114. Wirsbinna, A. (2020). PEFnet 2020 – European Scientific Conference of Doctoral Students: Evaluation of Economic Benefits of Smart City Initiative. S .2211st, 2020th ed.; H. V. David Hampel, Ed.). Brno: Mendel University in Brno, Zemědělská 1, 613 00 Brno.

115. Wirsbinna, A. (2021). Evaluation of Economic Benefits of Smart City Initiatives. SCENTIA International Economic Review, 1(1), 32–42. **https://doi.org/10.52514/sier.v1i1.4**

116. Yigitcanlar, T., Kankanamge, N., & Vella, K. (2021). How are smart city concepts and technologies perceived and utilized? A systematic geo-Twitter analysis of smart cities in Australia. Journal of Urban Technology, 28(1-2), 135-154. **https://doi.org/10.1080/10630732.2020.1753483**

117. Zheng, C., Yuan, J., Zhu, L., Zhang, Y., & Shao, Q. (2020). From digital to sustainable: A scientometric review of smart city literature between 1990 and 2019. Journal of Cleaner Production, 258. **https://doi.org/10.1016/j.jclepro.2020.120689**