

Helena Šlogar
Tomislav
Čakanić

**INOVACIJE U KONTEKSTU
ODRŽIVOG GRADA
KOPENAHGENA**

**INNOVATIONS IN THE
CONTEXT OF A
SUSTAINABLE CITY
COPENAHGEN**

SAŽETAK: Koncept održivih gradova temelji se na razvojnoj paradigmi koja prepoznaje brzi rast gradskog stanovništva i daje važan doprinos formiranju urbanističkog plana. Održivi urbani razvoj je preduvjet za stvaranje održivog grada. Održivi i pametan grad prožet je inovativnim rješenjima. U ovome radu definirat će se što je održivi grad, prikazat će se kako su određena inovativna rješenja uvedena u Kopenhagenu kako bi se postigla održivost grada. U tom smislu daje se pregled inovacija u kontekstu zaštite okoliša.

KLJUČNE RIJEČI: Kopenhagen, održivi razvoj, održivi grad, inovacije, zaštita okoliša

ABSTRACT: The concept of sustainable cities is based on a development paradigm that recognizes the rapid growth of the urban population and makes an important contribution to the formation of the urban plan. Sustainable urban development is a prerequisite for creating a sustainable city. A sustainable and smart city involves innovative solutions. This paper will define what a sustainable city is and it will show how certain innovative solutions were introduced in Copenhagen in order to achieve city sustainability. To that extent, an overview of innovations in the context of environmental protection is given.

KEY WORDS: Copenhagen, sustainable development, sustainable city, innovation, environment protection

UVOD

U radu će se obraditi razvoj održivog grada Kopenhagena u razdoblju od 2014. do 2019. godine. Cilj rada je kroz razvoj grada Kopenhagena analizirati politike zaštite okoliša, održivu zelenu mobilnost i politiku upravljanja vodama. Analizirat će se kružna ekonomija u kontekstu lučkog grada, problem otpada i pametno upravljanje otpadom i energijom te utjecaj zelene i urbane revitalizacije na stanovništvo Kopenhagena. Definirana su sljedeća istraživačka pitanja: 1. Utječu li inovacije na ostvarivanje ciljeva održivog razvoja? 2. Pridonose li zelene tehnološke inovacije postizanju održivosti u pametnim gradovima? 3. Može li primjena urbanih inovativnih rješenja u Kopenhagenu pridonijeti održivosti grada? Rezultati provedenog istraživanja mogu poslužiti kao primjer dobre prakse kako je Kopenhagen primijenio inovacije s ciljem ostvarenja održivog razvoja u samome gradu.

OSNOVNA OBILJEŽJA KOPENHAGENA

Kopenhagen treba promatrati u kontekstu skandinavske države blagostanja u kojem je uloga države izuzetno snažna. To je grad koji se percipira kao održiv, inovativan, kozmopolitski, s autentičnim životnim stilom i zelenim urbanim prostorima. Grad u Skandinaviji ima važnu ulogu pokretača ekonomskog rasta koji koristi poduzetničke, inovativne i kreativne gradske strategije za ekonomski razvoj. Kopenhagen je glavni grad Danske, a izabran je za dobitnika Europske zelene prijestolnice 2014. godine. Primjenom inovacija u održivom i pametnom gradu postiže se gospodarski razvoj i osigurava bolja kvaliteta života njegovih stanovnika (Šlogar, Bandov, Čakanić, 2020). U gradu Kopenhagenu i okolnim općinama živi 1,3 milijuna ljudi (Statistics Denmark, 2020). Kopenhagen je smješten na južnom ulazu u zaljev Øresund između Kattégata i Baltičkog mora. Prema Brüel (2012), dvije trećine grada nalazi se na razgranatim obalama, što otežava prometnu povezanost. Metropolitansko

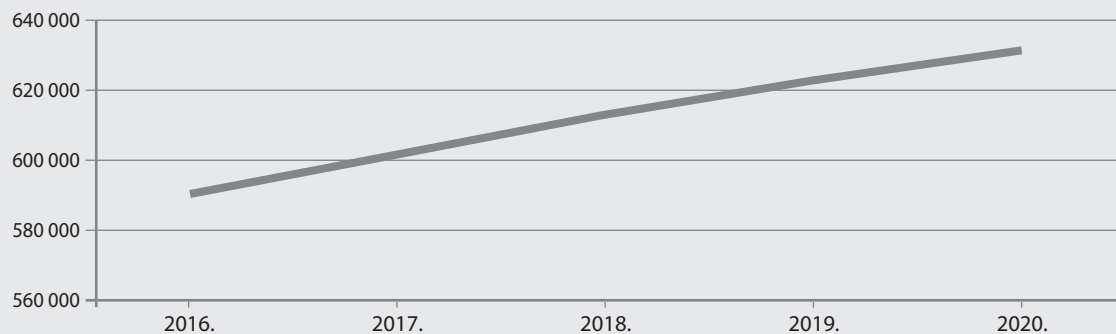
INTRODUCTION

This paper analyses the development of sustainable city Copenhagen in the period between 2014 and 2019. The objective of this paper is to analyse environment protection policies, sustainable green mobility and water management policy. We will analyse circular economy in the context of a harbour city, waste issues and smart waste and energy management, and the effect of green and urban revitalization on the population of Copenhagen. The following research questions have been defined: 1. Can innovation help to meet a goal of sustainable development? 2. Do green technological innovations contribute to sustainability in smart cities? 3. Can applying urban innovative solutions in Copenhagen contribute to city sustainability? The results of the research conducted may be a good practice example of how Copenhagen applies innovation in order to achieve sustainable development in the city itself.

BASIC FEATURES OF COPENHAGEN

Copenhagen must be observed in the context of a Scandinavian welfare state, in which the role of the state is extremely strong. It is a city that is perceived as sustainable, innovative, cosmopolitan with an authentic lifestyle and urban green areas. A city in Scandinavia has the important role of an economic growth propeller, that uses entrepreneurial, innovative and creative city strategies for economic development. Copenhagen is the capital of Denmark, and it won the European Green Capital Award for 2014. The use of innovation in the sustainable and smart city leads to economic development and provides a better quality of life for its citizens (Šlogar, Bandov, Čakanić, 2020). The population of the city of Copenhagen and its surrounding municipalities is 1.3 million (Statistics Denmark, 2020). Copenhagen is located in the southern part of Øresund strait between Kattégat and the Baltic Sea. According to Brüel (2012), two thirds of the

GRAFIKON 1. KRETANJE BROJA STANOVNIKA KOPENAHGENA OD 2016. DO 2020. GODINE
GRAPH 1. THE RISE OF THE POPULATION OF COPENHAGEN FROM 2016 TO 2020



Izvor: obrada autora prema Statistik Denmark, dostupno na: <https://www.statbank.dk/FT> (23. 5. 2020.)

Source: data analysed by the authors, according to Statistik Denmark, available at: <https://www.statbank.dk/FT> (website accessed on 23 May 2020)

područje odnosi se na ukupno (44%) danskog stanovništva, a samo regija glavnoga grada, što je entitet stvoren 2007. godine s 1,6 milijuna stanovnika, osigurala je 75% novih radnih mjesta u Danskoj (Copenhagen, 2014). U Kopenhagenu se nalaze najbolja sveučilišta u zemlji, a u gradu je također koncentrirano 80% danskih visokotehnoških tvrtki (Copenhagen, 2014). Na regionalnoj razini, otvaranje mosta Øresund, koji povezuje grad Kopenhagen i Malmö u Švedskoj, donijelo je nove mogućnosti za trgovinu i komunikaciju te se metropolitansko područje pozicioniralo kao regionalno čvorište u Baltičkom moru. Medicon Valley Alliance, Øresund IT Academy, Øresund Food Network i Øresund Environment su samo neke od organizacija koje igraju važnu ulogu u promicanju inovativnosti, umrežavanja i integracije u cijeloj regiji (<https://www.copenhagen.com/oresund>).

U Grafikonu 1 prikazuje se kretanje broja stanovnika Kopenhagena od 2016. do 2020. godine, pri čemu je vidljivo da je broj stanovnika konstantno rastao. Godine 2016. u Kopenhagenu je živjelo 591.481, a 2020. godine 632.340 stanovnika. Razlog tome jest

city are located on coasts, which interferes with transportation connections. The metropolitan area refers to the total of 44% of Danish population, while the capital area itself, an entity created in 2007, comprising 1.6 million citizens, provided 75% of new workplaces in Denmark (Copenhagen, 2014). The best universities this country has are located in Copenhagen, and 80% of high-tech Danish companies are concentrated in the city (Copenhagen, 2014). On the regional level, the opening of the Øresund Bridge, which connects the cities of Copenhagen and Malmö in Sweden, has opened new opportunities for trade and communication, and has established the metropolitan area as a regional hub in the Baltic Sea. Medicon Valley Alliance, Øresund IT Academy, Øresund Food Network and Øresund Environment are only some of the business organizations that play a vital role in promoting innovation, networking and integration in the entire area (<https://www.copenhagen.com/oresund>).

Graph 1 shows the changes of number of people living in Copenhagen between 2016 and 2020. It is evident that the number of inhabitants was

ulaganje u razvoj određenih područja grada gdje se stvaraju urbane lokacije koje postaju mjesta poželjna za život.

POLITIKA ZAŠTITE OKOLIŠA KOPENAHGENA

Gradsko vijeće Kopenhagena je 2009. godine usvojilo klimatski plan za Kopenhagen, koji utvrđuje politiku postizanja 20% smanjenja emisija CO₂ do 2015. godine i viziju postati CO₂ neutralan do 2025. godine (CPH 2025 Climate Plan, 2012). “Danska je vrlo energetski ovisna o drugim zemljama i smatrano je racionalnim ulagati u obnovljive izvore energije, posebice ako se uzme u obzir rastuća cijena fosilnih goriva” (van Doren i sur., 2020: 4). Većina (74%) smanjenja CO₂ postići će se na području proizvodnje energije i prelaskom iz ugljena na biomasu u termoelekttranama. Preostala smanjenja trebaju se postići inicijativama u prometu (11%), potrošnji energije (7%), gradskoj upravi (2%) i drugim područjima (6%) (van Doren i sur., 2020: 6).

Smanjivanje potrošnje energije zgrada izazov je za dekarbonizaciju Kopenhagena. Kako se zahtjevi za potrošnjom energije za nove zgrade redovito pooštavaju u skladu s Europskom direktivom o energetske učinkovitosti zgrada (Europski parlament, 2018), najveći izazov odnosi se na smanjenje otiska postojećih zgrada. Van Doren i sur. (2020) navode da postoji veliki potencijal da se postojeće zgrade dograde i postanu energetski učinkovitije, jer je 70% zgrada izgrađeno prije prvih građevinskih propisa. Smanjenje potrošnje energije postojećeg građevinskog fonda donosi određene ekonomske i socijalne koristi. Prema podacima danskog statističkog ureda, vidljivo je smanjenje broja objekata koji se griju pomoću električnih grijalica te centralnog grijanja na boiler sa 4.246 objekata na 3.995 (<https://www.statbank.dk/BYGB40>). U promatranom razdoblju od 2016. do 2020. godine, u Kopenhagenu se istovremeno broj objekata koji koriste ekološki najprihvatljiviji način grijanja – daljinsko grijanje – sustavno

growing continuously. In 2016 the population of Copenhagen was 591,481, whereas in 2020 it was 632,340. The reason for that are the investments in the development of particular areas, where urban locations appear, which then become places favourable to live.

ENVIRONMENT PROTECTION POLICY OF COPENHAGEN

In 2009 the City Council of Copenhagen adopted a climate plan for Copenhagen, according to which the CO₂ emission must be reduced by 20% until 2015, along with a vision to become CO₂ neutral by 2025 (CPH 2025 Climate Plan, 2012). “Denmark is energy-dependent on other countries and investing in renewable energy sources is considered to be rational, in particular if the increasing price of fossil fuels is taken into consideration” (van Doren et al., 2020: 4). The most (74%) of CO₂ reduction can be accomplished in energy production and transfer from coal to biomass in thermal power stations. Other reductions should be reached through traffic initiatives (11%), energy consumption (7%), city government (2%) and other areas (6%) (van Doren et al., 2020: 6).

Reducing energy consumption in buildings is a challenge for the decarbonization of Copenhagen. Since energy consumption requirements are continuously exacerbating in compliance with the Energy Performance of Buildings Directive (the European Parliament, 2018), the biggest challenge refers to the carbon footprint reduction of the existing buildings. Van Doren et al. (2020) talk about a large potential of the existing buildings which should be upgraded and made more energy-efficient, because 70% of buildings were built before the first construction regulations were introduced. The reduction of energy consumption of the existing stock of buildings has certain economic and social benefits. According to the data of the Danish Bureau of Statistics, the number of facilities which use electrical heating and boiler central heating was

povećava. Predmetni podaci ukazuju na realizaciju gradskog cilja smanjenja emisija CO₂. Da bi se gradski cilj CO₂ neutralnosti ostvario, Kopenhagen poduzima mjere za smanjenje potrošnje energije, poboljšanje energetske učinkovitosti novih zgrada i poticanje korištenja obnovljivih izvora energije. Velik napredak postignut je u smanjenju emisije CO₂ za 21% od 2005. do 2011. godine (<https://blueandgreentomorrow.com/features/sustainability-in-the-city-copenhagen-denmark/>).

Izvješće Organizacije za ekonomsku suradnju i razvoj (OECD) iz 2009. godine također ističe kako je epidemiološko istraživanje pokazalo da je zagađenje čestica u Kopenhagenu odgovorno za dodatnih 780 preuranjenih smrti građana. Izvješće OECD-a (2009) pokazuje i kako su čestice odgovorne za 860-2.260 dodatnih hospitalizacija zbog kardiovaskularnih bolesti i problema s disanjem na milijun stanovnika prema podacima koje su prikupili od danskog Nacionalnog instituta za istraživanje okoliša i Instituta za zdravlje ljudi. Drugi ključni problemi u ekološkoj politici grada uključuju povećanje onečišćenja tla i ugroženu kvalitetu vode. Kao odgovor na ekološke izazove grada, Kopenhagen je 2007. godine uspostavio ekološke ciljeve koje treba provesti. Ti ciljevi su prvotno uspostavljeni u "Eko-metropola: naša vizija za Kopenhagen 2015" (Copenhagen, 2007). Grad je prepoznao ekonomski potencijal industrije obnovljivih izvora energije u stvaranju radnih mjesta, posebno u pogledu vjetroagregata, gdje Danska kontrolira 35% svjetskog tržišta (OECD, 2009). Unatoč značajnim postignućima Kopenhagena, stanje u okruženju može biti ugroženo zbog porasta prometa. Iako je gustoća prometa u Kopenhagenu mala u usporedbi s drugim gradovima, njegova veličina te visoka stopa onečišćenja česticama kompromitira zdravlje stanovnika Kopenhagena i imidž metropole kao ekološkog grada. Onečišćenje česticama iz dizelskih automobila, peći na kruta goriva i druge materijale rezultirali su višim emisijama CO₂ nego u gradovima poput Pariza, Londona ili Berlina.

reduced from 4,246 to 3,995 (<https://www.statbank.dk/BYGB40>). The number of facilities which use remote heating, the most ecological solution, was on the increase steadily, in the observed period between 2016 and 2020. The data in question indicate that the city's objective of CO₂ reduction is being met. In order to accomplish the goal the city has set on CO₂ neutrality, Copenhagen has been taking actions to reduce energy consumption, improve energy-efficiency of new buildings and promote renewable sources of energy. A huge progress was achieved because CO₂ emission was reduced by 21% in the period between 2005 and 2011 (<https://blueandgreentomorrow.com/features/sustainability-in-the-city-copenhagen-denmark/>).

The report of the Organisation for Economic Co-operation and Development (OECD) from 2009 also highlights that an epidemiological study proved that particle pollution in Copenhagen accounts for extra 780 premature death cases. The same report (2009) shows that particles are responsible for 860-2,260 additional hospital admittances on a million inhabitants, due to cardiovascular diseases and respiratory problems, according to the data collected by the National Environmental Research Institute of Denmark and the Danish National Institute of Public Health. Other key problems of the city's environmental policy involve increased soil contamination and jeopardized water quality. As a response to environmental challenges, in 2007 Copenhagen defined environmental objectives, which need to be reached. These objectives were originally defined in "Eco-Metropolis: Our Vision for Copenhagen 2015" (Copenhagen, 2007). The city recognized the financial potential of renewable source industry in the creation of workplaces, in particular in wind farms, since Denmark controls 35% of the world market (OECD, 2009). Despite the substantial achievements Copenhagen has accomplished, the environmental conditions may be at risk, due to increased traffic. Even though traffic density is lower than in other cities, its size and high particle pollution rate are compromising the health of its inhabitants and the image Copenhagen

ODRŽIVA ZELENA MOBILNOST U KOPENHAGENU

Mobilnost održivog javnog prijevoza ovisi o dostupnosti i sigurnosti pješačke i biciklističke infrastrukture te se značaj implementacija inovacija u gradskom prometu ubrzano razvija. U Kopenhagenu su urbanisti prihvatili biciklističku kulturu i predložili rješenja koja su prilagođena gradskim biciklistima. Grad Kopenhagen smatra se jednim od najpoznatijih gradova u svijetu po uređenim biciklističkim stazama, pri čemu gotovo dvije trećine njegovih stanovnika koristi bicikl za svakodnevno putovanje, a plan grada je da se od 2015. do 2025. godine čak 75% svih putovanja obavlja pješice, biciklom ili javnim prijevozom (Copenhagen, 2014). Predmetni oblici prijevoza predstavljaju važan segment cilja Kopenhagena da bude ugljično neutralan do 2025. godine. Razgranata pješačka mreža Kopenhagena obuhvaća više od 33.000 m² ulica i 66.000 m² trgova (Copenhagen, 2014). Rješenje iz Kopenhagena inspiriralo je brojne urbaniste diljem svijeta da primijene inovativnu ideju Kopenhagena u svojim gradovima, čineći ih na taj način ugodnijima za bicikliste. Korištenjem bicikala smanjuju se emisije ugljičnog dioksida i zagađenje zraka u gradu, a u odnosu na korištenje automobila, bicikli štede vrijeme i novac. Poboļjšani dizajn raskrižja i niz javnih kampanja osigurali su sigurnu infrastrukturu biciklističkih staza. S takvim inicijativama, Kopenhagen želi postići porast udjela stanovnika koji se osjećaju sigurnim tijekom vožnje bicikla sa 67% u 2010. na 80% u 2015. i dalje na 90% u 2025. godini (Copenhagen, 2014).

Bez usklađenog djelovanja nacionalnih i lokalnih vlasti, Kopenhagen bi se mogao suočiti s prometnim zagušenjima i problemima zagađenja. Rješenje je ulaganje u integrirani prometni sustav koji objedinjuje sva vozila javnog prijevoza. Razvijen je novi inteligentni sustav za dijeljenje bicikala koji je implementiran u jesen 2013. godine (Copenhagen, 2014). Sustav radi po principu da

is building as an environmentally-conscious city. Particle pollutions deriving from diesel-driven cars, solid fuel stoves and stoves using other materials resulted in higher CO₂ emissions than the ones in cities like Paris, London or Berlin.

SUSTAINABLE GREEN MOBILITY IN COPENHAGEN

The mobility of sustainable public transport depends on the availability and safety of pedestrian and cycling infrastructure. The importance of implementing innovation into city transport is developing rapidly. The urban planners of Copenhagen have embraced the cycling culture and proposed solutions adapted to city cyclists. The city of Copenhagen is considered to be one of the most famous cities in the world in terms of cycle lanes, and nearly two thirds of all inhabitants use bicycles on daily basis. The urban planning predicts that between 2015 and 2025 75% of all commutes should be done on foot, by bike or public transport (Copenhagen, 2014). These means of transport represent an important segment of Copenhagen's objectives of carbon neutrality by 2025. The pedestrian network of Copenhagen incorporates more than 33,000 square meters of streets and 66,000 square meters of squares (Copenhagen, 2014). The Copenhagen solutions have inspired urban planners all over the world to implement the Copenhagen idea in their cities and make them more pleasant and agreeable for cyclists. The use of bicycles reduces carbon dioxide emission and air pollution in the city, and saves time and money, if compared to cars. Improved junction design and a group of public companies have provided a safe cycle lane infrastructure. By introducing such initiatives, Copenhagen is trying to raise the number of people who will feel safe riding a bike from 67% in 2010 to 80% in 2015, and even to 90% in 2025 (Copenhagen, 2014).

Copenhagen would face traffic congestion and pollution problems if national and local authorities

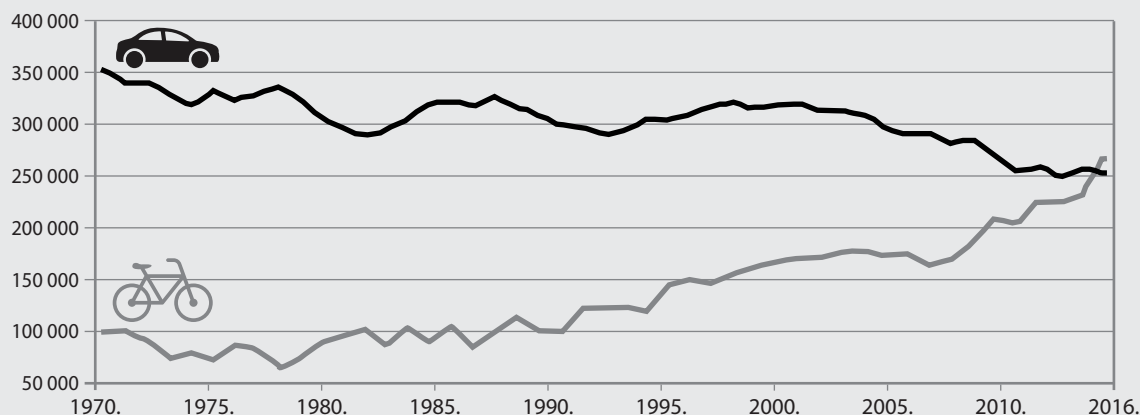
osoba koja putuje vlakom može rezervirati bicikl na stanici dolaska i koristiti bicikl do kraja radnog vremena ili kako bi doputovala na bilo koje drugo odredište u gradu. Inteligentno rješenje rezultiralo je povećanim brojem putovanja javnim prijevozom i smanjenjem korištenja osobnih automobila, što je dovelo do smanjenja prometnog zagušenja. Time se Kopenhagen promovira kao ekološki grad za brzo i pouzdano putovanje s mjesta polazišta do mjesta odredišta.

Grafikon 2 prikazuje odnos broja automobila i bicikala u centru Kopenhagena od 1970. do 2016. godine. *City of Cyclists* (2017) navodi kako je 1970. godine centrom grada prolazilo 351.133 automobila u odnosu na 100.071 bicikala. Nakon donošenja Biciklističke strategije 2011. godine (engl. *Bicycle Strategy 2011-2025*) vidljiva je velika promjena u porastu broja bicikala i smanjenju broja automobila na ulicama centra grada. Godine 2016. je broj bicikala, čiji je ukupni broj bio

did not work in coordination. The solution are the investments into the integrated transport system, which consolidates all means of public transport. A smart new bike-sharing system was implemented in the autumn of 2013 (Copenhagen, 2014). The system works in such a way that a person travelling by train can book a bike at the arrival stop and use that bike till the end of the working hours or to reach any other destination in the city. This smart solution has resulted in the increased public transport use and reduced use of cars, which led to a lower rate of traffic congestions. This helps to promote Copenhagen as an environmentally-friendly city in which commute is fast and reliable.

Graph 2 shows the ratio of the number of cars and bikes in the centre of Copenhagen between 1970 and 2016. *City of Cyclists* (2017) states that in 1970 there were 351,133 cars in the city centre, compared to 100,071 bikes. After the Bicycle Strategy was introduced in 2011, there has been an

GRAFIKON 2. PROMET AUTOMOBILA I BIKIKALA U CENTRU KOPENHAGENA OD 1970. DO 2016. GODINE
GRAPH 2. NUMBERS OF CARS AND BIKES IN THE CENTRE OF COPENHAGEN BETWEEN 1970 AND 2016



Izvor: Copenhagen City of Cyclists (2017), dostupno na: [https:// http://www.cycling-embassy.dk/wp-content/uploads/2017/07/Velo-city_handout.pdf](https://http://www.cycling-embassy.dk/wp-content/uploads/2017/07/Velo-city_handout.pdf) (28. 4. 2020.)

Source: Copenhagen City of Cyclists (2017), available at: [https:// http://www.cycling-embassy.dk/wp-content/uploads/2017/07/Velo-city_handout.pdf](https://http://www.cycling-embassy.dk/wp-content/uploads/2017/07/Velo-city_handout.pdf) (28th April 2020)

265.700, prvi put veći od broja automobila, koji je iznosio 252.600. Ulaganje u infrastrukturu, donošenje strategija i podizanje svijesti građana raznim kampanjama pridonijeli su tome da se promet biciklima u razdoblju od 1995. godine do 2016. godine povećao za 68%.

Prema podacima danskog statističkog ureda, Tablica 1 pokazuje kako je broj novoregistriranih električnih vozila ovisio o politikama koje se donose na lokalnoj i nacionalnoj razini. Za potrebe kućanstava 2015. godine bilo je registrirano 85.399 vozila na benzinski pogon, 16.095 na dizelski pogon, 2.335 na električni pogon i samo 188 vozila na hibridni pogon. U razdoblju od 2016. do 2018. godine broj vozila na benzinski pogon je u kontinuiranom padu, pri čemu je 2018. registrirano 79.238 vozila. Broj novoregistriranih vozila na dizelski pogon u istom razdoblju raste (87,7%), pri čemu 2018. broj vozila iznosi 30.214. Godine 2016. broj novoregistriranih vozila na električni pogon u kućanstvima iznosio je samo 152, što je 15 puta manje u odnosu na 2015.

apparent change in the increase of the number of bikes and the decrease of the number of cars in the city centre. In 2016 the number of bikes exceeded the number of cars, for the first time. It was 265,700, whereas the number of cars was 252,600. Investing in the infrastructure, implementation of strategies and raising awareness of people through various campaigns resulted in the increase of bike transport by 68% in the period between 1995 and 2016.

According to the data of the Danish Bureau of Statistics, Table 1 shows that the number of newly registered electric-driven vehicles depended on the policies introduced on local and state level. In 2015 there were 85,399 petrol-driven vehicles registered for household needs, 16,095 diesel-driven ones, 2,335 electric-driven vehicles and only 188 hybrids. Between 2016 and 2018 the number of petrol-driven cars was continuously declining. In 2018 79,238 vehicles were registered. The number of diesel-driven cars which were newly registered in the same period was on the increase (87,7%), hence the number of cars was 30,214

TABLICA 1. BROJ NOVOREGISTRIRANIH VOZILA U DANSKOJ S OBZIROM NA KUĆANSTVA I INDUSTRIJU OD 2015. DO 2019. GODINE
TABLE 1. THE NUMBER OF NEWLY REGISTERED VEHICLES IN DENMARK WITH REGARD TO HOUSEHOLD AND INDUSTRY IN THE PERIOD BETWEEN 2015 AND 2019

	POGON / DRIVE	2015.	2016.	2017.	2018.	2019.
Kućanstvo Household	Benzinski / Petrol	85.399	81.760	76.763	79.238	76.936
	Dizelski / Diesel	16.095	20.175	25.403	30.214	20.988
	Električni / Electric	2.335	152	114	781	3.410
	Hibridni / Hybrid	188	191	330	2.121	2.133
Industrija Industry	Benzinski / Petrol	52.299	58.611	65.844	62.082	78.932
	Dizelski / Diesel	48.108	60.036	52.089	42.264	39.381
	Električni / Electric	1.966	1.113	577	763	2.093
	Hibridni / Hybrid	218	376	290	1.004	1.635

Izvor: obrada autora prema Statistik Denmark, dostupno na: <https://www.statbank.dk/BIL51> (22. 5. 2020.)

Source: data analysed by the authors, according to Statistik Denmark, available at: <https://www.statbank.dk/BIL51> (website accessed on the 22nd May 2020)

godinu. Godine 2018. godine dolazi do ponovnog porasta broja registriranih električnih vozila, što se nastavlja i u 2019. promjenom porezne politike. Za potrebe industrije najviše je novoregistriranih vozila na benzinski pogon, čiji broj kontinuirano raste, s 52.299 vozila 2015. godine na 78.932 u 2019. godini. U istom razdoblju dolazi do smanjenja novoregistriranih vozila na dizelski pogon te do stagnacije novih registracija vozila na električni pogon.

UPRAVLJANJE VODAMA U KONTEKSTU ODRŽIVOG GRADA

Politika gospodarenja vodama jedan je od važnih elemenata koji pridonose održivosti grada. Povijesno gledano, Kopenhagen je bio opskrbljen pitkom vodom iz bunara podzemnih voda koji se nalaze u područjima koja okružuju grad. Potrebe za opskrbom vodom uzrokovale su značajna smanjenja potencijala podzemnih voda u većem dijelu Sjællanda, otoka na kojem se nalazi Kopenhagen. To je rezultiralo smanjenjem kvalitete vode, kao i iscrpljivanjem poželjnih resursa površinskih voda (Binning i sur., 2006). U Danskoj, crpljenje podzemnih voda je jedini ili gotovo isključivi izvor zalih pitke vode, a u slučaju Kopenhagena, polja za crpljenje nalaze se na udaljenosti do 55 kilometara od grada (Copenhagen, 2014). Grad Kopenhagen ima dva glavna strateška dokumenta koja se odnose na buduće upravljanje oborinskim vodama: Plan prilagodbe klimatskim promjenama iz 2011. (eng. Copenhagen Climate Adaptation Plan 2011) i Plan upravljanja iz 2012. godine (eng. Copenhagen Cloudburst management Plan 2012). "Plan za klimatsku prilagodbu uključuje odjeljke o podizanju razine mora i gradske otoke. Oba plana se, međutim, u velikoj mjeri usredotočuju na rizike povećanog obujma i intenziteta oborina u Kopenhagenu na temelju prihvaćenih projekcija klimatskih promjena" (Floater i sur., 2014: 99).

Rygaard i sur. (2014) napravili su studiju poslovnog slučaja za dokazivanje holističke procjene koncepata

in 2018. In 2016 the number of newly registered electric cars in households was only 152, which is 15 times fewer than in 2015. In 2018 there was again a growth of registered electric cars, which is a trend that continued in 2019, as a result of tax policy change. For industrial needs, most newly registered cars were petrol-driven and their number has been growing steadily, from 52,299 in 2015 to 78,932 in 2019. In the same period the decrease of diesel-driven new cars was recorded. As for newly registered electric cars, there was a stagnation.

WATER MANAGEMENT IN THE SUSTAINABLE CITY CONTEXT

Water management policy is one of the vital elements which contribute to city sustainability. Historically, Copenhagen has always been supplied with potable water from underground wells situated in the surrounding area. Demand of water supply caused considerable reduction of underground water potential in the major part of Sjælland, the island on which Copenhagen is situated. This led to reduced quality of water, as well as exhaustion of favourable resources of surface waters (Binning et al., 2006). In Denmark, underground water extraction is the only or exclusive source of potable water supply. In the case of Copenhagen, extraction fields are 55 km away from the city (Copenhagen, 2014). The city of Copenhagen has two major strategic documents which relate to future rainwater management: Copenhagen Climate Adaptation Plan and 2012 Copenhagen Cloudburst Management Plan. "The Climate Adaptation Plan comprises sections about rising of sea level and city islands. Both plans, however, largely focus on increased rain volume and intensity in Copenhagen, based on the accepted climate change projection" (Floater et al., 2014: 99).

Rygaard et al. (2014) made a business case study to prove the holistic assessment of the urban water concept in Nordhavn (Copenhagen), former industrial-harbour area, which has evolved

urbanih voda u Nordhavnu (u Kopenhagenu), nekadašnjem industrijsko-lučkom području, koje se razvilo u novi integrirani urbani dio grada. Navode kako se Danska ne smatra zemljom koja oskudijeva pitkom vodom, ali se glavni grad suočava s izazovima po pitanju vodnih resursa zbog onečišćenja podzemnih voda. Rygaard i sur. (2014) zaključili su kako bi trebalo proširiti postojeći vodovod u gradu Kopenhagenu. Ukazali su na problem složenosti donošenja odluka kod izgradnje modernih vodovodnih sustava. Njihova procjena dovela je do nepobitnih rezultata o održivosti provedbe sekundarne opskrbe vodom u Nordhavnu.

KRUŽNA EKONOMIJA U KONTEKSTU LUČKOG GRADA

Lučki gradovi svojevrsna su dodirna točka između gradova i mora, a nalaze se na osjetljivim mjestima upravo zbog klimatskih promjena. Glavni problem s kojim se luke susreću odnosi se na onečišćenje brodskim otpadom i utjecaj klimatskih promjena. U ovom dijelu navest će se negativni vanjski utjecaji koji predstavljaju prijetnju održivosti luke Kopenhagen-Malmö te inovacije u upravljanju lukom u kontekstu kružne ekonomije. Klimatske promjene zbog kojih dolazi do povećanja razine mora na obalama ili poplava glavni su izazovi s kojima se suočavaju lučki gradovi (Karimpour i sur., 2019). Svjetska trgovinska organizacija navodi kako se više od 90% svjetske trgovine odvija kroz luke (Karimpour i sur., 2019) i upravo su one glavni pokretači gospodarstva zbog logističkih i industrijskih aktivnosti.

Održivi lučki grad predstavlja mjesto na kojem su uravnotežene društvene, ekonomske i okolišne vrijednosti. Lučki gradovi pridonose zatvaranju protoka materijalnih i energetske resursa kroz cirkularne procese i sinergiju između dionika. Na razini Europske unije, kroz strategiju su postavljena načela kružnog gospodarstva koja mogu biti pokretač za lučke gradove prema

into a newly integrated urban neighbourhood. Denmark is not considered a country of potable water shortage, yet the capital is facing some water resource challenges, due to underground water contamination. Rygaard et al. (2014) conclude that the current waterworks of Copenhagen should be upgraded and extended. They pointed at the problem of decision-making complexity when it comes to modern water system construction. Their evaluation has yielded irrefutable results in sustainability of secondary water supply in Nordhavn.

CIRCULAR ECONOMY IN THE CONTEXT OF A PORT

Port cities are somewhat a common ground between cities and the sea. They are usually located in sensitive places, precisely because of the climate change. The major problems that ports face are ship-generated waste contamination and the influence of climate changes. In this section we will discuss negative external effects which jeopardize the sustainability of Copenhagen-Malmö port and innovation in port management in the context of circular economy. Climate change caused by rising sea level and floods are the main obstacles port cities need to face (Karimpour et al., 2019). World Trade Organization claims that more than 90% of world trade is conducted through ports (Karimpour et al., 2019). They are major economy generators, due to their logistic and industrial activities.

A sustainable port city represents a place of balanced social, economic and environmental value. Ports play an important role in ending the flow of material and energy resources through circular processes and synergy among stakeholders. On the EU level, circular economy principles have been implemented through a strategy, and they may be the driving force of port cities toward sustainable development. Circular economy is a strong support of economic growth and its employment promotor. The European

održivom razvoju. Kružno gospodarstvo snažno podupire gospodarski rast i potiče zapošljavanje. Europska komisija navodi kako se 75% robe izvan Europske unije i 37% teretnog prometa unutar Europske unije otprema putem europskih luka (Europska komisija, 2016) Rotterdam, Amsterdam, Hamburg i druge, stoga su lučki gradovi predstavili svoje strategije u poduzimanju koraka prema kružnom gospodarstvu.

Luka Kopenhagen-Malmö nalazi se u regiji Øresund između Danske i Švedske te predstavlja područje gdje se događa određena integracija tih dvaju lokalnih područja. Jedinstveni geografski položaj luke Kopenhagen-Malmö pruža ekonomske potencijale za ulaganja, istovremeno sve više brinući o lokalnom području i zaštiti okoliša (Karimpour i sur., 2019). U pomorskoj luci Kopenhagen-Malmö predstavljena je inovacija u upravljanju u smislu kružnog modela kao odgovor na onečišćenja u lukama. Predloženi model sastoji se od četiri ključna elementa, koje čine upravljanje brodskim otpadom, upravljanje lučkim otpadom, bioplinska elektrana u vlasništvu luke i postrojenje na obali (Karimpour i sur., 2019). Od 2019. godine kruzerima i putničkim trajektima zabranjeno je ispuštati neobrađene otpatke u Baltičko more (Karimpour i sur., 2019). Drugi element odnosi se na gospodarenje lučkim otpadom u luci Kopenhagen-Malmö, pri čemu se navodi kako luka ima dobru reputaciju u pružanju usluga prikupljanja i zbrinjavanja organskog i drugog otpada. Treći element modela je bioplinska elektrana, odnosno postrojenje koje je poznato kao čisti i obnovljivi izvor energije (Karimpour i sur., 2019). Danska je vodeća zemlja u bioplinskoj industriji, u kojoj su 2014. godine radile 154 bioplinske elektrane, s godišnjom proizvodnjom od 1,2 TWh, a predviđa se da će je danska energetska agencija povećati na 4,7 TWh u 2020. godini (Karimpour i sur., 2019). Četvrti element odnosi se na obalno postrojenje za napajanje brodova. Definiran je kao proces opskrbe plovih brodova električnom energijom dok su njihovi pomoćni motori isključeni. Obalnim se postrojenjem smanjuju troškovi rada i održavanja pomoćnih

Commission claims that 75% of non-EU goods and 37% of cargo transport within the EU is shipped through European ports (the European Commission, 2016): Rotterdam, Amsterdam, Hamburg etc. Therefore, port cities have introduced their strategies for circular economy.

The Copenhagen-Malmö port is situated in the Øresund region between Denmark and Sweden. It represents the area of jurisdiction of two local regions. A unique geographical position of the Copenhagen-Malmö port provides economic investment potential, and, at the same time, it shows the increasing concern for the local area and environment protection (Karimpour et al., 2019). An innovation of circular model management was introduced in the Copenhagen-Malmö port, as a response to port contamination. The suggested model consists of four key elements: ship-generated waste management, port-generated waste management, biogas electrical power station in the ownership of the port and coast machinery plant (Karimpour et al., 2019). Since 2019 cruisers and ferries are not allowed to release unprocessed waste into the Baltic Sea (Karimpour et al., 2019). The second element refers to port-generated waste management in the Copenhagen-Malmö port. It states that the port has a good reputation of collecting and managing organic and other waste. The third model element is a biogas electrical power station, a plant known as a clean and renewable energy source (Karimpour et al., 2019). Denmark is the leading biogas industry country. In 2014 there were 154 biogas electrical power stations, which manufactured 1.2 TWh annually. It is assumed that the Danish Energy Agency is going to increase the production to 4.7 TWh in 2020 (Karimpour et al., 2019). The fourth element refers to the coastal machinery plant for ship power supply. It is a plant which supplies seaworthy ships with electrical energy, while their auxiliary engines are turned off. The coastal machinery plant reduces operating expenses and the expenses of auxiliary engine maintenance

motora (Karimpour i sur., 2019). Prikazani su razni inovacijski modeli koje Kopenhagen implementira u svojoj luci no tek ostaje za vidjeti hoće li oni poslužiti luci Kopenhagen-Malmö za razvoj kružnog gospodarstva.

UPRAVLJANJE ENERGIJOM U KOPENHAGENU

U Kopenhagenu postoje izazovi s kojima se grad susreće u pogledu proizvodnje električne energije dobivene iz vjetra te udjela obnovljivih izvora energije u bruto potrošnji ukupne energije u kućanstvima i industriji. “Obnovljiva energija dobiva se uz pomoć: vjetra, koji također proizvodi valove; vode, koja uključuje hidroenergetsku, plimnu i geotermalnu energiju (voda grijana vrućim podzemnim stijenkama); i sunca, koje uključuje fotonaponske i solarne elektrane koje fokusiraju sunčevu svjetlost na zagrijavanje tekućine koja pokreće turbinu za proizvodnju električne energije” (Jacobson i Delucchi, 2009: 59). Floater i sur. (2014) navode kako je emisija u 2011. godini iznosila 1,9 milijuna tona CO₂ za grad Kopenhagen, pri čemu postojeće inicijative predviđaju da će se to smanjiti na 1,2 milijuna tona do 2025. godine. Stacionarna proizvodnja energije zadužena je za isporuku otprilike tri četvrtine smanjenja emisija potrebnih kako bi se ostvario cilj Kopenhagena da bude ugljično neutralan do 2025. godine (Floater i sur., 2014). Održavanje sigurnosti opskrbe i performansi sustava uz smanjenje trenutačno visoke razine ovisnosti o fosilnim gorivima morat će se oslanjati na mješavinu obnovljivih izvora energije kao i na spaljivanje otpada. Da bi grad ispunio svoj cilj CO₂ neutralnosti, značajan fokus stavljen je na mreže za proizvodnju, opskrbu i distribuciju energije. Cilj Kopenhagena ostvariti je navedeno iz svoje mreže za biomasu i vjetroelektranama izvan Kopenhagena (Floater i sur., 2014).

U Danskoj se 22% ukupne potrošnje struje proizvede vjetroagregatima, što je najviša stopa

(Karimpour et al., 2019). Different innovation models, which Copenhagen is implementing in its port, are shown. It remains to be seen if they are going to be of use to the Copenhagen-Malmö port in the circular economy development.

ENERGY MANAGEMENT IN COPENHAGEN

There are challenges that Copenhagen is facing in terms of electrical energy production, which is generated by wind and the share that renewable sources of energy in gross have in the total consumption in households and industry. “Renewable energy is obtained from wind, which produces waves; water, which involves hydro, tidal and geothermal energy (water heated by hot underground rocks); and sun, which involves photovoltaic and solar power plants, that focus sunlight to heat the liquid that generates the turbine, which then manufactures electrical energy” (Jacobson and Delucchi, 2009: 59). Floater et al. (2014) say that emission in 2011 was 1.9 million tonnes of CO₂ for the city of Copenhagen. The current initiatives anticipate that they will be reduced to 1.2 million tonnes by 2025. Stationary energy production is responsible for providing three quarters of emission reduction, necessary to accomplish Copenhagen’s goal to become carbon neutral by 2025 (Floater et al., 2014). If the city wants to maintain the supply and system performance safe, along with reducing currently high reliance on fossil fuel, it will have to rely on the combination of renewable energy sources as well as incineration. In order for Copenhagen to meet its CO₂ neutral goal, a substantial focus is put on production networks, energy supply and distribution. The goal that Copenhagen is trying to reach is to achieve all these things from its biogas network and wind farms outside of the city (Floater et al., 2014).

Denmark generates 22% of total electricity consumption through wind aggregates, which is the highest rate in the world (Copenhagen, 2014).

na svijetu (Copenhagen, 2014). Kopenhagen se suočava s brojnim izazovima u proizvodnji električne energije dobivene iz vjetra. Izazovi se odnose na ograničen prostor za proizvodnju veće energije vjetra u urbanim sredinama, visoku cijenu gradnje takvog agregata kao i dobivenih količina megavat sati (mWh) po jedinici te otpor javnosti prema takvim agregatima zbog vizualnog utjecaja na okoliš, ali i buke koju emitiraju. Prva vjetroelektrana postavljena je u luci u Middelgrundenu, pri čemu su bili posebno razvijani temelji koji se mogu nositi s ledom tijekom jakih zima. Također su bili uključeni elementi kao što su kretanje plime i oseke, jačina valova, agresivni morski okoliš na podmorskim kablovima i slično. Rezultati iz analize postavljanja vjetroelektrana u luci u Middelgrundenu poslužili su za formiranje naknadnih planova da se u Kopenhagenu postavljaju nove vjetroelektrane.

Kopenhagen je već poduzeo značajne korake u okviru Klimatskog plana CPH 2025. Stopostotni prelazak na obnovljive izvore je ekonomski održiv u Danskoj, ali bit će potrebne neke ključne tehnološke promjene na nacionalnoj razini. To uključuje razvoj vjetroelektrana na kopnu, implementaciju toplinskih crpki u pojedinim zgradama i sustavima daljinskog grijanja te uvođenje ušteda na razini krajnjih korisnika. Grad će imati važnu ulogu tijekom ove tranzicije iz dva razloga: prvo, Kopenhagen je dom za 10% stanovništva Danske, tako da akcije provedene u gradu imaju velik utjecaj na ukupni nacionalni napredak, i drugo, provedba nove tehnologije zahtijevat će djelovanje na lokalnoj, odnosno općinskoj razini (Mathiesen i sur., 2015). “Emisije CO₂ iz energetskeg sektora značajno pridonose klimatskim promjenama. Za postavljanje okvira pri smanjenju emisija CO₂ u sve više decentraliziranom energetskeg sektoru uključenost lokalnih općina i zajednica iznimno je važna” (Ben Amer i sur., 2019: 21).

“Nordhavn je nova četvrt u gradu Kopenhagenu, za koju se očekuje da će do 2030. godine imati 40.000 novih stanovnika i 40.000 radnih mjesta” (Ben Amer i sur., 2019: 23). Mreža daljinskog grijanja na širem području grada obuhvaća 17

Copenhagen is facing numerous challenges in electricity generation from wind. These challenges refer to constrained production of high-energy wind in urban areas, high building cost of a wind aggregate, as well as obtained quantity of megawatt-hours (mWh) per unit, and public resistance to such aggregates because of their visual effect on the environment, and the noise they are producing. The first wind farm was built in the port in Middelgrunden. Special foundations were built there in order to resist ice during harsh winters. Furthermore, elements, such as tide and ebb, wave strength, sea environment, which is aggressive to underwater cables, were taken into consideration. The results of analysis of constructing a wind farm in the port in Middelgrunden helped further plans to build new wind farms in Copenhagen.

Copenhagen has already taken all crucial steps regarding the Climate Plan CPH 2025. A complete transition to renewable energy sources is economically sustainable in Denmark. However, key technology changes on the state level need to be implemented. It involves the development of wind farms on the mainland, implementation of heat pumps in individual buildings and remote heating system, and savings on the level of end users. The city will play a major role in this transition, for two reasons: firstly, Copenhagen is the home to 10% of the population of Denmark. Therefore, actions carried out in the city largely affect the entire national progress. And secondly, the implementation of new technologies requires actions on the state, local and municipal level (Mathiesen et al., 2015). “The CO₂ emissions from energy sector contribute to climate change on a large scale. The involvement of local community is of extraordinary importance for the setting of CO₂ reduction framework in the energy sector that is becoming increasingly decentralized.” (Ben Amer et al., 2019: 21).

“Nordhavn is a new neighbourhood in Copenhagen, which is expected to have 40,000 new inhabitants and 40,000 new workplaces by 2030” (Ben Amer et al., 2019: 23). Remote heating network in the

općina i koherentan je sustav gdje se toplina može izmjenjivati između različitih pružatelja usluga daljinskog grijanja. Na tom području toplina se proizvodi prvenstveno u četiri kombinirana postrojenja (koristeći biomasu, prirodni plin i ugljen) i tri spalionice otpada. Ako je potrebno, skladišti se u akumulatorima topline (Ben Amer i sur., 2019). Trenutno se velik udio topline u kopenhaskoj mreži daljinskog grijanja (eng. *District heating*) proizvodi pomoću biomase, komunalnog otpada i ugljena. Međutim, zbog smanjenja emisije CO₂ i ciljeva obnovljive energije, ugljen predstavlja vrstu goriva koje je neophodno postupno ukinuti. Model koji su razvili Ben Amer i sur. (2019) pokazuje kako će šire područje grada Kopenhagena u 2025. godini dostići nula emisija u sektorima tople vode i električne energije te time postići svoj cilj postupnim ukidanjem fosilnih goriva.

PROBLEM PAMETNOG UPRAVLJANJA OTPADOM

Kopenhagen se suočava s brojim izazovima u gospodarenju otpadom. Prema dokumentu (Copenhagen, 2014) navodi se da građani Kopenhagena stvaraju znatno manje otpada od prosječnog Danca, a velike se količine otpada uglavnom spaljuju kako bi se napajale gradske energetske mreže. Danska vlada zabranila je odlaganje otpada na odlagališta koja bi inače mogla biti spaljena. Također je uvela visoki porez na otpad na odlagališta, a niski porez na otpad za spaljivanje te izuzima otpad za recikliranje. Na lokalnoj razini, uz plan gospodarenja komunalnim otpadom, postoji značajna kontrola nad prikupljanjem otpada te se mnogo polaže na obrazovni aspekt, koji posljedično utječe na promjene u ponašanju građana, kao i na programe koji utječu na stope recikliranja i na postavljanje centara za recikliranje (Floater i sur., 2014). "Testiranje pametnog gospodarenja otpadom započeto je 2016. godine i postalo je najperspektivnija studija poslovnog slučaja" (Falch i Maestrini, 2019: 2). U Kopenhagenu,

wider area comprises 17 municipalities and forms a coherent system, where heat can be exchanged among different remote heating service providers. In this area the heat is primarily produced in four combined production plants (using biomass, natural gas and coal) and three incineration plants. If necessary, it is stored in heat accumulation tanks (Ben Amer et al., 2019). A large share of heat in Copenhagen District heating is produced with biomass, municipal solid waste and coal. However, due to the objectives of CO₂ reduction and renewable energy, coal is a type of fuel that needs to be eliminated gradually. The model developed by Ben Amer et al. (2019), shows that a broader Copenhagen area will reach zero emission in hot water and electricity sectors by 2025, and thereby accomplish the goal of gradual elimination of fossil fuel.

SMART WASTE MANAGEMENT ISSUE

Copenhagen is facing numerous challenges in waste management. According to the document Copenhagen, 2014, the inhabitants of Copenhagen generate considerably less waste than an average Dane. Large quantities of waste are mostly incinerated in order to supply city energy power networks. The government of Denmark has mostly banned depositing the waste into landfills which could be incinerated. They have also introduced a high tax on landfill deposits and low tax on incineration waste. Recycled waste is exempt from the taxation. On the local level, apart from the communal solid waste management plan, there is a waste collection control and a lot of attention is given to the educational aspect which consequently affects people's behaviour changes, as well as the programmes that affect recycling rate and building of recycling centres (Floater et al., 2014). "The testing of smart waste management started in 2016 and it became a business case study with the most perspective" (Falch and Maestrini, 2019: 2). In Copenhagen, it is the municipality that is responsible for waste collection and disposal

općina je odgovorna za prikupljanje i odvoz otpada iz privatnih domova i tvrtki. Cijeli projekt pametnog gospodarenja otpadom odnosi se samo na prikupljanje otpada u javnim prostorima. U svrhu projekta pametnog gospodarenja otpadom postavljeni su senzori u kontejnere za otpad kako bi se mogla pratiti njegova razina, što bi trebalo omogućiti učinkovitije upravljanje odvozom otpada. Nakon provedenog istraživanja i testiranja sustava, Lundin i sur. (2017) napravili su test na kampusu Tehničkog sveučilišta u Danskoj. U tu svrhu danska *start-up* tvrtka NordSense proizvela je senzor za praćenje. Njihovo rješenje uključuje tri različita dijela, senzor (eng. NS Pod), platformu (eng. NS platform) i navigaciju (eng. NS Navigator) (Falch i Maestrini, 2019).

Senzor (eng. NS Pod) je ključni dio tog rješenja koji se može smjestiti u bilo koju vrstu spremnika. To omogućava pružanje 3D dubinskih karata sadržaja kante, a Nordsense tvrdi da je prva tvrtka koja je pouzdano mogla izmjeriti razinu punjenja u posudama obloženim plastičnim vrećama. Nadalje, senzori mjere temperaturu i registriraju se prilikom pomicanja posuda, na primjer, kada su prazni. NS platforma pruža pregled podataka prikupljenih u stvarnom vremenu. Također uključuje razne analitičke alate za planiranje ruta i optimalno postavljanje kontejnera. NS Navigator dizajniran je za upotrebu na mobilnom uređaju kako bi vozačima pomogao u planiranju ruta i daje upozorenja kada je kanta za otpad u blizini napunjena i potrebno ju je isprazniti (Falch i Maestrini, 2019). U takvom procesu nema fiksnog rasporeda za odvoz otpada već se kante prazne samo kada su pune. Inovativno rješenje odvoza otpada smanjuje broj odvoza za milijun ili 45% bez smanjenja kvalitete komunalne usluge (Falch i Maestrini, 2019). S obzirom na razvoj pametnih gradskih usluga, općine su usmjerene na razvoj inovacija kako bi se građanima pružile adekvatne javne usluge temeljene na novim tehnologijama. Također imaju značajnu ulogu pri uvođenju inovacija u lokalnoj industriji. Na temelju navedenog može se utvrditi da je Kopenhagen i u pitanju pametnog gospodarenja otpadom

from private homes and business organizations. The entire smart waste management relates only to waste collection from public areas. Waste containers have sensors installed, which allow the tracking of smart management waste level, and which should improve waste disposal. Upon the study and system testing, Lundin et al. (2017) conducted a test at the Denmark Technical College campus. The Danish start-up company NordSense manufactured a tracking sensor. Their solution includes three parts, a sensor (NS Pod), a platform (NS platform) and a navigator (NS Navigator) (Falch and Maestrini, 2019).

The sensor (eng. NS Pod) is the key part of the solution, which can be placed into any kind of tank or container. It provides 3D charts of the container contents, and Nordsense claims that they are the first company that can reliably measure the level of content in containers coated with plastic bags. Furtheron, sensors measure the temperature and register when containers are being moved, if they are empty. The NS platform provides the data collected in real time. It also involves various analytical tools for route planning and optimal container setting. The NS Navigator is designed for mobile phone use so that drivers may plan their routes and receive notifications that a container is full and needs to be emptied (Falch and Maestrini, 2019). This process does not have a fixed timetable for waste disposal. Containers are emptied when full. The innovative waste disposal solution reduces the number of disposals by a million or 45%, and the communal service quality remains intact. (Falch and Maestrini, 2019). Since smart municipal services are being developed, municipalities are focusing on developing innovation to provide appropriate public service based on new technologies. They also play an important role in local industry innovation. Based on all this, it can be stated that Copenhagen has implemented innovative solutions for smart waste management, with the ultimate goal of reducing the CO₂ emission and enlarging the percentage of recycled waste. However, there is a long way

implementirao inovativna rješenja, a sve kako bi se smanjile emisije CO₂ i kako bi se povećao postotak recikliranog otpada. Ipak, dug je put da Kopenhagen ostvari svoj cilj grada bez otpada.

ahead of Copenhagen to achieve its goal of being a zero waste city.

UTJECAJ ZELENE I URBANE REVITALIZACIJE NA STANOVNIŠTVO KOPENAHGENA

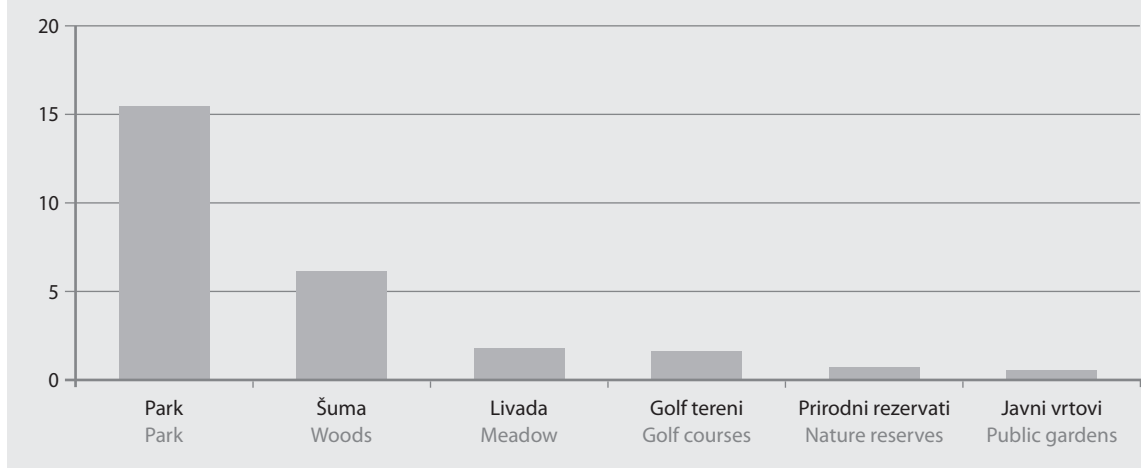
THE EFFECT OF GREEN AND URBAN REVITALIZATION ON THE INHABITANTS OF COPENHAGEN

Zbog porasta broja stanovnika, Kopenhagen svoj politički i investicijski okvir za razvoj zemljišta i infrastrukture prioritetno daje mješovitim, unutar-urbanim (engl. *brownfield*) razvojnim područjima (Floater i sur., 2014). “Općinski plan u Kopenhagenu identificira glavne prometne veze, centre za zapošljavanje i glavne razvojne lokacije ili ‘područja akcijskog plana’ kao ona na koja će se usmjeriti rast” (Floater i sur., 2014: 11). Potreba za održivijim gradovima jedna je od ključnih točaka Urbane agende Europske unije (<https://ec.europa.eu/futurium/en/urban-agenda>).

Due to the increased number of inhabitants, Copenhagen prioritizes the political and investment framework for land and infrastructure development over brownfield developing areas (Floater et al., 2014). “The Copenhagen municipal plan identifies major transport links, employment centres and major developing locations or ‘action plan areas’ as the ones to which it will steer the growth to” (Floater et al., 2014: 11). A need for more sustainable cities is one of the key points of the Urban Agenda for the EU (<https://ec.europa.eu/futurium/en/urban-agenda>). In the previous

GRAFIKON 3. BROJ ZELENIH POVRŠINA U KOPENAHGENU U m² PO STANOVNIKU, 2018.

GRAPH 3. NUMBER OF URBAN GREEN SPACES IN COPENHAGEN, IN SQUARE METERS PER INHABITANT, 2018



Izvor: obrada autora prema podacima Statista, dostupno na: <https://www.statista.com/statistics/858892/green-areas-per-inhabitant-in-copenhagen-denmark> (11. 5. 2020.)

Source: data analysed by the authors, according to Statista, available at: <https://www.statista.com/statistics/858892/green-areas-per-inhabitant-in-copenhagen-denmark> (website accessed on the 11th May 2020)

eu/futurium/en/urban-agenda). Tijekom posljednjih desetljeća potreba za održivijim gradovima jedan je od najvažnijih ciljeva europskih planova za urbano okruženje. Europska unija iznimno je predana poticanju gradova kako bi bili ekološki prihvatljivi, konkurentni na globalnom tržištu i orijentirani na socijalnu uključenost. Cucca (2017) navodi da su nacionalne i lokalne vlasti promovirale urbani razvoj kako bi se povećala atraktivnost grada te se Kopenhagen predstavio kao jedan od ekološki najprihvatljivijih gradova u Europi. Politike urbanog razvoja imale su izravan utjecaj na sposobnost grada da privuče investitore i međunarodne događaje o održivosti. Unaprjeđenje kvalitete urbane sredine u Kopenhagenu potaknuto je specifičnim razvojem planova koji se odnose na obnavljanje obale, nove ekološke četvrti, zeleno (socijalno) stanovanje i urbanu obnovu susjedstva u skladu sa standardima održivosti (Cucca, 2017). Osim toga, gotovo polovica (48%) stanovništva glavnog grada regije ima pristup zelenim površinama na udaljenosti od 500 metara, a Kopenhagen je također promovirao učinkovitu mrežu “džepnih parkova” kako bi urbanu sredinu učinio useljivom (Cucca, 2017).

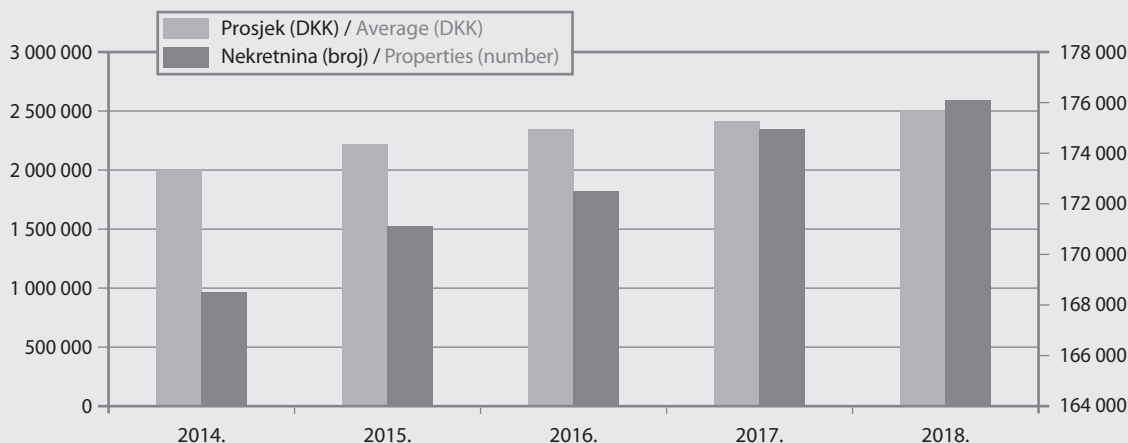
Grafikon 4 pokazuje broj zelenih površina po stanovniku u m² na području grada Kopenhagena u Danskoj za 2018. godinu, raščlanjen po kategorijama na parkove, šume, livade, golf terene, prirodne rezervate i javne vrtove. Dostupnost zelenih površina jedan je od parametara grada ugodnog za život. Prema podacima, ukupna zelena površina po osobi u Kopenhagenu je bila 31,91 m², od toga najveći dio zauzimaju parkovi s 15,54 m² po stanovniku, zatim slijede šume sa 6,22 m² po stanovniku. Najmanji dio odnosi se na javne vrtove, sa svega 0,57 m² po stanovniku. Kopenhagen je do devedesetih godina prošloga stoljeća bio orijentiran na poticanje socijalnog, subvencioniranog i jeftinog stambenog prostora. Zelena urbana obnova dovela je do djelomične zamjene urbanog stanovništva i pozicionirala Kopenhagen na međunarodnoj razini kao primjer održivog i urbanog zelenog grada za novu kreativnu klasu građana (Cucca, 2017).

decades the need for more sustainable cities was one of the major European plans of urban surroundings. The EU is exceptionally committed to making cities environmentally-acceptable, more competitive on the global market and social-inclusion-oriented. Cucca (2017) claims that state and local authorities have been promoting urban development in order to boost the city appeal and to present Copenhagen as one of the most environmentally-acceptable ones in Europe. Urban development policies have had a direct influence on the city's competence to attract investors and international sustainability events. The progress of urban quality in Copenhagen was enticed by specific plan development, referring to coastal restoration, new eco neighbourhoods, green (social) housing and urban neighbourhood revitalization in compliance with sustainability standards (Cucca, 2017). Apart from that, nearly a half (48%) of the capital's inhabitants have an access to green urban spaces within a 500-meter-distance. Copenhagen has also been promoting a “pocket park” network to make the urban area more livable (Cucca, 2017).

Graph 4 shows the number of green urban spaces in Copenhagen, Denmark, in square meters per inhabitant for 2018, divided into categories: parks, woods, meadows, golf courses, nature reserve parks and public gardens. The accessibility of green urban spaces is one of the parameters of a beautiful place to live. According to the data, the total green urban space was 31,91 m² per person in Copenhagen. The largest portion is taken by parks, with 15,54 m² per person, followed by woods with 6,22 m² per person. The smallest share comprise public gardens, with only 0,57 m² per inhabitant. By 1990s Copenhagen was focused on promoting social, subsidized and cheap housing. Green urban revitalization has resulted in partial exchange of urban inhabitants and placed Copenhagen, on the international level, as an example of a sustainable urban green city designed for a creative class of inhabitants (Cucca, 2017).

Graph 5 presents the number and average price of properties in Copenhagen between 2014 and

GRAFIKON 4. BROJ I PROSJEČNA CIJENA NEKRETNINA U KOPENHAGENU OD 2014. DO 2018. GODINE
GRAPH 4. NUMBER AND AVERAGE PRICE OF PROPERTIES IN COPENHAGEN BETWEEN 2014 AND 2018



Izvor: obrada autora prema Statistik Denmark, <https://www.statbank.dk/EJDFOE1> (10. 5. 2020.)

Source: Data analysed by the authors, according to Statistik Denmark, <https://www.statbank.dk/EJDFOE1> (website accessed on the 10th May 2020)

Grafikon 5 prikazuje broj i prosječnu cijenu nekretnina u Kopenhagenu od 2014. do 2018. godine. U razdoblju od 2014. do 2018. godine prosječna cijena nekretnina u Kopenhagenu rasla je po godišnjoj stopi od 5,7%, odnosno cijene nekretnina u gradu ukupno su porasle za više od 25%. U isto vrijeme broj novih stambenih jedinica porastao je za manje od 8.000. S druge strane, valja uzeti u obzir kako se u istom razdoblju u Kopenhagen doselilo gotovo 40.000 novih stanovnika, čime se stvorio pritisak na cijene novoizgrađenih stambenih jedinica, koje ne mogu pratiti povećanu potražnju. Za očekivati je da će shodno tome cijene nekretnina i dalje nastaviti rasti približnim stopama. Sve to uvelike utječe na imidž grada, pri čemu do izražaja dolazi teza kako će to postati grad rezerviran samo za ljude više platežne moći.

Od 1990-ih postoje primjeri privatnih unutrašnjih dvorišta u pretežno niskim do srednje visokim zgradama u Kopenhagenu, koje su urbanim

2018. In this period the average property price rose by 5,7% annually, i.e. the total increase of property price in the city was more than 25%. At the same time, the number of new housing units increased by less than 8,000. On the other hand, it must be considered that, in this period, 40 000 new people moved to Copenhagen, which put a pressure on the price of newly built housing units, which could not follow the increase in demand. It is expected that the price of property will continue to rise at a similar rate. All these elements strongly affect the image of the city, highlighting that Copenhagen is going to become the city reserved only for the affluent.

Since the 1990s, there have been private inner courtyards in relatively low or medium-height buildings in Copenhagen, which were redecorated in an urban manner and have set an exclusive approach to sheltering middle-class families (Winter, 2019). "Before it started, in the 1960s the Nørrebro activists tried to take over the closed

preuređenjem postavile ekskluzivni pristup u zbrinjavaju obitelji srednje klase (Winter, 2019). “Prije nego što je to počelo, aktivisti Nørrebroa u šezdesetim godinama prošloga stoljeća pokušali su preuzeti zatvorena dvorišta za javnu upotrebu, a to se nastavlja i danas projektom Otvoreni grad (dan. Åben By)” (Winter, 2019: 19). Aktivisti su zabrinuti zbog učinaka gentrifikacije na stanovnike s niskim primanjima jer je Nørrebro privukao kreativnu klasu s visokim primanjima (Winter, 2019). Getrifikacija je postupak u kojem se starije jeftine građevine (uglavnom stambene zgrade) ili čitavi dijelovi gradova, najčešće radnička naselja, pretvaraju u skuplje luksuzne građevine za pripadnike srednjeg sloja, koji se najčešće doseljava na mjesto autohtonog stanovništva, istisnutog iz tih građevina zbog povišenih troškova života. Takvu privilegiju da imaju siguran, zeleni prostor koji se uglavnom, kako navodi Winter (2019) i ne koristi previše, dobivaju samo oni koji si mogu priuštiti nekretninu, pritom ostavljajući izopćene beskućnike iz takvog životnog stila. Gradskim čelnicima Kopenhagena predstoje značajni naponi pronaći ravnotežu kako bi veći postotak stanovništva bio zadovoljan povoljnim stambenim prostorom i kako bi u konačnici bio grad ugodan za život.

ZAKLJUČAK

Implementacija inovacija u održivom gradu ostvaruje gospodarski razvoj te osigurava njegovim stanovnicima bolju kvalitetu života. Gradska uprava Kopenhagena prepoznala je na vrijeme važnost održivog razvoja te su ostvarili značajne rezultate u podizanju svijesti građana kroz organizaciju raznih kampanja o održivom razvoju. Kao ograničenje istraživanja može se smatrati primijenjena metodologija te neuključivanje svih mogućih čimbenika koji utječu na razvoj održivog grada Kopenhagena. Sljedeći nedostatak ovog istraživanja jest nemogućnost provedbe empirijskog istraživanja s obzirom na udaljenost promatranog grada. U skladu s postavljenim ciljem rada pokazalo se da su

courtyards and repurpose them for public use, and it is continued to this day through the Open City project (dan. Åben By)” (Winter, 2019: 19). The activists are concerned with the effects that gentrification has on low-income inhabitants because Nørrebro has been attracting high-income creative class (Winter, 2019). Gentrification is the process of changing the character of older cheaper buildings (mostly resident buildings) or whole parts of town (mostly working class neighbourhoods) into luxury buildings through the influx of more affluent residents, for middle class members, who then move into where native residents used to live, but were now displaced from these buildings, as they can no longer afford higher living costs. Such privilege of having a safe green area which is, according to Winter’s statements (2019) not used too much, in the first place, is obtained only by those who can afford the property, excluding the displaced homeless people from this sort of lifestyle. The city government of Copenhagen needs to find the balance between making a larger percentage of inhabitants happy with affordable housing and, eventually, making the city a nice place to live.

CONCLUSION

Implementing innovation in a sustainable city leads to economic development and provides a better quality of life for the inhabitants. The government of Copenhagen has recognized the importance of sustainable development. They have achieved remarkable results in making people aware of that importance, through various sustainable development campaigns. One of the limits of this research is the methodology applied and the fact that not all factors, which affect the development of sustainable city of Copenhagen, were involved. Another drawback is the impossibility to conduct an empirical research, taking the distance of the observed city into account. In accordance with the set objectives, it turns out that the research questions

istraživačka pitanja korektno oblikovana. Na temelju prvog postavljenog istraživačkog pitanja utječu li inovacije na ostvarivanje ciljeva održivog razvoja, može se utvrditi da inovacije utječu na ostvarivanje ciljeva održivog razvoja, što je vidljivo na primjeru gospodarenja otpadom u gradu Kopenhagenu. Na drugom istraživačkom pitanju pridonose li zelene tehnološke inovacije postizanju održivosti u pametnim gradovima pokazalo se da su informacijsko-komunikacijske tehnologije ključne u postizanju održivosti grada. Tehnologije osiguravaju nove mogućnosti upravljanja gradom, primjerice, razvoj pametnih gradskih prometnih mreža, što je implementirano u Kopenhagenu kroz inteligentni sustav za upotrebu bicikala. Odgovor na treće istraživačko pitanje: Može li primjena urbanih inovativnih rješenja u Kopenhagenu pridonijeti održivosti grada zapravo je ključno u ovom radu. Nakon sveobuhvatne analize može se naglasiti da su inovacije usmjerene na razvoj javnog prijevoza, gospodarenje otpadom, urbanističko planiranje, upravljanje vodama i kružnu ekonomiju pretvorile Kopenhagen u održiv grad. Uz navedeno, istraživanje bi trebalo pridonijeti rezultatima koji će biti od praktične koristi svim gradovima kojima nove spoznaje o održivom i pametnom gradu mogu pomoći pri budućem planiranju i donošenju kvalitetnijih odluka. Takve odluke generirat će daljnji razvoj grada. Jednako tako, rezultati dobiveni ovim istraživanjem mogli bi biti poticaj za slična istraživanja na ovu temu, posebice empirijska istraživanja.

were well-phrased. Based on the first research question, if innovation affects the accomplishment of sustainable development objectives, it can be concluded that it does, which is evident from the example of waste management in Copenhagen. The second research question, if green technology innovation is contributing to achieving sustainability in smart cities, it turns out that information-communication technologies are crucial for that. Technologies allow new possibilities of city governing, like e.g. the development of smart transportation networks, which have been implemented in Copenhagen through a smart bicycle system. The answer to the third research question: Can the application of urban innovative solutions contribute to city sustainability?, is the crucial question of this paper. Upon a comprehensive analysis, it can be said that innovation is directed toward public transport development, waste management, urban planning, water management and circular economy, and that they have turned Copenhagen into a sustainable city. Apart from all that, the research should lead to results which will be of practical use for all those cities which will then make plans and better decisions on their way to becoming smart cities. Such decisions are going to generate further city development. Equally, results obtained through this research may be an incentive for further research on this subject, empirical ones, in particular.

LITERATURA / LITERATURE

- BEN AMER, S., PEDERSEN, R. B. B., BALYK, O. & NIELSEN, P. S. (2019), "Modelling the future low-carbon energy systems" – case study of Greater Copenhagen, Denmark. *International Journal of Sustainable Energy Planning and Management*, 24, 21-32. <https://doi.org/10.5278/ijsepm.3356>
- BINNING, P. J., HAUGER, M. B., RYGAARD, M., EILERSEN, A. M., ALBRECHTSEN, H. J. (2006), "Rethinking the urban water management of Copenhagen". *Water Practice and Technology*, 1(2). <http://dx.doi.org/10.2166/wpt.2006.027>
- BRÜEL, M. (2012), "Copenhagen, Denmark: Green City amid the Finger Metropolis". U: Beatley, T. (ur.), *Green Cities of Europe*. Washington: Island Press
- COPENHAGEN (2007), "Eco-Metropolis: Our vision for Copenhagen 2015". Dostupno na: www.proyectomilenio.org/documents/10156/52626/Copenhaguen+2015+EcoMetropolis.pdf
- COPENHAGEN (2011), Copenhagen Climate Adoption Plan. Dostupno na: http://en.klimatilpasning.dk/media/568851/copenhagen_adaption_plan.pdf
- COPENHAGEN (2012), Cloudburst Management Plan 2012. Dostupno na: https://en.klimatilpasning.dk/media/665626/cph_-cloudburst_management_plan.pdf
- COPENHAGEN, CITY HALL (2014), Copenhagen: Solutions for sustainable cities. State of Green. 3rd Edition. Dostupno na: http://kk.sites.itera.dk/apps/kk_pub2/pdf/1353_58936BnEKE.pdf
- COPENHAGEN (2012), CPH 2025 Climate Plan: A Green, Smart and Carbon Neutral City. Dostupno na: <https://urbandevelopmentcph.kk.dk/artikel/cph-2025-climate-plan>
- CUCCA, R. (2017), "The social impact of green urban renewal in two European Capital Cities: Copenhagen and Vienna in comparison". CSU Conference Proceedings and Events, Environmental Justice in the Anthropocene Symposium <http://dx.doi.org/10.25675/10217/183745>
- EUROPSKI PARLAMENT (EP), (2018). Direktiva (EU) 2018/844 europskog parlamenta i vijeća od 30. svibnja 2018. o izmjeni Direktive 2010/31/EU o energetske svojstvima zgrada i Direktive 2012/27/EU o energetske učinkovitosti. Dostupno na: <http://eur-lex.europa.eu/legal-content/HR/TXT/PDF/?uri=CELEX:32018L0844&from=HR>
- FALCH, M., MAESTRINI, M. (2019), "Public Private Partnership in Smart city waste management" – a Business Case, CTTE-FITCE: Smart Cities & Information and Communication Technology (CTTE-FITCE), 1-6. <http://dx.doi.org/10.1109/CTTE-FITCE.2019.8894820>
- FLOATER, G., RODE, P., ZENGHELIS, D. (2014), Copenhagen: green economy leader report. Economics of Green Cities Programme, LSE Cities, London School of Economics and Political Science, London, UK, 4-90. <http://www.lse.ac.uk/cities/publications/research-reports/Copenhagen-Green-Economy-Leader-Report>
- JACOBSON, M. Z., DELUCCHI, M. A. (2009), "A Path To Sustainable Energy By 2030". *Scientific American*, 301 (5), 58-65. <https://www.jstor.org/stable/26001592>
- KARIMPOUR, R., BALLINI, F. & ÖLCER, A. I. (2019), Circular economy approach to facilitate the transition of the port cities into self-sustainable energy ports – a case study in Copenhagen-Malmö Port (CMP). *WMU Journal of Maritime Affairs* 18, 225-247. <https://dx.doi.org/10.1007/s13437-019-00170-2>
- LUNDIN, A. C., ÖZKIL, A. G. & SCHULDT-JENSEN, J. (2017), "Smart cities: A case study in waste monitoring and management". In: Proceedings of the 50th Hawaii International Conference on System Sciences (HICSS 2017) (pp. 1392-1401) <https://doi.org/10.24251/HICSS.2017.167>
- MATHIESEN, B. V., LUND, R. S., CONNOLLY, D., RIDJAN, I., NIELSEN, S. (2015), "Copenhagen Energy Vision: A sustainable vision for bringing a Capital to 100% renewable energy". Department of Development and Planning, Aalborg University. https://vbn.aau.dk/ws/files/209592938/Copenhagen_Energy_Vision_2050_report.pdf
- ORGANIZACIJA ZA EKONOMSKU SURADNJU I RAZVOJ (OECD) (2009), OECD Territorial Reviews: Copenhagen, Denmark 2009. OECD Territorial Reviews, OECD Publishing, Paris, 7.-8. Dostupno na: <https://dx.doi.org/10.1787/9789264060036-en>
- RYGAARD, M., GODSKESEN, B., JØRGENSEN, C., HOFFMANN, B. (2014), "Holistic assessment of a secondary water supply for a new development in Copenhagen, Denmark". *Science of The Total Environment*, Vol. 497-498, 430-439. <http://dx.doi.org/10.1016/j.scitotenv.2014.07.078>
- ŠLOGAR, H., BANDOVIĆ, G., ČAKANIĆ, T. (2020), "A sustainable city the context of urban development". In: Bevanda, V. (Ed.), Conference Proceedings of the Sixth International Scientific Conference, ERAZ, Knowledge based sustainable development, Online-virtual, May, 21, 2020, pp. 253- 257
- VAN DOREN, D., DRIESSEN, P. P. J., RUNHAAR, H. A. C., GIEZEN, M. (2020), Learning within local government to promote the scaling-up of low-carbon initiatives: A case study in the City of Copenhagen.

Energy Policy, 136, 111030. <https://dx.doi.org/10.1016/j.enpol.2019.111030>

WINTER, A. K. (2019), "The green city citizen: Exploring the ambiguities of sustainable lifestyles in Copenhagen". ENVIRONMENTAL POLICY AND GOVERNANCE, 29 (1). 14–22. <http://dx.doi:10.1002/eet.1837>

Internetski izvori / Online sources

<https://blueandgreentomorrow.com/features/sustainability-in-the-city-copenhagen-denmark/>

https://http://www.cycling-embassy.dk/wp-content/uploads/2017/07/Velo-city_handout.pdf <https://www.copenhagen.com/oresund>

https://ec.europa.eu/transport/modes/maritime/news/2016-06-27-ports_en

<https://ec.europa.eu/futurium/en/urban-agenda>

<https://www.statista.com/statistics/858892/green-areas-per-inhabitant-in-copenhagen-denmark>

Statistik Denmark, <https://www.statbank.dk/EJDFOE1>

Statistik Denmark , <https://www.statbank.dk/FT>

<https://www.statbank.dk/BIL51>

<https://www.statbank.dk/BYGB40>

<https://www.statista.com/statistics/858892/green-areas-per-inhabitant-in-copenhagen-denmark>