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Trajnostna urbana infrastruktura

Ljubljana – Pogled v leto 2050

Raziskovalni projekt Mestne občine Ljubljana, Centra za energetsko učinkovitost Instituta Jožef Stefan in Siemensa

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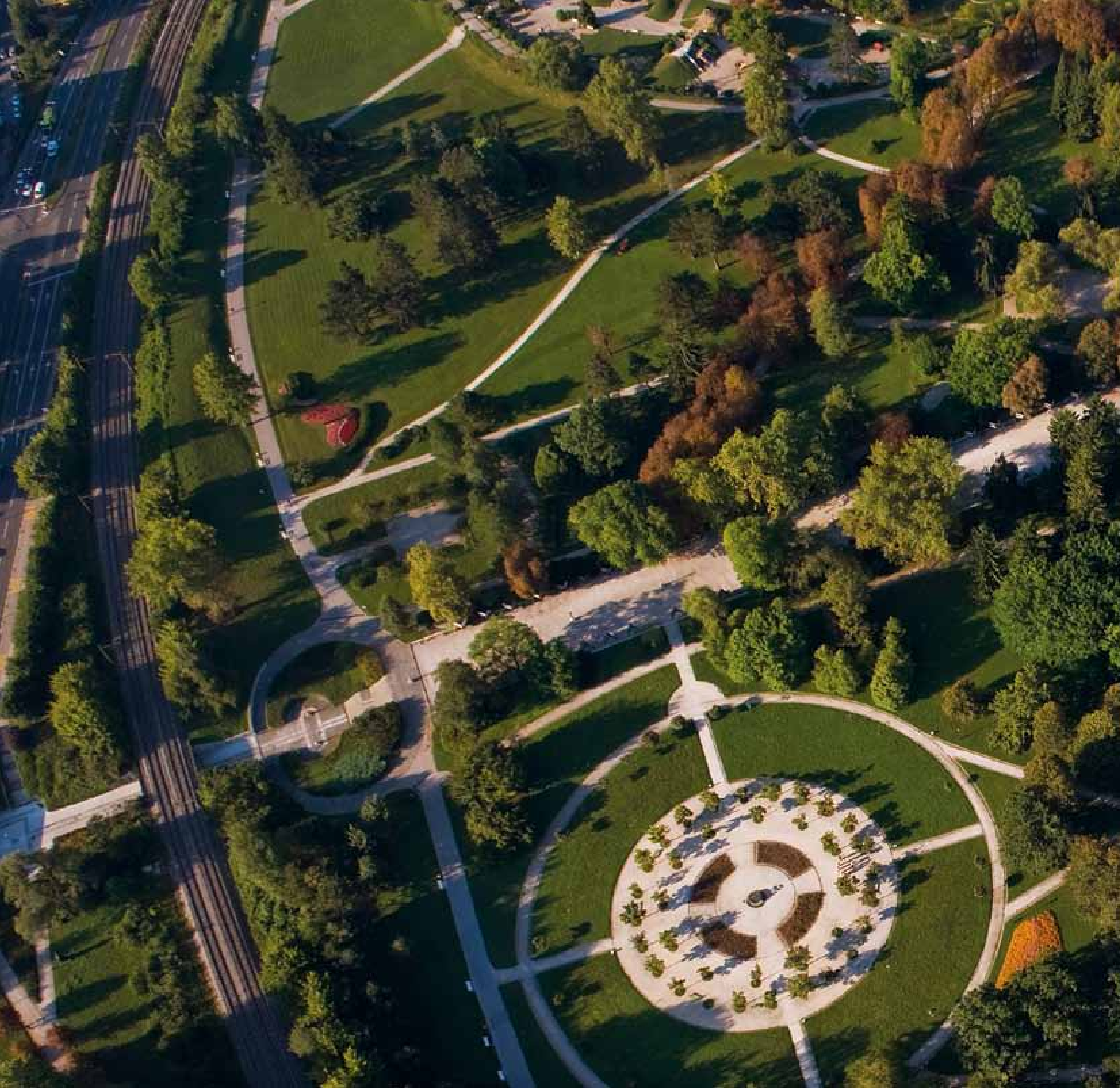
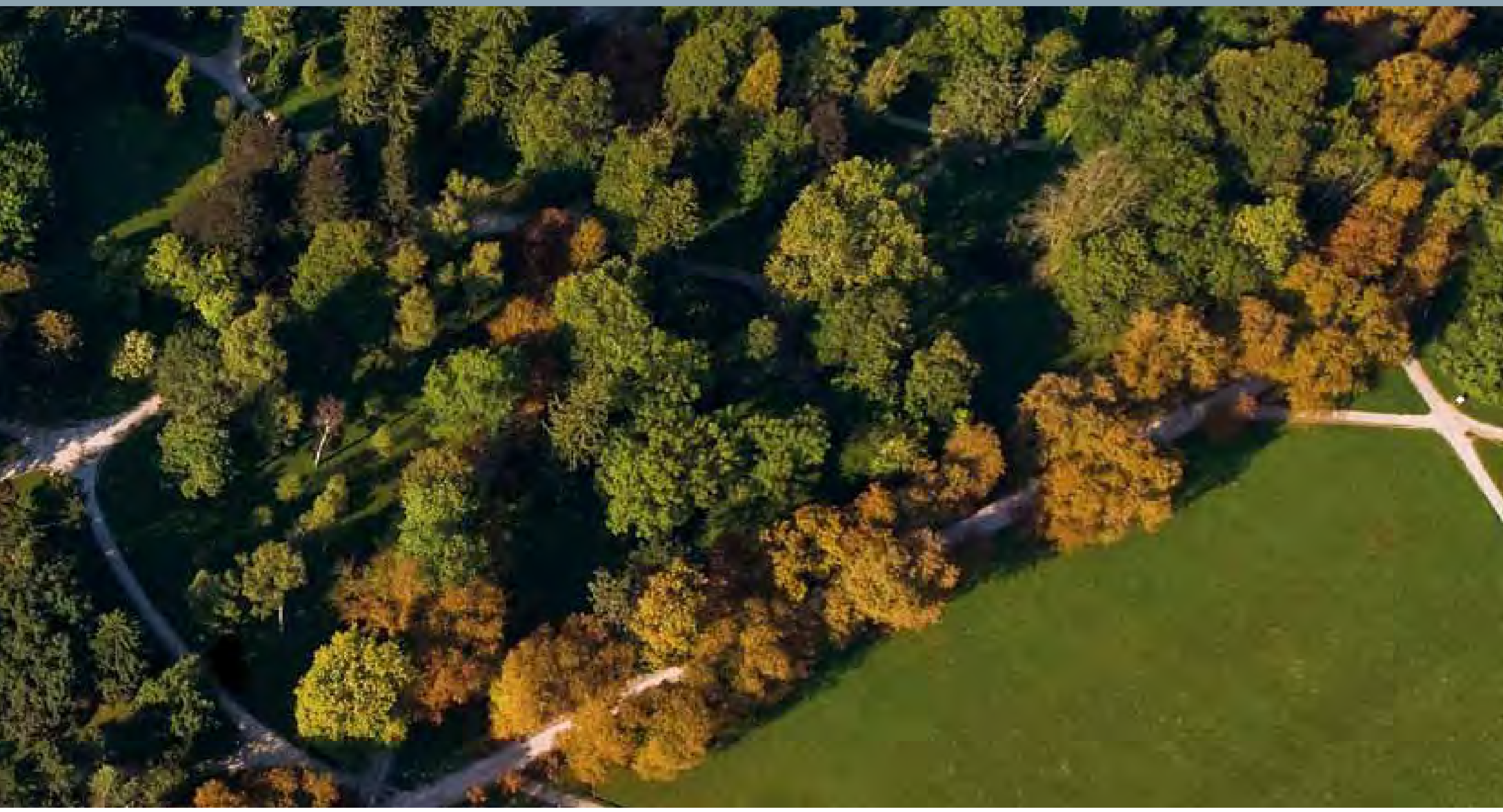
Kazalo



I. Vizija in strateški okvir



Mesta so s svojim okoljskim vplivom zelo pomemben dejavnik klimatskih sprememb – pozitivnih in negativnih. Zaradi svoje ekonomske moči igrajo v državah odločilno vlogo v gospodarskem razvoju. Tako kot gospodarske organizacije tudi mesta nastopajo v močno globaliziranem konkurenčnem okolju, kjer si prizadevajo za rast in napredek z ustvarjanjem delovnih mest, dobrih pogojev za bivanje in ponujanjem odličnih storitev posameznikom in organizacijam. Mestna uprava Ljubljane si prizadeva za trajnostno rast in za nenehno zviševanje kakovosti bivanja. Ne glede na časovni obseg svojega mandata želi že danes izvajati ukrepe, ki bodo prihodnjim generacijam omogočile primerno okolje za ustvarjanje in življenje.

Unikatnost študije

Tovrstna študija v Sloveniji na ravni mesta še ni bila izdelana. Sorodni strateški dokumenti so namreč zastavljeni na krajši rok: do leta 2030 (Nacionalni energetski program) oziroma do leta 2020 (Lokalni energetski koncept).

Po naših informacijah ne obstaja veliko mest, ki bi izvajala podobne raziskovalno-analitske projekte. Ljubljana je torej v elitni družbi nekaj zahodnoevropskih prestolnic, ki so se odločile, da želijo že danes stopiti na pot okoljske trajnosti.

Izsledki sorodnih mednarodnih analitičnih projektov v Munchnu, Londonu, Dublinu in Berlinu namreč kažejo, da imajo mesta veliko potencialov pri izboljševanju svoje okoljske učinkovitosti – pri tem pa pozitivni učinki segajo tudi na področje ekonomike mesta, kakovosti življenja in s tem njihove mednarodne konkurenčnosti.

Kontekst študije

Študija je nastala v sklopu projekta Ljubljana, pametno mesto, v katerem Mestna občina Ljubljana (MOL) v sodelovanju z družbo Siemens razvija, komunicira in promovira svoje projekte in dosežke na področju okoljske učinkovitosti.

Razvoj mesta je dolgoročen proces. Sedanja uprava MOL si prizadeva za dolgoročen, trajnostni razvoj mesta ne glede na časovne omejitve trenutnega mandata. Zato študija daje uvid v dejavnike, ki na ta razvoj lahko vplivajo. Projekcije so narejene do leta 2050.

Ljubljana ima visok delež v porabi energije in povzročanju emisij v Sloveniji. Samo z ukrepi mestne oblasti ni možno doseči ambicioznih okoljskih ciljev. **Prehod v trajnostno odličnost prestolnice torej ne more biti zgolj vprašanje mesta, pač pa je nacionalno vprašanje**, pri reševanju katerega mora aktivno sodelovati država, organizacije in posamezniki. Investicije v tehnologije in infrastrukturo, ki bodo omogočile pot v trajnostno odlično družbo, so visoke, zato mora obstajati konsenz med mestnimi in nacionalnimi strukturami, organizacijami in posamezniki. Študija daje izhodišča za dialog, ki lahko do takšnega konsenza pripelje. Ponuja ukrepe, ki lahko vodijo k doseganju ciljev.

Mestna uprava danske prestolnice Kopenhagen je vzpostavila načrt okoljske učinkovitosti in trajnostnega razvoja že leta 1970, ko so zaradi naftne krize želeli zmanjšati energetsko odvisnost od nafte. Zastavili so okoljske smernice, ki jim sistematično sledijo že desetletja, in se jim danes obrestujejo. **Študija daje izhodišča za postavljanje dolgoročnih okoljskih politik na ravni mesta.** S študijo mestna uprava dokazuje, da je naravnana dolgoročno, strateško in ciljno, predvsem pa, da je prepoznala prihodnje izzive in jih naslovila že danes, čeprav morda ne bo nosila odgovornosti za soočanje z njimi.

Relevantnost študije

Energija je visok strošek v proračunu katerekoli organizacije. Prihranek energije je pomemben okoljski cilj, a hkrati tudi izjemna poslovna priložnost.

V Sloveniji je leta 2008 letni strošek skupne rabe primarne energije znašal 1,95 milijard EUR (5,2% bruto domačega proizvoda).

- Okrog 80% energije se je porabilo v mestnih naseljih in v mestih, kar pomeni da so mestna naselja in mesta odgovorna za 1,6 milijard EUR stroškov za energijo.
- Z zmanjšanjem rabe energije za 20% na ravni mestnih naselij in mest bi lahko prihranili okrog 312 milijonov EUR/letno oziroma skoraj 1% BDP iz leta 2008.

Tudi na ravni mesta Ljubljana je poraba energije bistvena postavka v ekonomiki delovanja:

- Strošek za energijo v objektih MOL je v letu 2008 znašal 5,9 milijona EUR (približno 2% mestnega proračuna 2008).
- Z uvajanjem sistematičnega upravljanja z energijo bi lahko stroške za energijo znižali na letni ravni za 708.000 EUR (znesek je primerljiv s proračunsko postavko »transferi nezaposlenim« v letu 2008).
- Investicija, potrebna za doseganje teh prihrankov, je ocenjena na 4,15 milijona EUR, njena vračilna doba je 5,5 let.
- S poslovnim modelom energetskega pogodbeništva je možno doseči, da MOL v doseganje prihrankov ni potrebno neposredno vlagati, po 6 letih pa lahko "obdrži" dosežene energetske prihranke (življenjski cikel opreme, predvidene za doseganje prihrankov, je praviloma daljši od 10 let).

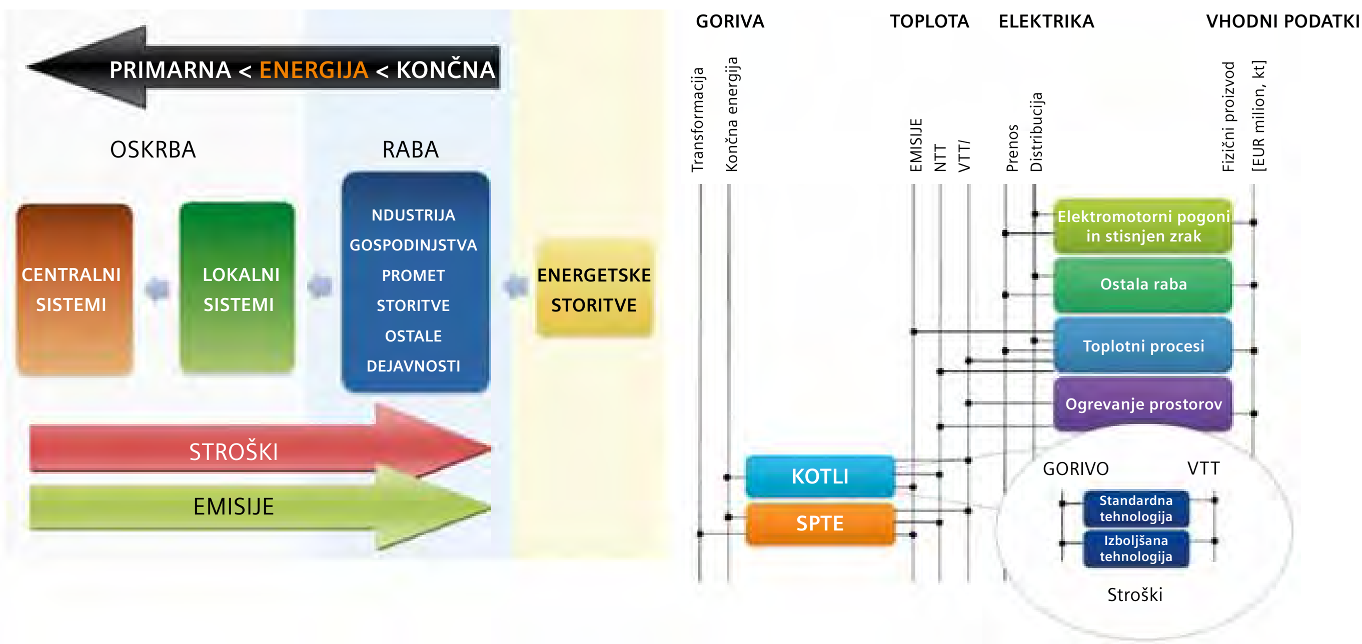
Metodologija

V študiji je osrednje metodološko orodje za izdelavo izračunov in projekcij **Referenčni energetsko-ekološki model REES MOL**:

- je skupek programov in orodij, s katerimi matematično opišemo posamezne podsisteme energetskega sistema v korelaciji s parametri, ki nanje vplivajo, in jih nato zopet združimo v celoto;
- omogoča konsistentno modeliranje rabe energije na podlagi potreb ter izračune emisij, stroškov in drugih učinkov.

Tovrstna raba metodologije je bila na ravni mesta in v širši regiji uporabljena prvič.

Projekcije temeljijo na veljavnih statistikah MOL ter nacionalnega in mednarodnih statističnih uradov. Pri izboru dobrih praks smo si pomagali s širokim naborom literature in virov.



Slika 1: Referenčni energetsko-ekološki model REES MOL

Ljubljana, pametno mesto

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Povzetek ključnih ugotovitev

V študiji smo analizirali dva scenarija znižanja emisij glede na referenčno leto 2008. **Ciljni scenarij predvideva znižanje emisij za 50%** in pomeni izpolnjevanje že sprejetih zahtev na ravni EU. Uresničimo ga lahko z izvajanjem naslednjih ukrepov in predpostavk:

- visoka stopnja energetskih prenov stavbnega fonda;
- prenova voznega parka v prometu;
- povečevanje deleža obnovljivih virov pri oskrbi z energijo;
- učinkovitejše energetsko izkoriščanje odpadkov;
- intenzivna prenova vodovodnega omrežja za zmanjševanje izgub.

Scenarij trajnostne odličnosti predvideva znižanje emisij za 80%, preseganje sprejetih ciljev in zavez ter preoblikovanje Ljubljane v trajnostno odlično, nizkoogljično prestolnico. Za njegovo uresničevanje morajo biti poleg zgoraj opisanih ukrepov izpolnjene še naslednje predpostavke:

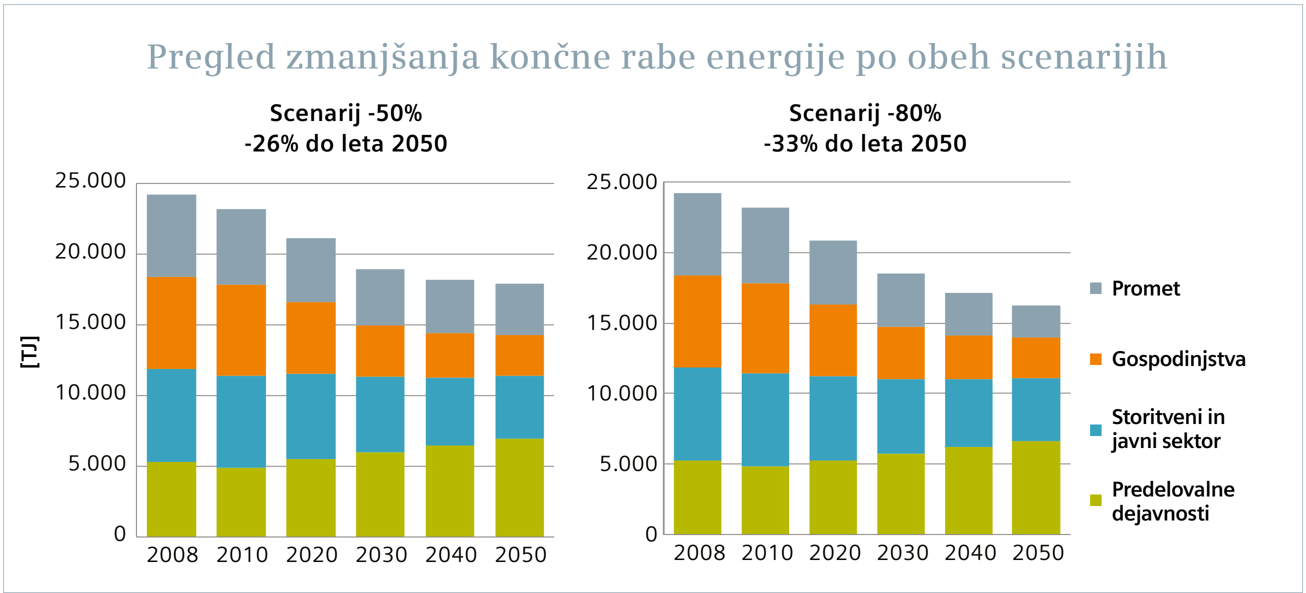
- v industriji se kot dodatni energent uporablja vodik;
- v oskrbi z energijo (proizvodnja toplote in električne energije) in industriji začnemo uporabljati tehnologije zajema in shranjevanja ogljika.

	Gospodinjstvo	Storitve	Industrija	Promet	Oskrba z energijo	Oskrba z vodo in ravnanje z odpadki
Scenarij -50%	enaka oba	enaka oba	V SPTE enotah predviden izključno zemeljski plin	Struktura voznega parka ohranja deleže iz 2030	Ni predvidenih tehnologij CCS	enaka oba
Scenarij -80%	scenarija	scenarija	V SPTE enotah predviden zemeljski plin, po letu 2015 tudi vodik	Predviden prodor hibridnih in vodikovih tehnologij	Predvidene tehnologije CCS	scenarija

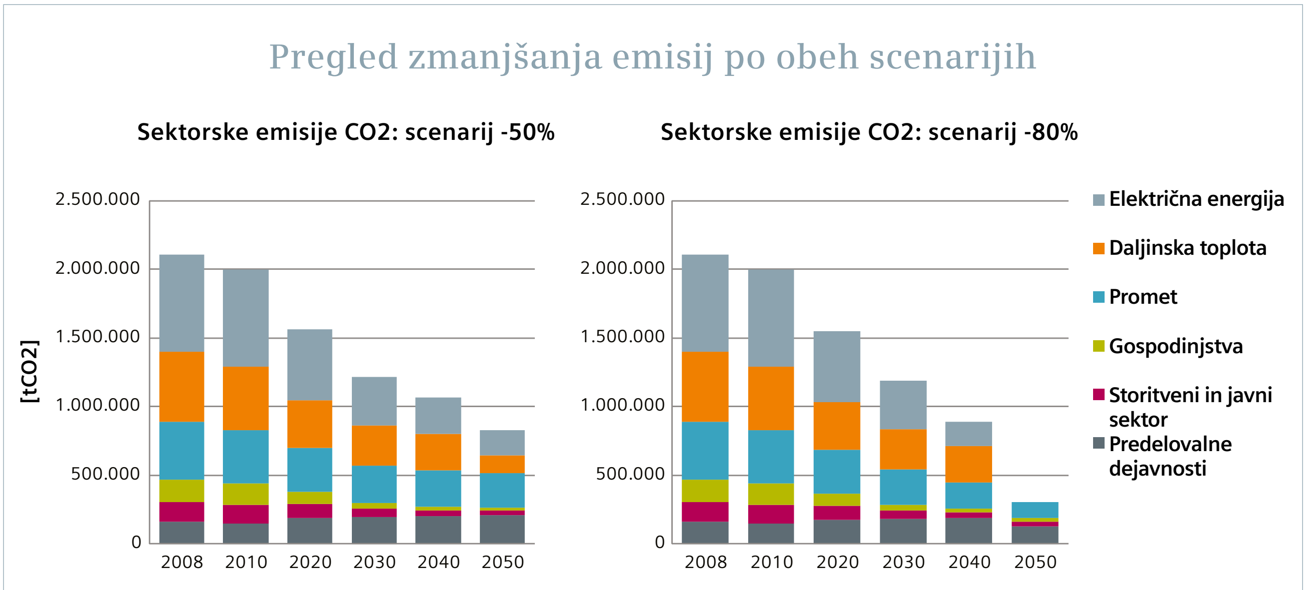
Slika 2: Pregled ukrepov obeh scenarijev po kategorijah

Ključne ugotovitve študije:

- **Ljubljana ima možnosti, da do leta 2050 doseže oba scenarija** (ciljni scenarij in scenarij trajnostne odličnosti), ne da bi se bilo treba njenim prebivalcem, organizacijam in uporabnikom storitev mesta kakorkoli odreči že doseženem udobju.
- Še več, **z investiranjem v nove tehnologije**, ki znižujejo rabo energije in emisije, **se lahko kakovost življenja in dela v Ljubljani močno poveča**. S tem lahko Ljubljana kot mesto postane še bolj konkurenčna v mednarodnem okolju.
- **Investicije v doseganje obeh ciljev niso nizke**, vendar pa imajo tiste, ki jih lahko opravi mestna uprava, **razmeroma kratek rok vračanja**. Poleg tega prinašajo investicije v energetsko učinkovitost razvoj tudi v kontekstu ustvarjanja novih virov prihodkov za podjetja in novih delovnih mest.



Slika 3: Pregled zmanjšanja končne rabe energije po obeh scenarijih



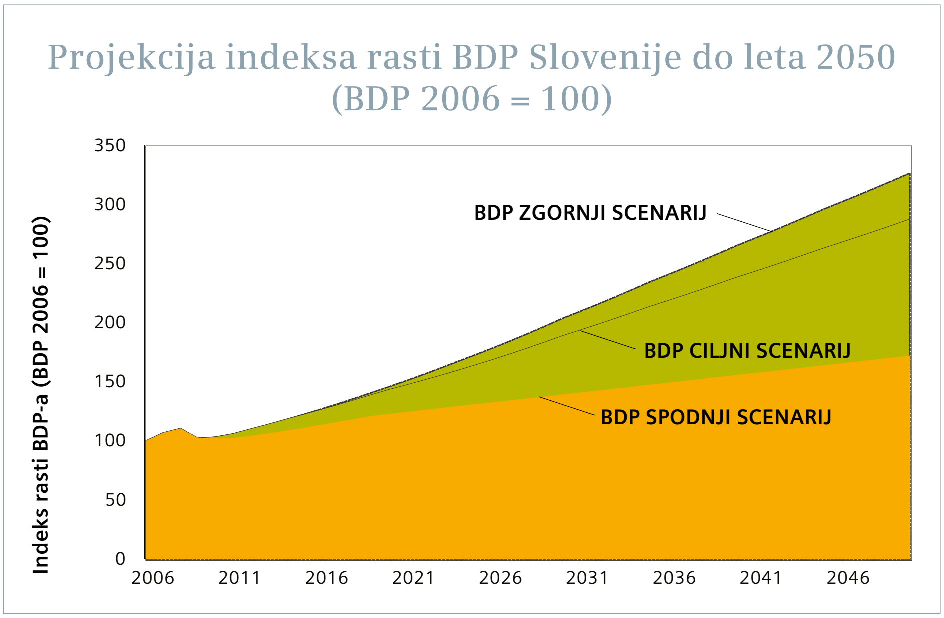
Slika 4: Pregled zmanjšanja emisij po obeh scenarijih

II. Vhodni podatki in predpostavke

V času močno spremenjenih in zaostrenih gospodarskih razmer so napovedi za desetletja v prihodnost lahko nehvaležne. Vseeno pa je bolje izkoristiti podatkovni in metodološki instrumentarij, ki nam je trenutno na voljo, kot pa pred prihodnostjo zaradi njene nepredvidljivosti povsem zatisniti oči. Projekcije v nadaljevanju tega gradiva so izdelane na podlagi veljavnih statistik slovenskega in mednarodnih statističnih uradov ter optimističnega predvidevanja, da se bo ekonomska kriza spreobrnila v konjunkturo. Vključujejo znana predvidevanja o pričakovanih tehnoloških spremembah in opisujejo, kakšni pogoji so potrebni, da Ljubljana doseže ambiciozne okoljske cilje.

Projekcija BDP do leta 2050

V izračunih je do leta 2030 upoštevan ciljni scenarij gospodarskega razvoja, ki so ga za predlog Nacionalnega energetskega programa pripravili strokovnjaki Urada Republike Slovenije za makroekonomske analize in razvoj (UMAR). Projekcija gospodarskega razvoja do leta 2050 temelji na predpostavki ohranjanja absolutne vrednosti rasti fizičnega proizvoda, ki je bila predvidena med letoma 2025 in 2030. Po spodbudnem začetku v letu 2007, ko je Slovenija dosegla rekordno gospodarsko rast, se je zaradi finančne krize in recesije na ključnih izvoznih trgih soočila z gospodarsko krizo. Gospodarska rast se je že v letu 2008 močno upočasnila, v letu 2009 pa je bila močno negativna (-8,1%) in bistveno nižja od pričakovanj. V skladu z izdelanimi projekcijami gospodarske rasti povprečna letna rast BDP-a v ciljnem scenariju za obdobje od 2010 do 2050 znaša 2,6%. Zaradi razmer na globalnih trgih in v regiji so napovedi gospodarskih gibanj v tem trenutku sicer izjemno negotove.

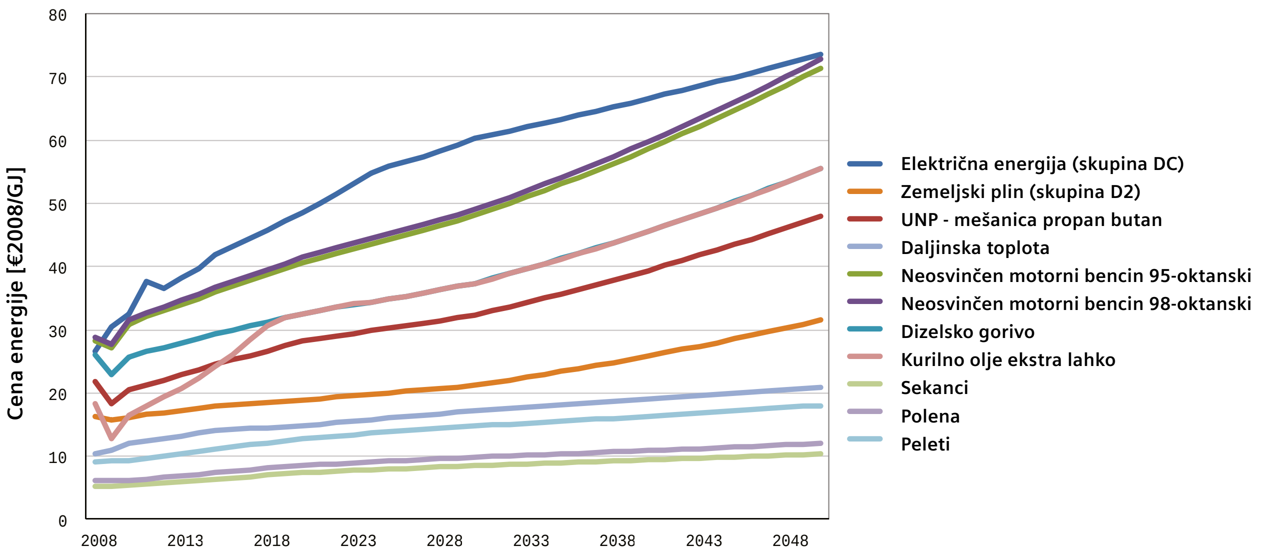


Slika 5: Projekcija indeksa rasti BDP Slovenije do leta 2050 (BDP 2006 = 100)

Projekcija cen energije do leta 2050

V izračunih do leta 2030 smo upoštevali projekcije cen energije iz predloga Nacionalnega energetskega programa (intenzivni scenarij, v katerem pristojne institucije preko reguliranih dejavnosti in davčne politike vplivajo na cene in ustvarjajo podporno okolje za izvedbo vseh donosnih projektov URE, OVE in SPTE ter pospešen razvoj na področju aktivnih omrežij).

Projekcija cen energije za tipično porabniško skupino za gospodinjstva (električna energija skupina DC, zemeljski plin D2) do leta 2050[1]

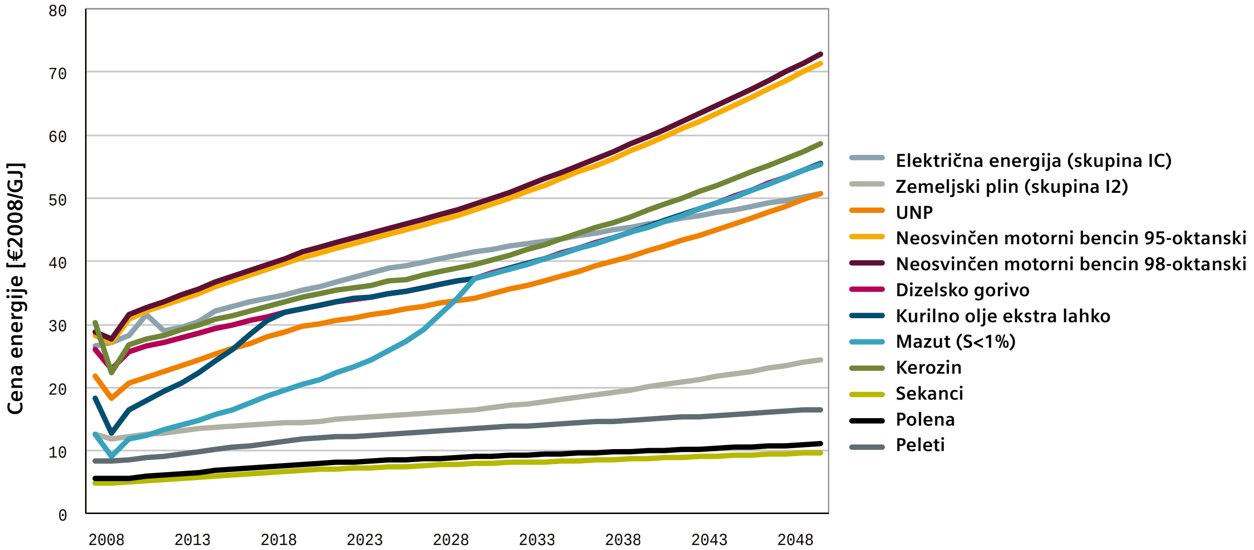


Slika 6: Projekcija cen energije za tipično porabniško skupino za gospodinjstva (električna energija skupina DC, zemeljski plin D2) do leta 2050[2]

[1] Cene so izražene v stalnih cenah 2008 (EUR2008) in ne vključujejo DDV.

Projekcija cen energije do leta 2050 temelji na predpostavkah nadaljnjega razvoja tehnologij in aktivnega izvajanja ukrepov za prehod v nizkoogljično družbo, ki so povzete po dostopnih mednarodnih študijah[1].

Projekcija cen energije za tipično porabniško skupino za industrijo (električna energija skupina IC, zemeljski plin I3) do leta 2050[2]



Slika 7: Projekcija cen energije za tipično porabniško skupino za industrijo (električna energija skupina IC, zemeljski plin I3) do leta 2050[3]

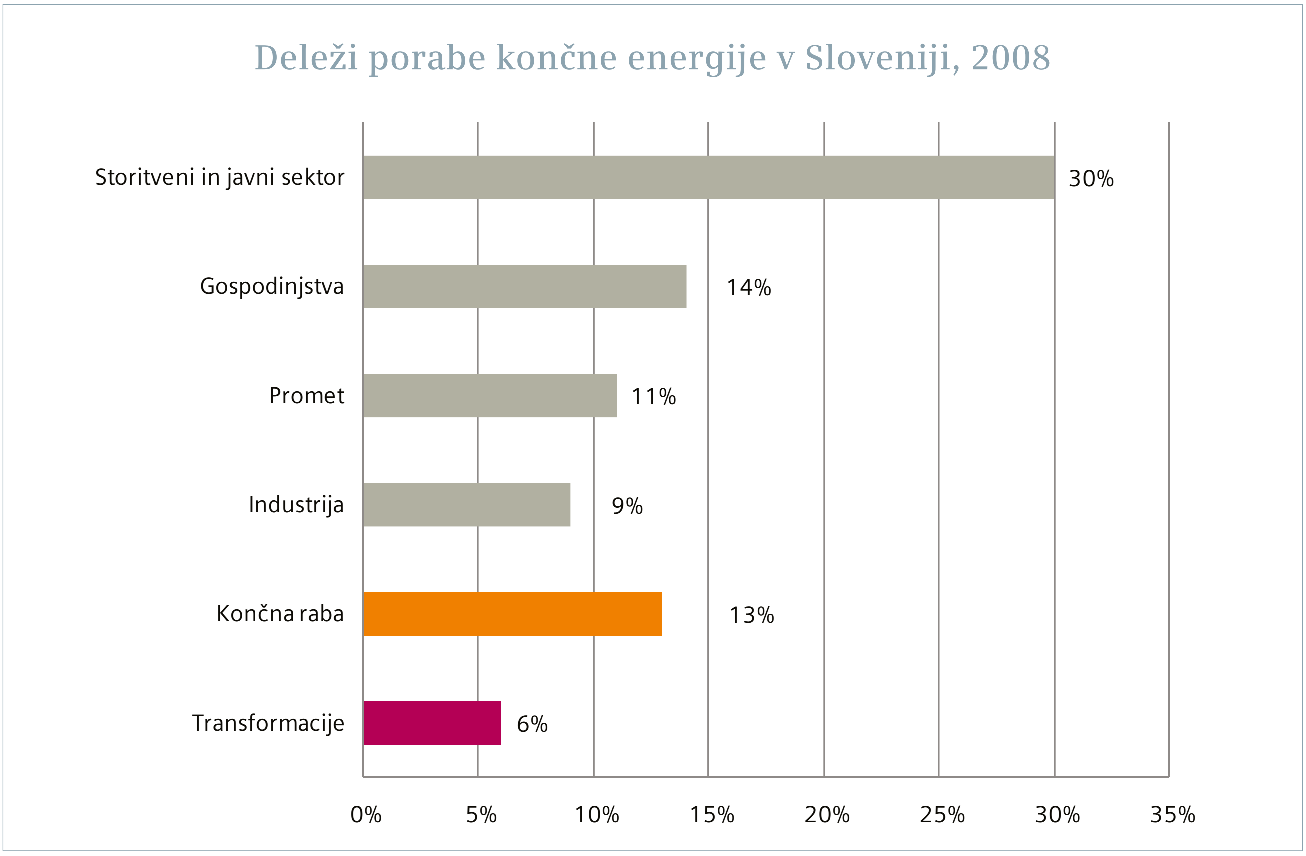
[1] Npr. Mednarodna agencija za energijo: Svetovne energetske perspektive 2010 – angl. World Energy Outlook 2010; Združenje Eurelectric: Energetske izbire – Poti v brezogljično proizvodnjo električne energije v Evropi do leta 2050, angl. Power Choices – Pathways to Carbon – Neutral Eletricity in Europe by 2050; Eurelectric 2010 ali WWF v sodelovanju z Ecofys in OMA (angl. The Office for Metropolitan Architecture): Energetsko poročilo – 100% obnovljivi viri energije do leta 2050, angl. The Energy Report – 100% Renewable Energy by 2050, WWF 2011).

[2] Cene so izražene v stalnih cenah 2008 (EUR2008) in ne vključujejo DDV.

Delež MOL v rabi energije v Sloveniji

V Mestni občini Ljubljana se porabi 13% končne energije v Sloveniji. Raba energije v stavbah v lasti MOL znotraj javnega sektorja predstavlja samo 14% tega deleža. Podatek potrjuje, da so tematike okoljske učinkovitosti Mestne občine Ljubljana in države Slovenije neločljivo povezane, saj:

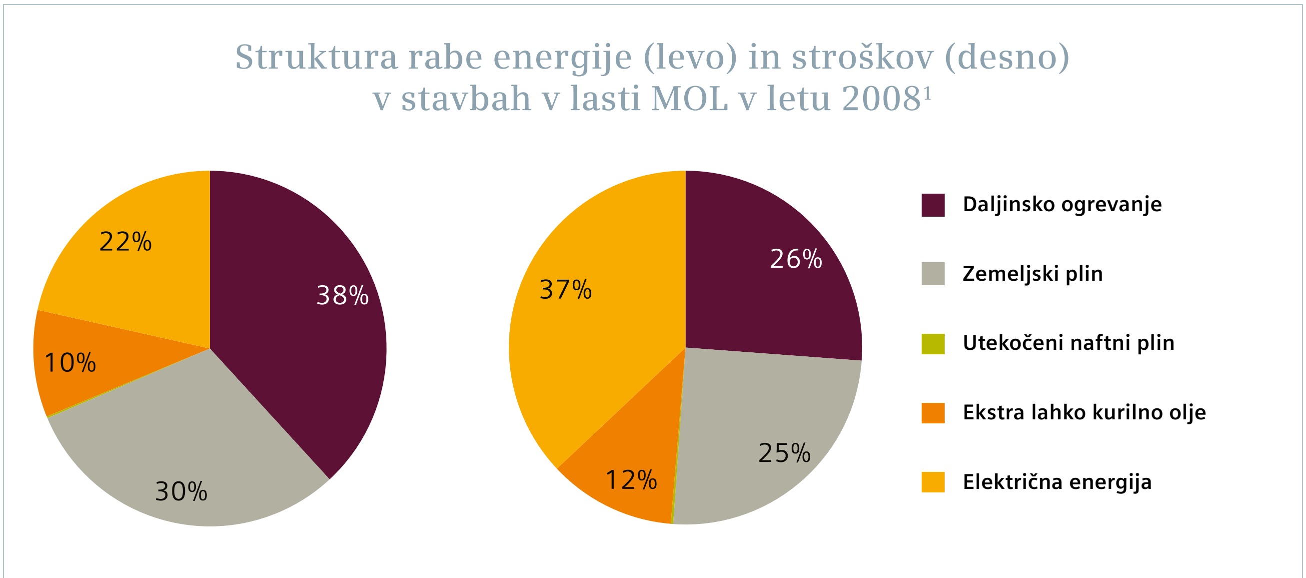
- ima Mestna občina Ljubljana visok delež v energetski porabi Slovenije,
- ima Mestna občina Ljubljana kot entiteta mestnega upravljanja zelo majhen končni vpliv na energetsko sliko mesta.



Slika 8: Deleži porabe končne energije v Sloveniji, 2008

Struktura rabe energije in stroškov v stavbah v lasti MOL

Za doseganje obeh razvojnih scenarijev (ciljnega scenarija in scenarija trajnostne odličnosti) mora biti prvi okoljski cilj Ljubljane širitev daljinskega ogrevanja in njegova nadgradnja na daljinsko hlajenje, ter krepitev deleža obnovljivih virov ali zemeljskega plina (preko zamenjave kotlovnic) v energetskem spletu na račun ekstra lahkega kurilnega olja. Slika namreč nazorno kaže razmerja med stroškovno in energetsko učinkovitostjo posameznih energentov, aplicirati pa jo je mogoče na katerokoli entiteto upravljanja.



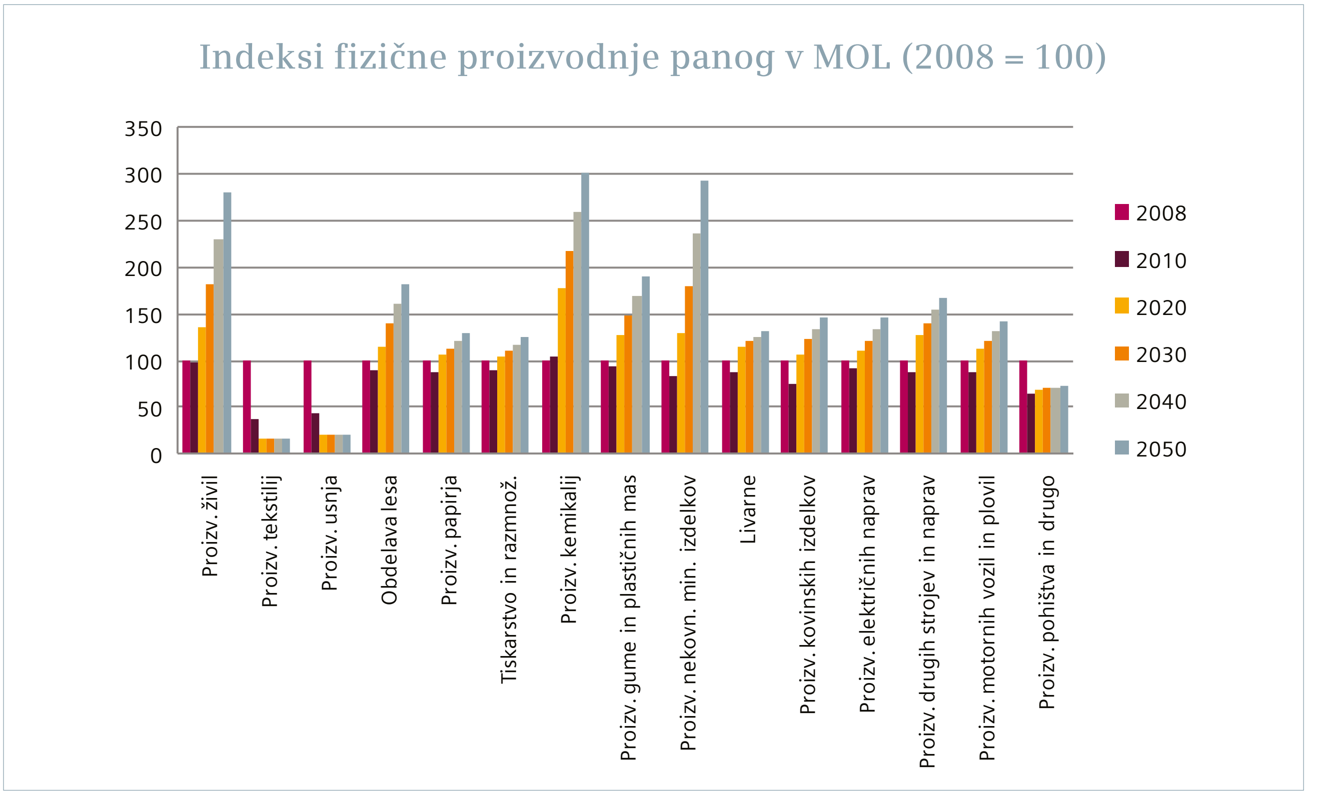
Slika 9: Struktura rabe energije (levo) in stroškov (desno) v stavbah v lasti MOL v letu 20084

[1] Vir: IJS-CEU, podatki URS, IE-Energis.

Struktura rabe energije in stroškov v industriji

V analizah smo predpostavili, da se **industrija ne bo selila v druge regije**, pač pa bo ostala v MOL ter zagotavljala delovna mesta in davčne prihodke, s tem pa rast in ekonomsko krepitev mesta.

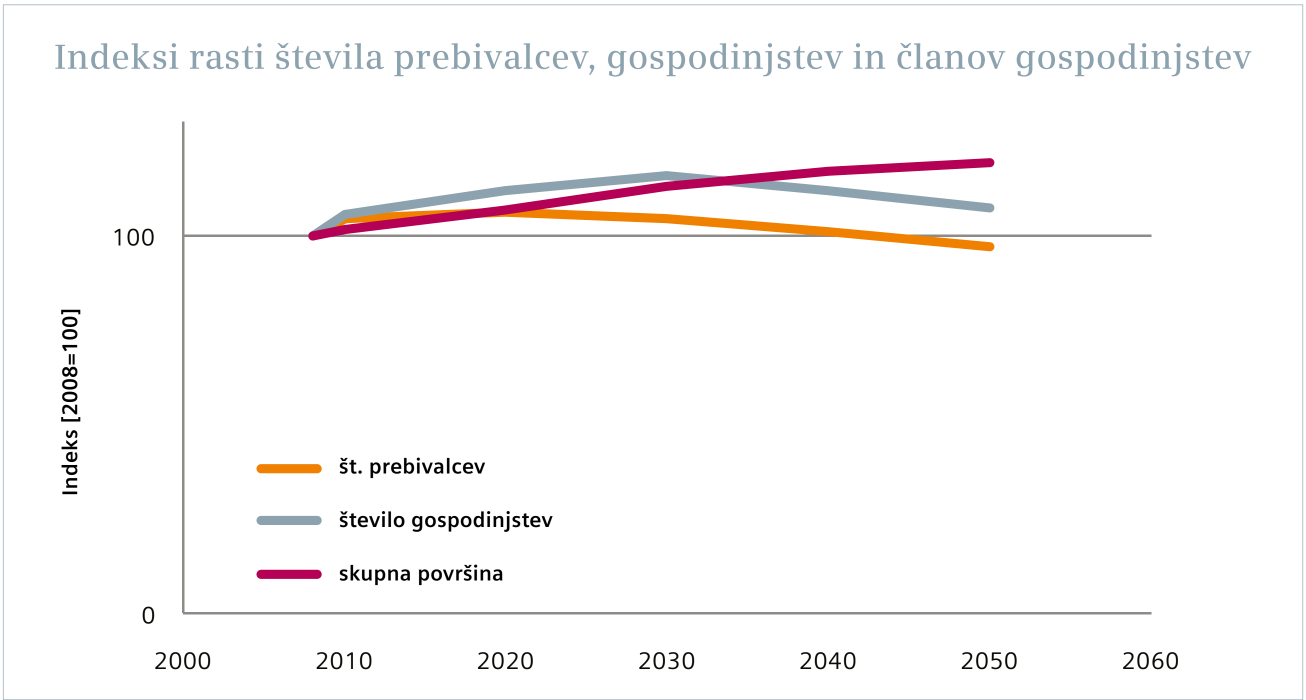
Najbolj bodo po predvidevanjih rasle proizvodnje živil, kemikalij in zdravil ter nekovinskih izdelkov. Industrija sicer **izkazuje visoke potenciale za energijske in emisijske prihranke**.



Slika 10: Indeksi fizične proizvodnje panog v MOL (2008 = 100)

Rast števila prebivalcev in gospodinjstev

Število prebivalcev naj bi se glede na demografske statistične projekcije (predvsem na račun staranja prebivalstva) v Ljubljani v naslednjih nekaj letih večalo, potem pa bo ostalo na podobni ravni. Gospodinjstva bodo imela vse manj članov, število gospodinjstev pa bo višje. To pomeni, da se bo v Ljubljani povečevalo število stanovanj. Potrebe po nekaterih storitvah (npr. šolstvo) se bodo zlagoma zmanjševale, po drugih (npr. zdravstvo) pa povečevale.



Slika 11: Indeksi rasti števila prebivalcev, gospodinjstev in članov gospodinjstev

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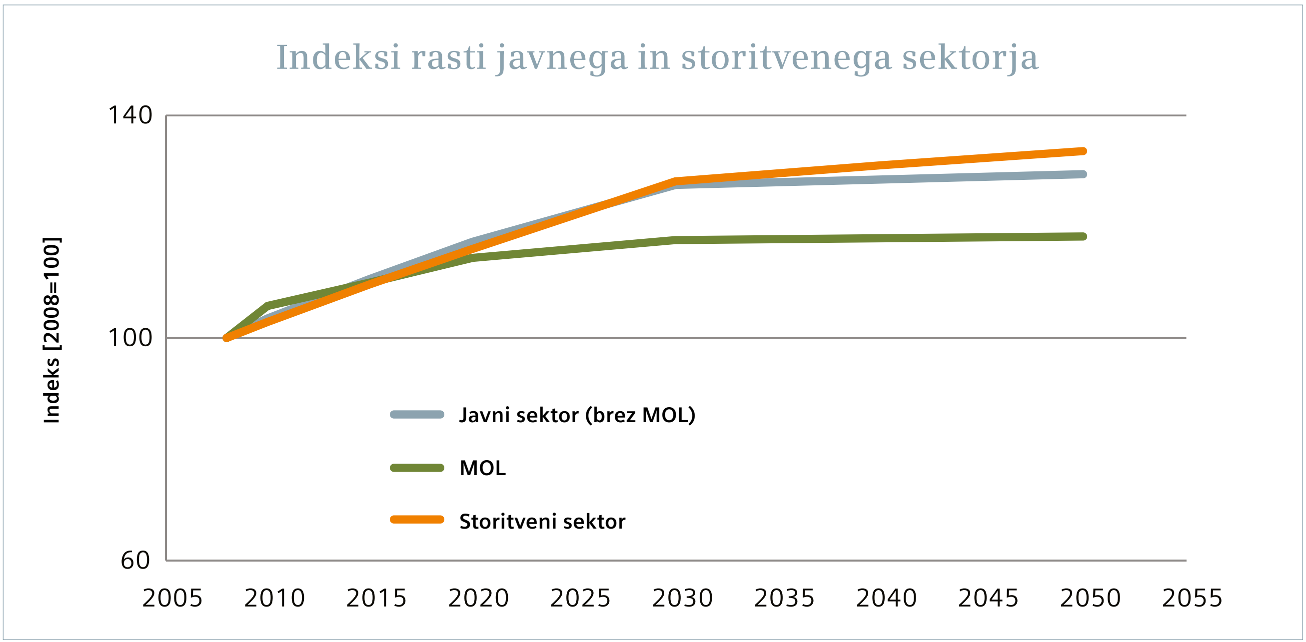
Ljubljana, pametno mesto

Stavbne površine javnega in storitvenega sektorja

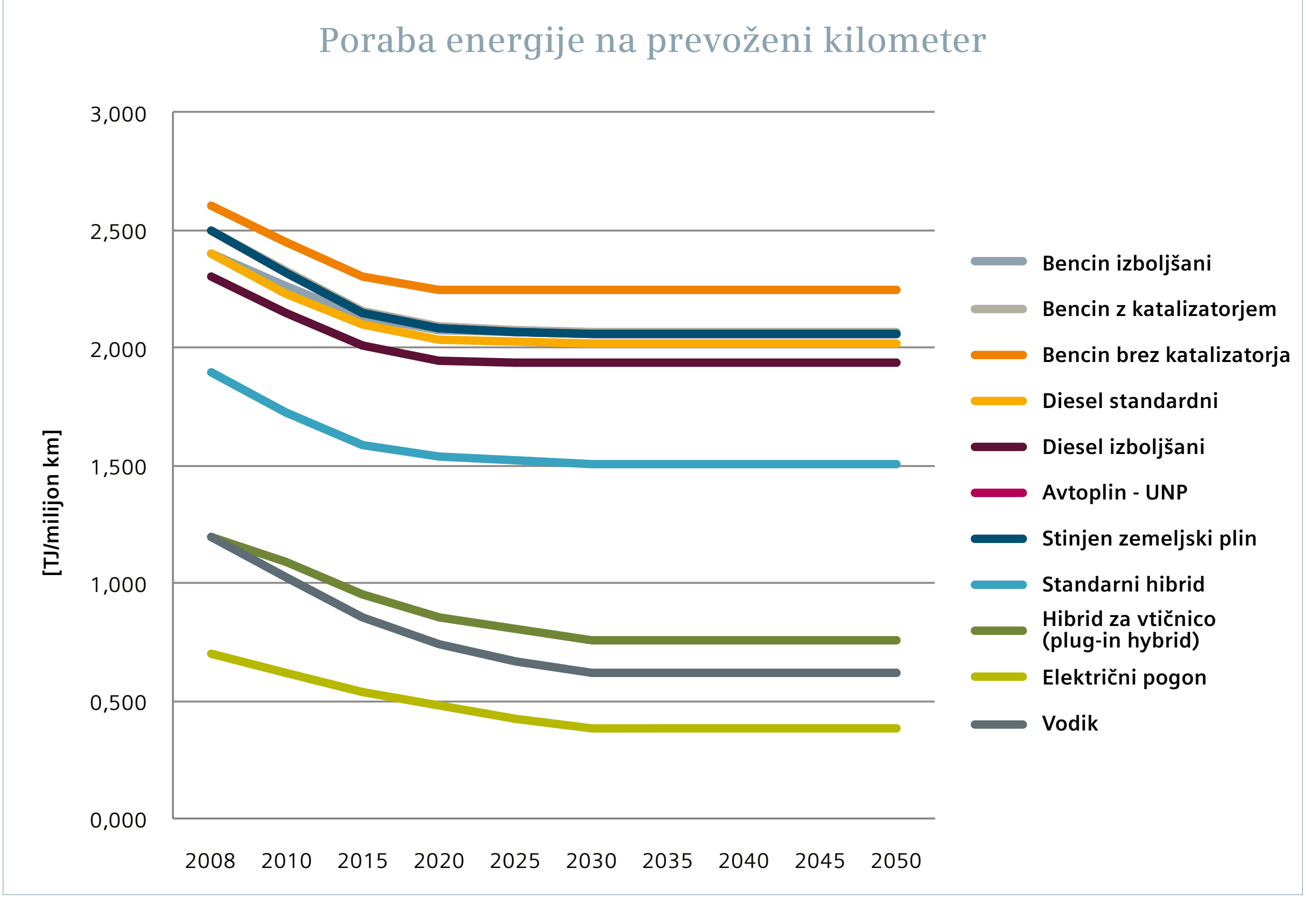
Javni in storitveni sektor bosta v Ljubljani še naraščala, predvsem zaradi demografskih trendov in trendov razvoja industrije v mestu, zato bosta potrebovala več površin. Rast sektorja bo pozitivno vplivala na rast Ljubljane kot mesta in na njen pomen v širšem okolju.



Slika 12: Indeksi rasti javnega in storitvenega sektorja

Promet – poraba na prevoženi kilometer

Izkoristek goriv bo z izboljševanjem tehnologij vedno večji. Do leta 2020 se bo povprečna specifična poraba vseh osebnih vozil glede na leto 2008 zmanjšala za 22%. Zmanjšanje je v največji meri posledica izboljševanja tehnologije bencinskih in dizelskih vozil (v povprečju za 18%). Med letoma 2020 in 2050 se bo povprečna specifična poraba vseh osebnih vozil glede na leto 2020 zmanjšala za nadaljnjih 20%, kar bo skoraj izključno posledica prodora novih tehnologij.



Slika 13: Poraba energije na prevoženi kilometer

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Ind. cona

III. Možnosti doseganja scenarijev

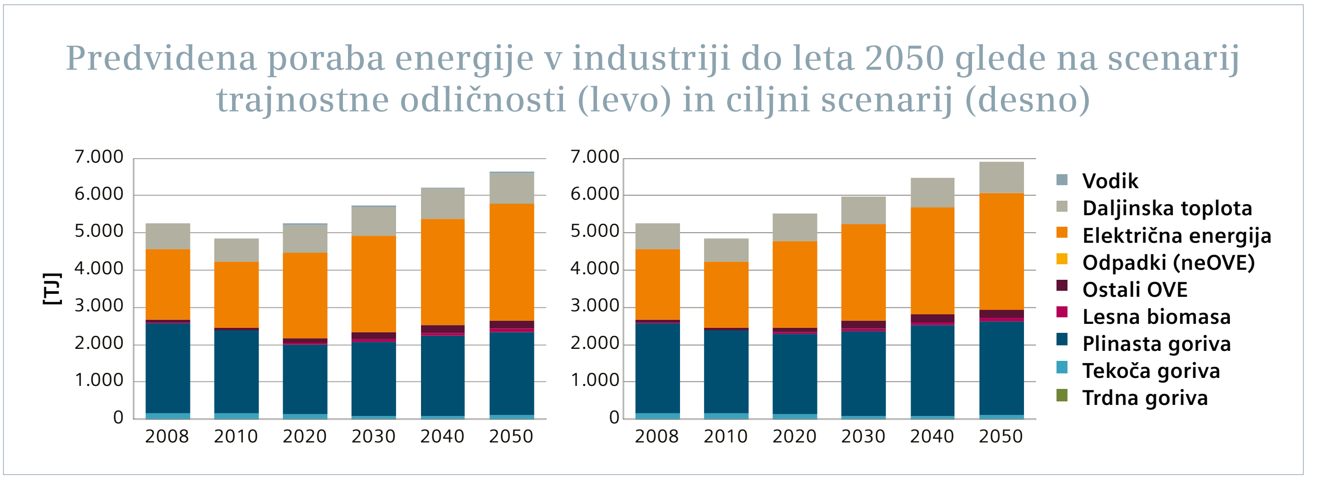
V študiji smo analizirali dva scenarija: ciljni scenarij, ki predvideva zmanjšanje emisij za 50%, ter **scenarij trajnostne odličnosti**, po katerem bi Ljubljana do leta 2050 zmanjšala emisije za 80%. Največ pozornosti smo posvetili oskrbi z energijo v industriji, gospodinjstvih in javnem ter storitvenem sektorju, podrobno smo analizirali tudi področje prometa. V tem poglavju opisujemo pogoje, potrebne za doseganje vsakega od scenarijev na različnih področjih, analiziramo potrebne ukrepe in tehnološke spremembe ter, kjer je možno, ocenjujemo finančne posledice uresničevanja posameznega scenarija.

Industrija – poraba energije

Poraba energije (še posebej električne) bo v industriji naraščala. Rast porabe energije v industriji na območju MOL je neposredno povezana z obsegom fizičnega proizvoda po posameznih panogah.

Ciljni scenarij (zmanjšanje emisij za 50%) je mogoče doseči z obsežnim izvajanjem ukrepov energetske učinkovitosti (ukrepi na toplotnih procesih in kotlih ter elektromotornih pogonih) ter z večanjem deleža obnovljivih virov energije. Delež plina in daljinske toplote mora ostati na približno enaki ravni kot danes (ne glede na siceršnje večanje potreb industrije).

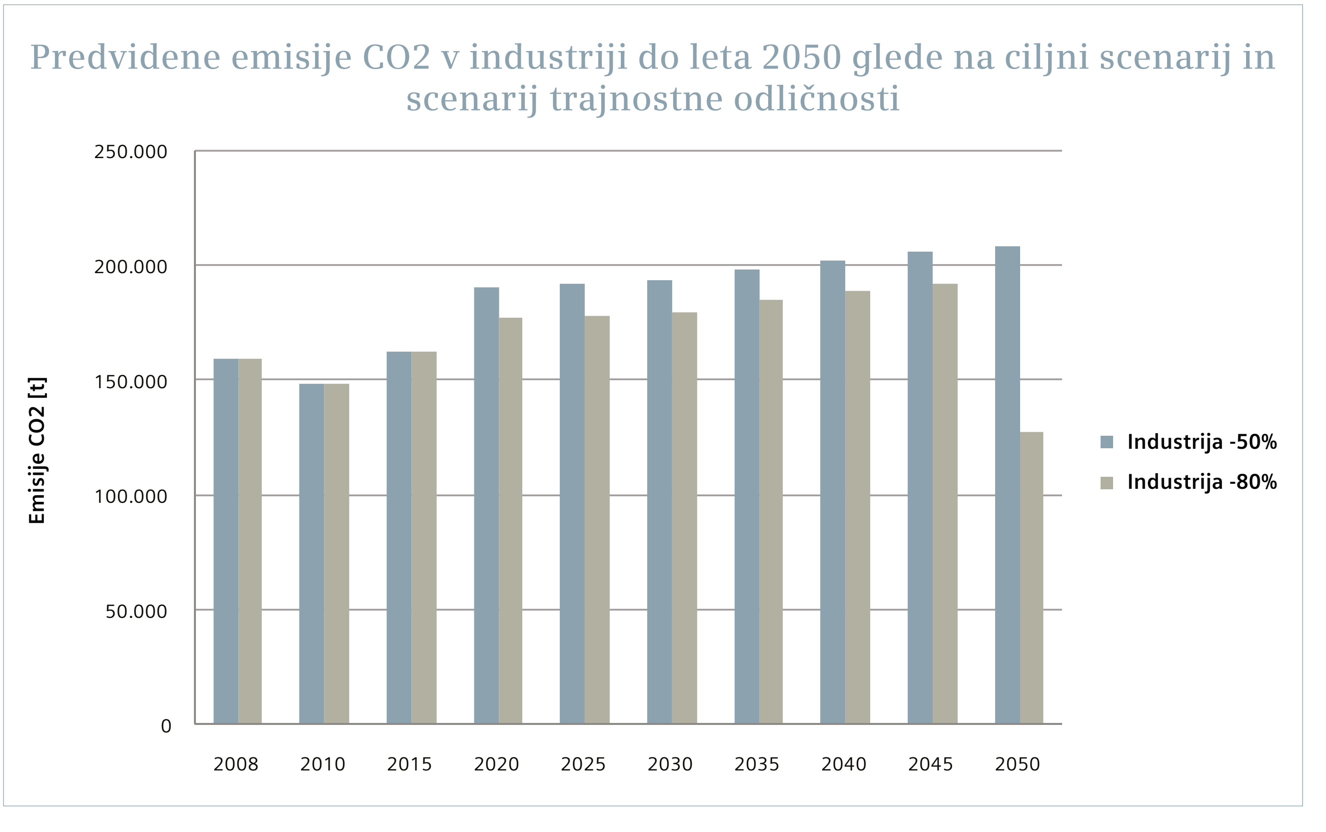
Scenarij trajnostne odličnosti (zmanjšanje emisij za 80%) bo Ljubljana lahko dosegla, če bodo industrijski proizvajalci poleg že omenjenih ukrepov energetske učinkovitosti začeli vlagati tudi v tehnologije, ki kot energent uporabljajo vodik. Delež ostalih energentov ostane v približno enakih razmerjih kot v ciljnem scenariju.



Slika 14: Predvidena poraba energije v industriji do leta 2050 glede na scenarij trajnostne odličnosti (levo) in ciljni scenarij (desno)

Industrija – emisije CO_2

V scenariju trajnostne odličnosti (zmanjšanje emisij za 80%) nosi industrija sorazmerno večji delež odgovornosti za doseganje emisijskih učinkov, **ključna vsebinska razlika je v novem energentu (vodik) ter uporabi tehnologij za zajem in shranjevanje ogljika (CCS).**

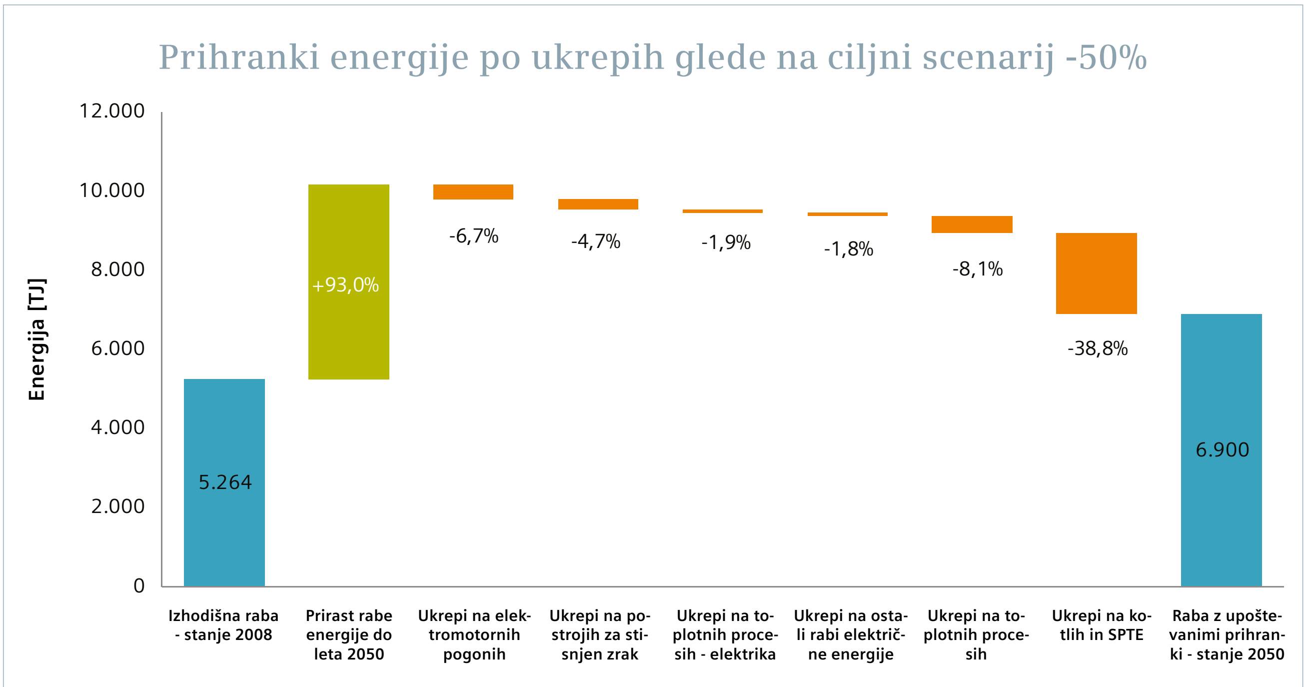


Slika 15: Predvidene emisije CO2 v industriji do leta 2050 glede na ciljni scenarij in scenarij trajnostne odličnosti

Emisije CO2 v industriji so za bazno leto 2008 znašale 158.955 t CO2. Do leta 2015 ni pomembnih razlik v doseganju obeh scenarijev. Po letu 2020 je za doseganje scenarija trajnostne odličnosti predviden prodor vodikovih tehnologij v industrijskih enotah za soproizvodnjo toplote in elektrike, kar bo prispevalo k dodatnemu znižanju emisij v primerjavi s ciljnim scenarijem. Zaradi predvidene uporabe tehnologij zajema in shranjevanja ogljika (CCS) v scenariju trajnostne odličnosti lahko dosežemo v letu 2050 občutno znižanje emisij CO2, kar za 20% glede na izhodiščno leto 2008 (ne glede na dejstvo, da bo industrija sicer okrepila svojo dejavnost in s tem relativno porabo energije).

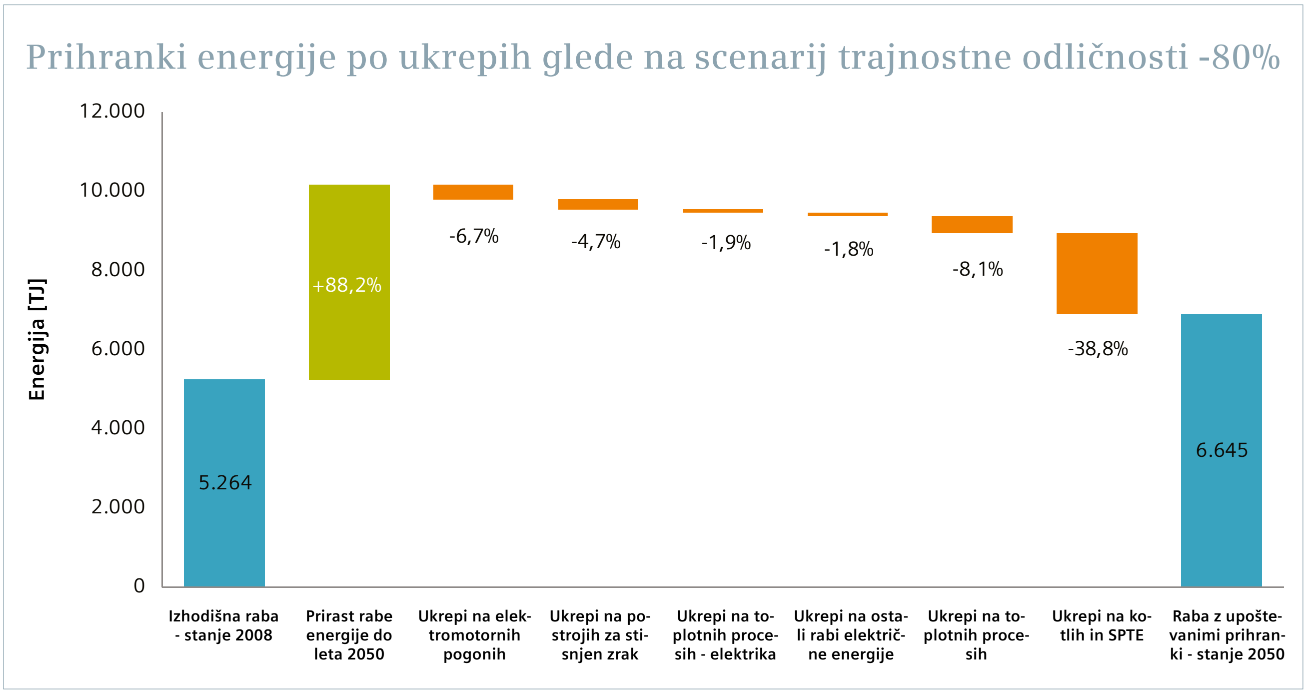
Industrija – ukrepi in njihovi učinki

V letu 2008 je industrija (sektor predelovalnih dejavnosti) na območju Mestne občine Ljubljana porabila 5.264 TJ energije. Zaradi širitve industrije smo v **ciljnem scenariju** do leta 2050 predvideli prirastek energije na +93% izhodiščne rabe (deloma na račun širitve dejavnosti, deloma pa tudi na račun neizvajanja ukrepov učinkovite rabe energije) ter zmanjšanje porabe za 62% glede na izhodiščno rabo in pričakovano rast. **Investicije**, potrebne za izvedbo ukrepov, smo ocenili na 22 milijonov EUR do leta 2030 in 52 milijonov EUR do leta 2050 (kumulativno).



Slika 16: Prihranki energije po ukrepih glede na ciljni scenarij

V **scenariju trajnostne odličnosti** se odstotki prihrankov ne razlikujejo od ciljnega scenarija, nižji je le predvideni prirastek končne energije (88,2%) v letu 2050 zaradi uporabe vodika, ki bo v enotah za soproizvodnjo toplote in elektrike nadomestil plin.

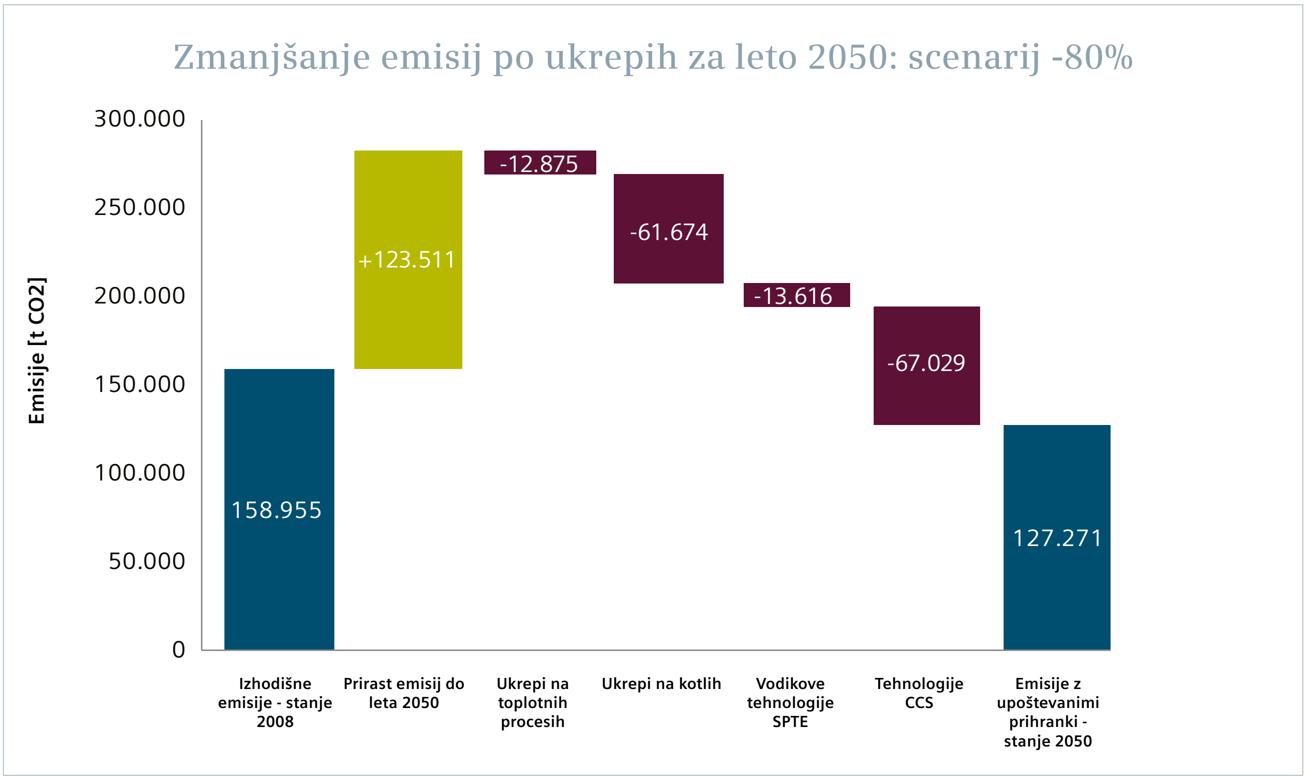


Slika 17: Prihranki energije po ukrepih glede na scenarij trajnostne odličnosti

Pregled ukrepov, ki bodo prispevali k večji okoljski učinkovitosti industrije:

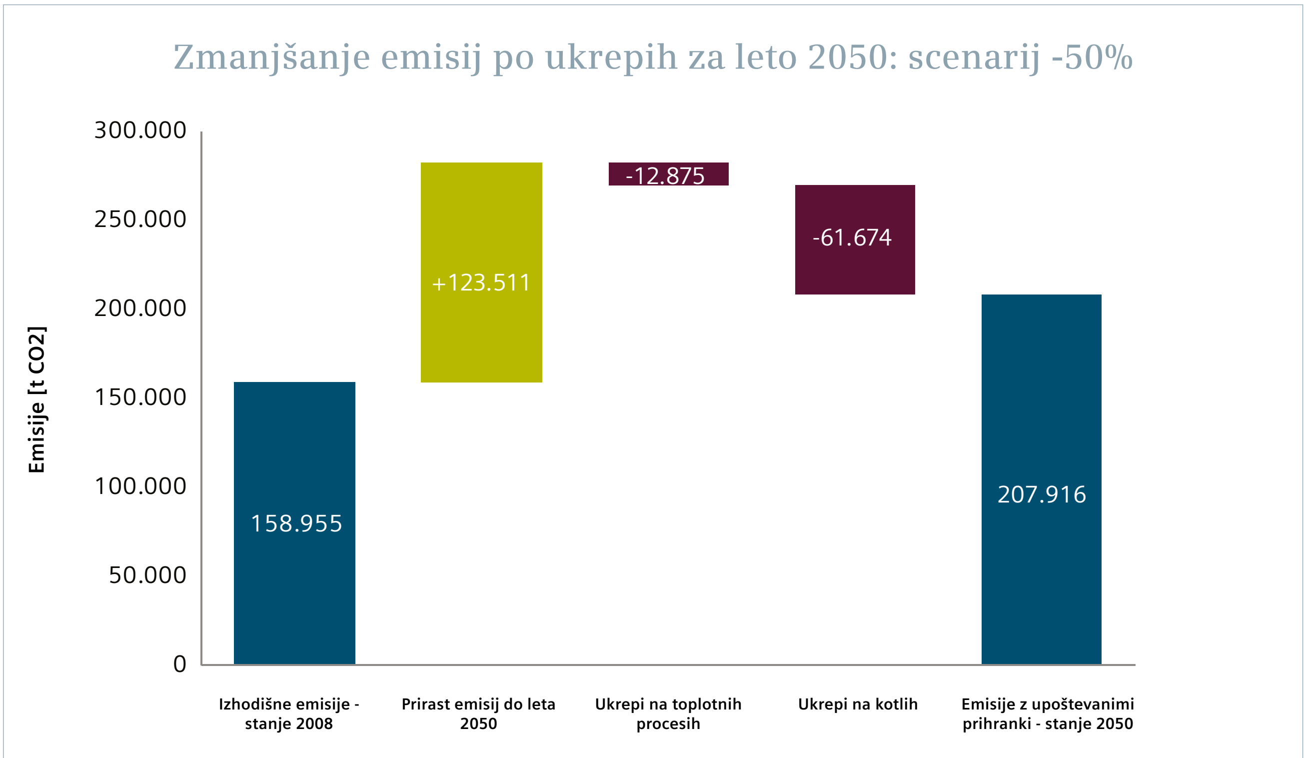
- **Ukrepi na elektromotornih pogonih: ocenjeni prihranek končne energije 6,7%** - izboljšanje učinkovitosti z rabo frekvenčne regulacije elektromotornih pogonov, uporaba energetsko učinkovitih elektromotorjev, črpalk in ventilatorjev.
- **Ukrepi na postrojih za stisnjen zrak: ocenjeni prihranek končne energije 4,7%** - zmanjševanje puščanj, optimizacija razvodov in optimizacija regulacije za zmanjšanje porabe stisnjenega zraka.
- **Ukrepi na toplotnih procesih (elektrika): ocenjeni prihranek končne energije 1,9%** - uvajanje energetskega knjigovodstva in spremljanja porabe, usposabljanje zaposlenih, izboljšano vzdrževanje, zamenjava in posodobitev naprav (nova tehnologija).
- **Ukrepi na ostali rabi električne energije: ocenjeni prihranek končne energije 1,8%** - varčna razsvetljava, uvajanje energetskega knjigovodstva in spremljanja porabe, usposabljanje zaposlenih, izboljšano vzdrževanje, zamenjava in posodobitev naprav (nova tehnologija).
- **Ukrepi na toplotnih procesih (toplota): ocenjeni prihranek končne energije 8,1%** - uvajanje energetskega knjigovodstva in spremljanja porabe, usposabljanje zaposlenih, izboljšano vzdrževanje, optimizacija transporta in zmanjšanje potreb po transportu, optimizacija voznega parka (znižanje specifične porabe, prehod na druge energente), zamenjava in posodobitev naprav (nova tehnologija).
- **Ukrepi na kotlih, SPTE in kurilnih napravah: ocenjeni prihranek končne energije 38,8%** – ukrepi izboljšav na kotlih in zamenjava ter posodobitev naprav (nova tehnologija).

Posledica učinkovite rabe energije bo tudi zmanjšanje emisij. Oba scenarija predvidevata prirastek emisij za 123.511 t CO2 do leta 2050, vendar pri scenariju trajnostne odličnosti zaradi drugačnega spleta tehnologij, uporabe vodikovih tehnologij in tehnologij CCS lahko dosežemo zmanjšanje emisij za 155.252 t CO2, kar je 20% prihranek glede na referenčno leto 2008.



Slika 18: Gibanje emisij po ukrepih glede na scenarij trajnostne odličnosti

Pri ciljnem scenariju pa beležimo kljub ukrepom učinkovite rabe energije (ukrepi na toplotnih procesih in kotlih) povečanje emisij CO2 za 48.961 t CO2.



Slika 19: Gibanje emisij po ukrepih glede na ciljni scenarij

Industrija – zgodba o uspehu

Energetsko učinkovita proizvodnja papirja

Papirnica Vevče sodi med najstarejše industrijske obrate v Sloveniji. Ustanovljena je bila 1842 (torej letos praznuje 170-letnico delovanja), med drugim je za svoje delovanje uporabljala tudi eno najstarejših slovenskih elektrarn, danes pa proizvede skoraj 90.000 ton papirja za embalažo in etikete na leto. V papirnici so že stopili tudi na pot energetske učinkovitosti.

Frekvenčni pretvorniki v industriji igrajo podobno vlogo kot prestave pri avtomobilu – motorjem omogočajo, da so obremenjeni optimalno, proizvodnja pa je tako učinkovitejša in fleksibilnejša. Ker motorji ne delajo s polno zmogljivostjo 24 ur na dan, porabijo tudi manj energije.

»V vsakem primeru bi začeli postopoma nadomeščati našo tehnologijo z bolj energetsko učinkovitimi napravami, dodatno pa nas je k temu spodbudila možnost pridobivanja sredstev v okviru razpisa Ministrstva za gospodarstvo,« razlaga Andrej Smrekar, vodja tehnike v Papirnici Vevče: »Industrijske motorje sproti zamenjujemo z bolj učinkovitimi, poleg tega pa smo izključno zaradi doseganja energetskih prihrankov v lanskem letu proizvodnjo opremili s Siemensovimi frekvenčnimi pretvorniki. Iz istega razloga smo deloma zamenjali tudi osvetlitev – zunanja osvetlitev uporablja LED tehnologijo, notranja pa energetsko varčnejše sijalke.«

Učinki so bili takojšnji – v Papirnici Vevče jih redno spremljajo in vrednotijo, doseženi prihranki so odvisni od tipa opreme. »Z orodji, dostopnimi na Siemensovi spletni strani, smo izračunali, da se nam, denimo, investicija v frekvenčne pretvornike povrne v 5 do 22 mesecih. Poleg tega bomo predvidoma v enem letu od uvedbe novih tehnologij prihranili 1500 megavatnih ur elektrike,« še dodaja Smrekar.

vir: Delo, 30.3.2012

Gospodinjstva – poraba energije v stavbah

Največji delež energije v gospodinjstvu se porabi za ogrevanje in toplo vodo, sledi energija za gospodinjske aparate.

Ljubljana lahko doseže ciljni scenarij in scenarij trajnostne odličnosti z energetsko obnovo objektov, zamenjavo virov za ogrevanje, toplo vodo in kuhanje v gospodinjstvih ter z izboljšanjem energetske učinkovitosti aparatov in razsvetljave.

Z izvajanjem teh ukrepov lahko Ljubljana:

– **za 65% zmanjša porabo energije** za pripravo toplote za ogrevanje, toplo vodo in kuhanje v gospodinjstvih;

– **za 85% zmanjša emisije**, ki jih povzroči energija za pripravo toplote za ogrevanje, toplo vodo in kuhanje;

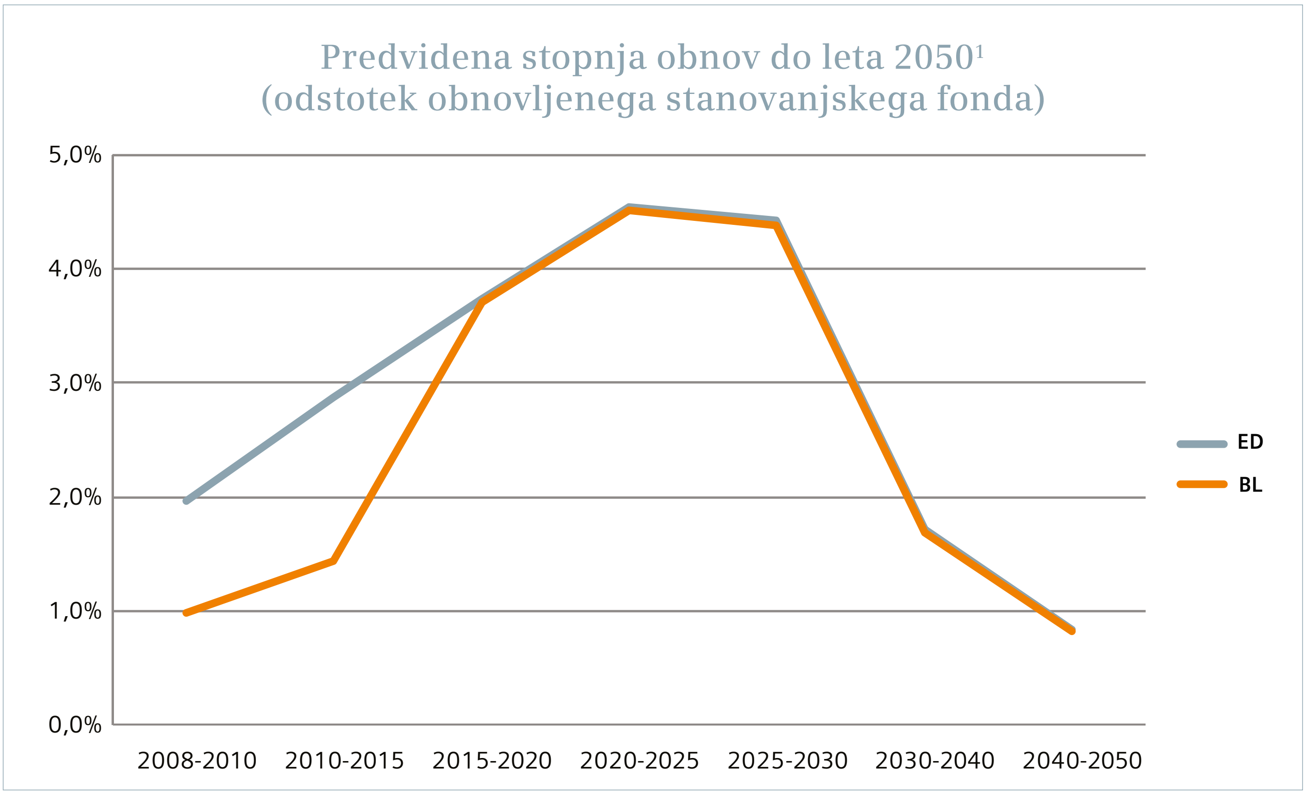
– na račun večje energetske učinkovitosti gospodinjskih aparatov lahko do 2050 **dodatno zmanjša rabo energije za 4%**.

Ker tovrstnih ukrepov ni možno administrativno predpisati, je bistveno še osveščanje prebivalcev in razvoj finančnih produktov (ugodni krediti, energetsko pogodbeništvo), ki lahko stimulirajo odločitve posameznikov (lastnikov stanovanj) in organizacij (investitorjev, finančnih ustanov, upraviteljev in drugih subjektov).

Investicije za celovito prenovo stavbenega fonda v sektorju gospodinjstva so do leta 2050 ocenjene na 3,1 milijard EUR od tega 1,95 milijard EUR za enodružinske hiše in 1,15 milijard EUR za večstanovanjske objekte.

Gospodinjstva – obnove stavb kot vzvod zmanjševanja porabe energije

Danes obnovimo v povprečju 1,6% stanovanj letno. Da bi dosegli kateregakoli od scenarijev, bi se stopnja obnov stanovanj morala več kot dvakrat povečati, s čimer bi do leta 2030 obnovili večino stavbnega fonda. Po tem obdobju bi se lahko stopnja obnov predvidoma precej zmanjšala.



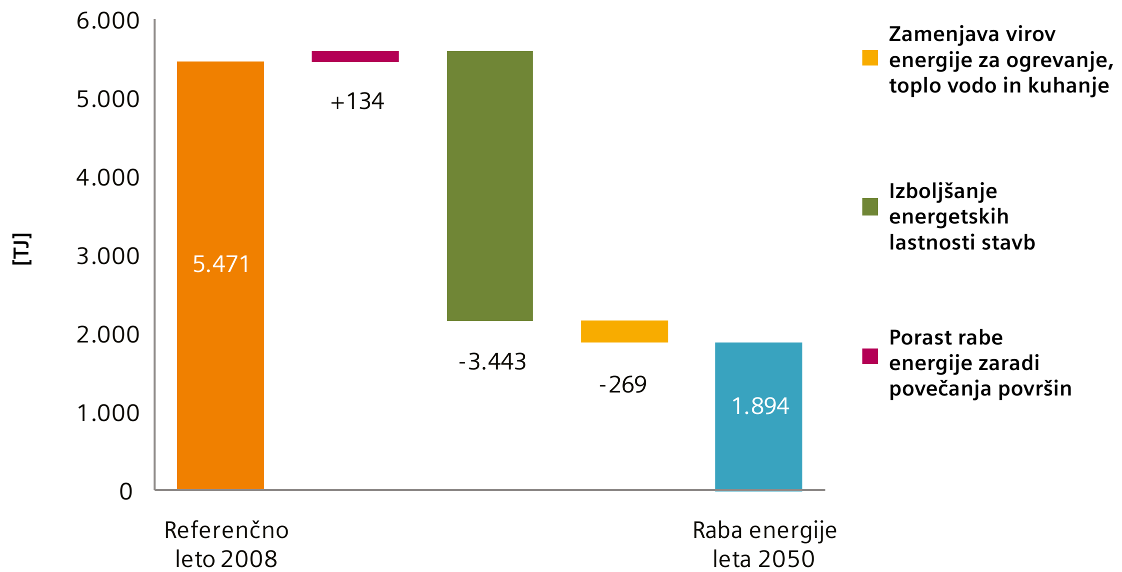
Slika 20: Predvidena stopnja obnov do leta 2050 (odstotek obnovljenega stanovanjskega fonda)

[1] ED je kratica za enodružinske stavbe, BL pa za večstanovanjske objekte.

Gospodinjstva – ukrepi in njihov prispevek k nižanju porabe energije

Posledica povečanja energetske učinkovitosti stavb bo tudi zmanjšanje rabe končne energije pri pripravi toplote za ogrevanje, toplo vodo in kuhanje. Največji (kar 96%) delež v nižanju rabe energije ima izboljšanje energetskih lastnosti stavb. **Raba energije se lahko v tem segmentu do 2050 zmanjša za 65%, emisije pa kar za 85%[1].**

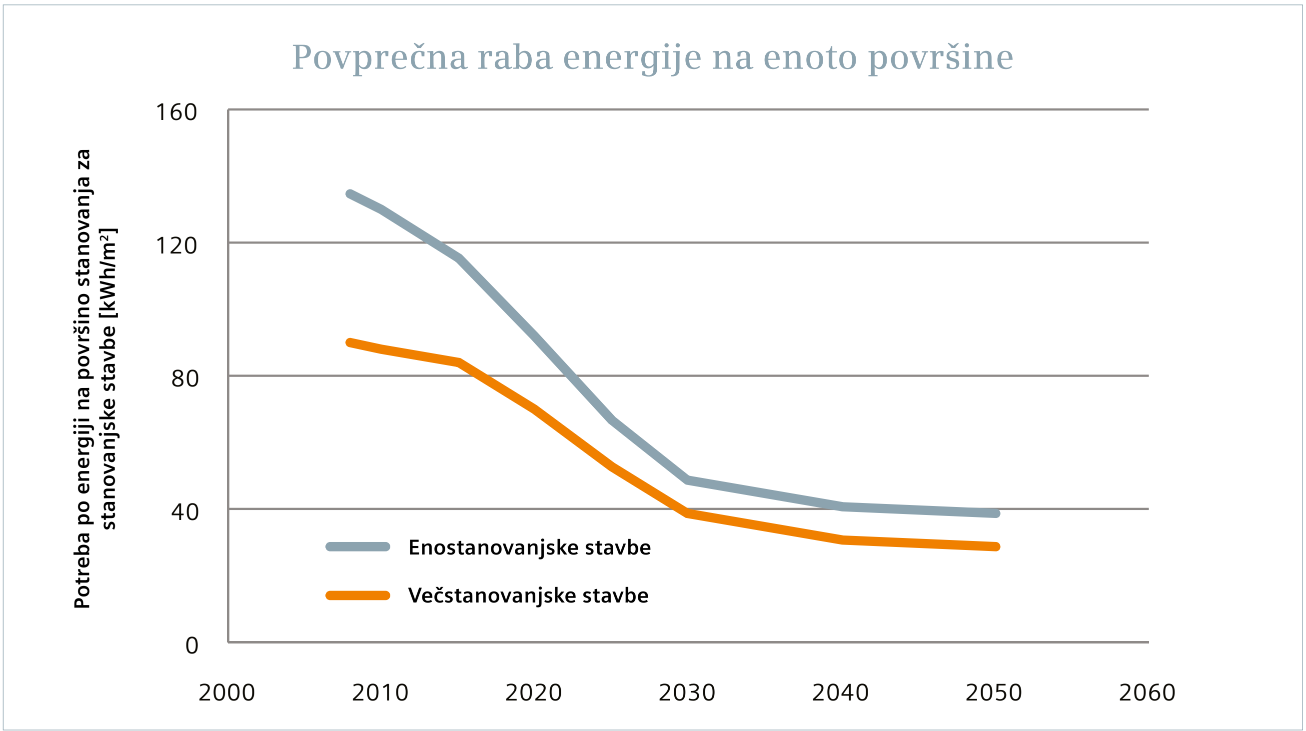
Zmanjšanje rabe končne energije pri pripravi toplote za ogrevanje, toplo vodo in kuhanje v gospodinjstvih



Slika 21: Gibanje porabe končne energije po ukrepih do leta 2050

[1] V izračunu zmanjšanja emisij so upoštevani tudi učinki izboljšanega deleža obnovljivih virov energije v energetskem spletu.

Obnovljena stanovanja bodo za ogrevanje potrebovala v povprečju **3 krat manj energije kot danes**. Izboljševale se bodo tudi energetske lastnosti novo zgrajenih stavb, predvsem na podlagi že uvedenih administrativnih ukrepov (PURES).

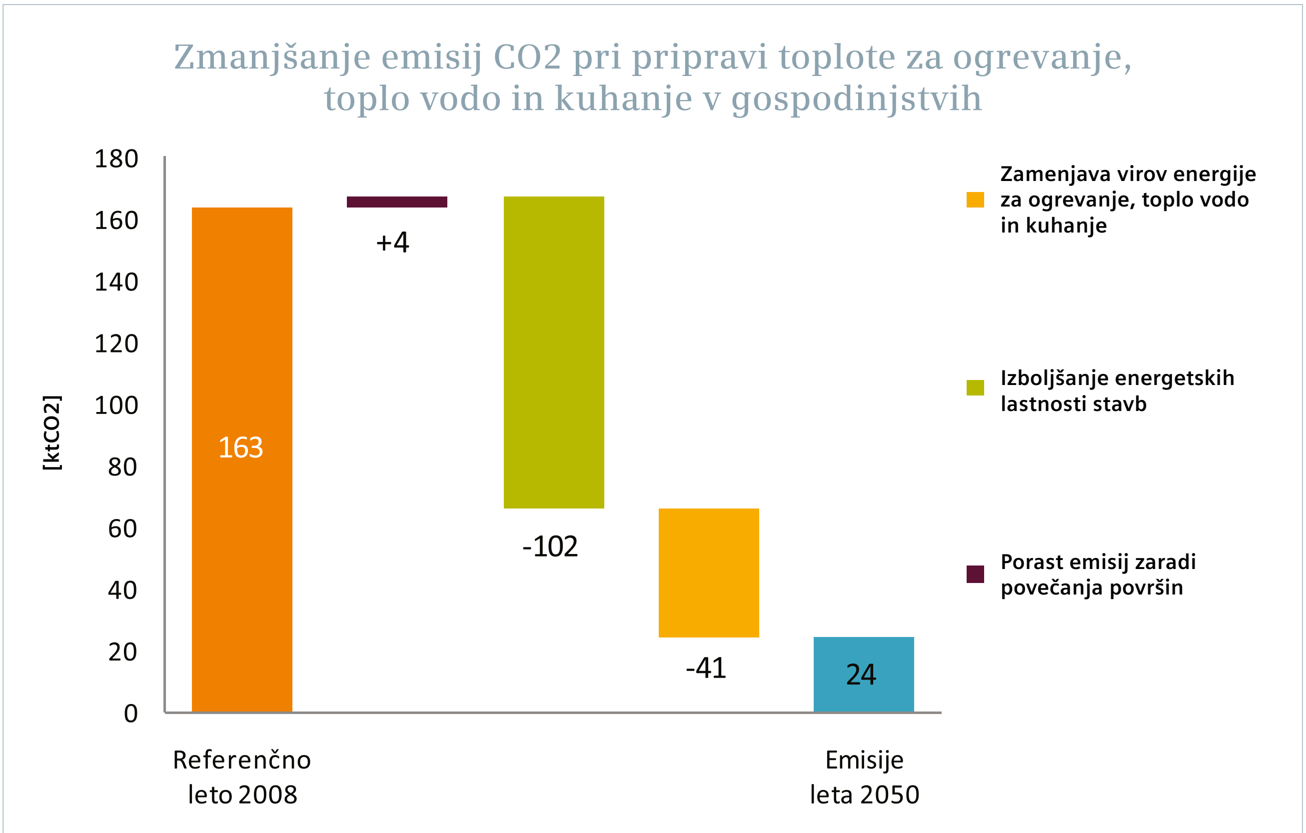


Slika 22: Povprečna raba energije na enoto površine gospodinjstva do leta 2050

Gospodinjstva – nižanje emisij

Emisije CO2 zaradi rabe fosilnih goriv pri pripravi toplote za ogrevanje, toplo vodo in kuhanje so leta 2008 znašale 163 kt. **Do leta 2050 se bodo zmanjšale na 24 kt oziroma za 85% glede na leto 2008**.

K zmanjšanju bo največ prispevalo izboljšanje energetskih lastnosti stavb, sledi zamenjava virov energije, pri čemer so upoštevani tudi obnovljivi viri.

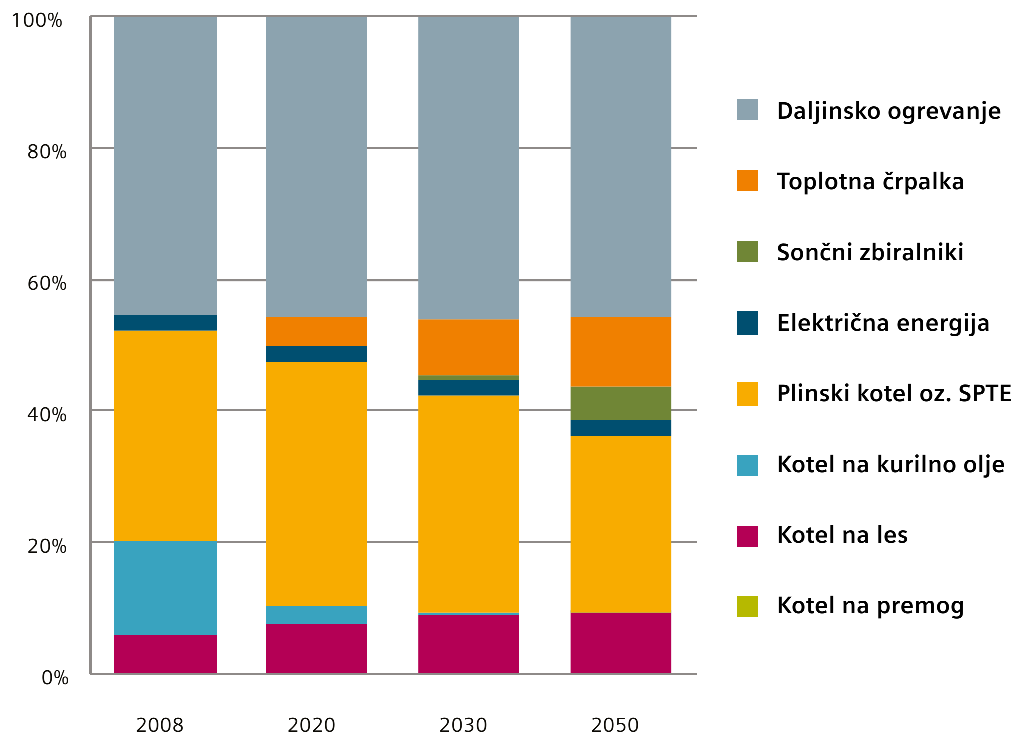


Slika 23: Gibanje emisij CO2 pri pripravi toplote za ogrevanje, toplo vodo in kuhanje v gospodinjstvih po ukrepih do leta 2050

Gospodinjstva – tehnologije za ogrevanje in pripravo tople vode

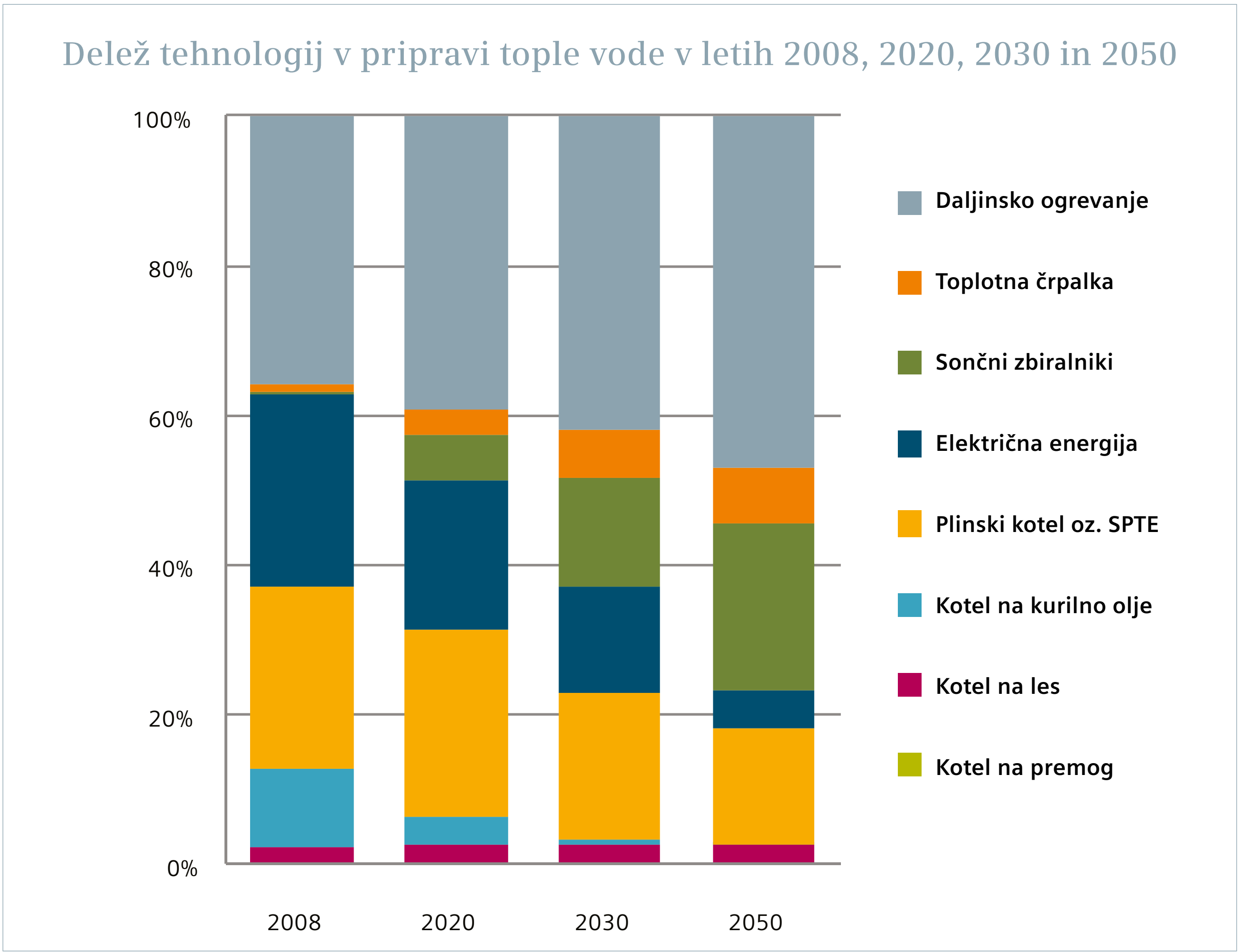
Za uresničevanje obeh scenarijev je pomembna tudi struktura tehnologij za ogrevanje stanovanj in pripravo tople vode, kjer bomo priča temeljitim spremembam. Leta 2008 ima največji delež daljinsko ogrevanje, ta vrednost se bo v prihodnjih obdobjih ohranila na enaki ravni. Drugi največji delež imajo plinski kotli (na utekočinjeni naftni plin ali zemeljski plin), katerih uporaba se bo, kljub temu, da je to okolju najbolj prijazno fosilno gorivo, do leta 2050 zmanjšala, nadomeščale jih bodo mikro enote za soproizvodnjo toplote in elektrike.

Delež tehnologij v pripravi potrebne energije za ogrevanje v letih 2008, 2020, 2030 in 2050



Slika 24: Delež tehnologij v pripravi potrebne energije za ogrevanje v letih 2008, 2020, 2030 in 2050

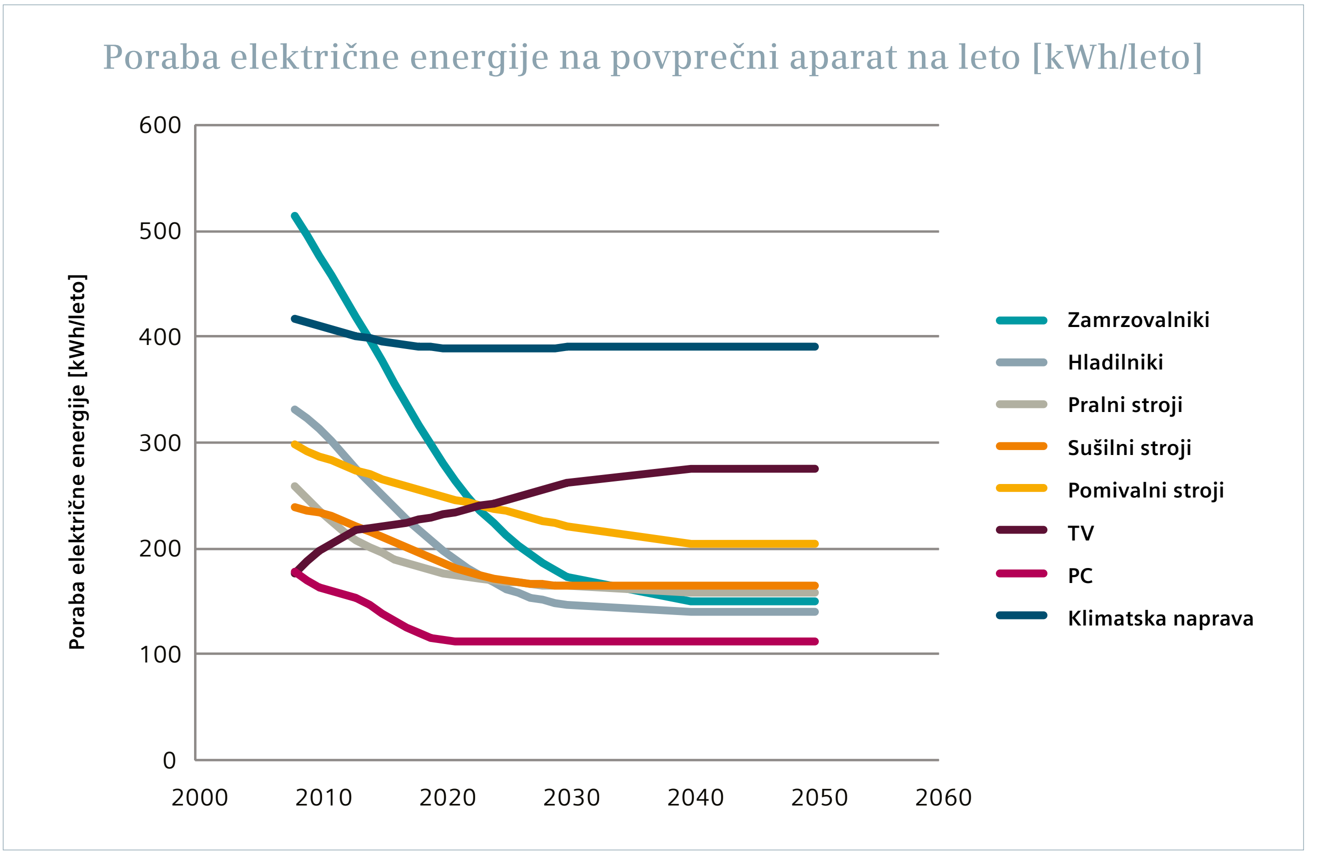
Še bolj drastično je zmanjšanje deleža pri kotlih na kurilno olje, ki jih po letu 2030 skoraj ne bo več. Povečal se bo delež lesa, uporabe sonca ter v največji meri toplotnih črpalk.



Slika 25: Delež tehnologij v pripravi tople vode v letih 2008, 2020, 2030 in 2050

Gospodinjstva – manjšanje rabe energije za delovanje električnih aparatov

Električni gospodinjski aparati sicer predstavljajo manjši delež pri energetskih prihrankih. Nove tehnologije bodo prispevale, da bodo energetsko precej varčnejši, kot so danes, največja razlika bo v kategoriji zamrzovalnikov in hladilnikov.



Slika 26: Poraba električne energije na povprečni aparat na leto (KWh/leto)

Gospodinjstva – zgodba o uspehu

Energetska prenova večstanovanjskih stavb

Javni stanovanjski sklad MOL je leta 2007 prenovil dve večstanovanjski stavbi z namenom znižanja obratovalnih stroškov ob ohranitvi kakovosti bivanja. Izvedena je bila dodatna toplotna zaščita ovoja stavb (zunanje stene, strop nad kletjo, strop proti neogrevanemu podstrešju, balkoni), zamenjana so bila okna, vgrajena so bila senčila in izveden je bil sistem mehanskega prezračevanja z izmenjavo toplote. Pred sanacijo je bila raba energije samo za ogrevanje med 75 in 85 kWh/m^2, po sanaciji pa naj bi se zmanjšala vsaj za 80%[1]. Dejanske meritve rabe energije so pokazale, da se je raba energije zmanjšala na 50 kWh/m^2, kar pomeni 38% zmanjšanje[2]. Razlika med pričakovanim in doseženim zmanjšanjem je predvsem posledica neuporabe sistema mehanskega prezračevanja, saj pozimi še vedno prevladuje prezračevanje z odpiranjem oken. Iz tega sledi, da bo za dosego polnega potenciala ukrepov potrebno uporabnike stanovanj dodatno poučiti in ozavestiti o uporabi vseh nameščenih sistemov v stanovanju.

[1] vir: Energijska sanacija večstanovanjskih stavb; Inženirska zbornica Slovenije, dostopno na: http://www.izs.si/dobra-praksa/primeri-dobre-prakse/stanovanjski-objekti/energijska-sanacija-vecstanovanjskih-stavb/

[2] vir: Zmanjšanje porabe energije za ogrevanje v prenovljenih stanovanjih JSS MOL, Ljubljana pametno mesto, dostopno na: http://www.ljubljanapametnomesto.si/aktualno/arhiv/clanek?aid=127

Javni in storitveni sektor – poraba energije v stavbah

Največji delež energije se tudi v javnem in storitvenem sektorju (JSS) porabi za ogrevanje in toplo vodo, sledi električna energija za naprave in razsvetljavo.

Ciljni scenarij in scenarij trajnostne odličnosti je mogoče doseči z naslednjimi ukrepi:

- energetska obnova objektov;
- ukrepi na ogrevalnih sistemih;
- zamenjava virov za ogrevanje in pripravo tople vode;
- izboljšanje energetske učinkovitosti razsvetljave in naprav na električno energijo.

Z izvajanjem teh ukrepov lahko dosežemo več pozitivnih učinkov:

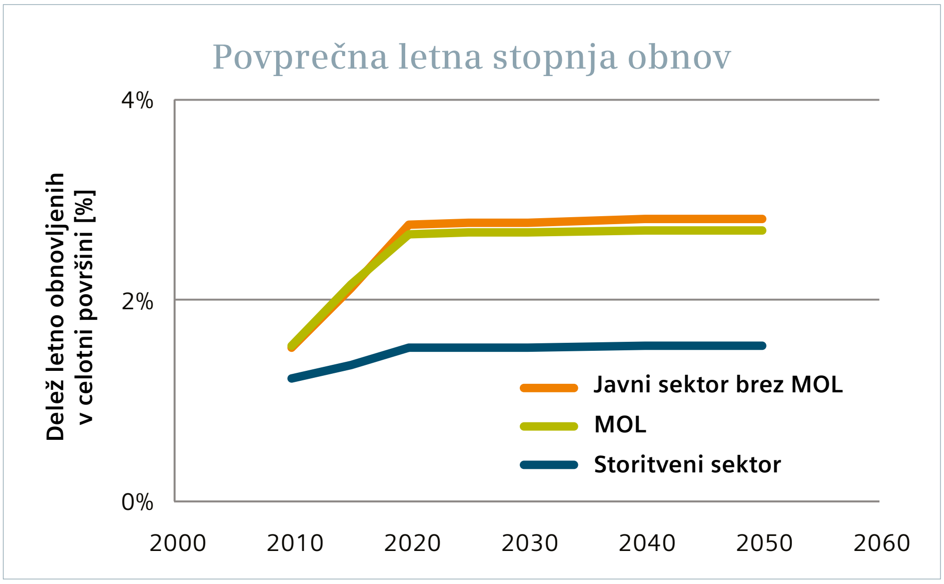
- **zmanjšanje rabe energije za pripravo toplote za ogrevanje in toplo vodo** (v javnem sektorju brez objektov v lasti MOL je zmanjšanje lahko 59%, v objektih MOL 61%, v storitvenem sektorju pa 30%);
- **zmanjšanje emisij** (v javnem sektorju brez objektov v lasti MOL je zmanjšanje emisij lahko 82%, v objektih MOL 80%, v storitvenem sektorju pa 70%);
- **zmanjšanje rabe električne energije za druge namene** (brez ogrevanja in priprave tople vode) se lahko v javnem sektorju (brez stavb MOL), kljub občutnemu povečanju dejavnosti, poveča samo za 4%, zmanjša pa v objektih MOL (za 13%) in v storitvenem sektorju (za 13%).

Ker gre za javne stavbe, uporabniki posledic neracionalnega ravnanja ne čutijo kot svoj strošek. Zato je izjemnega pomena osveščanje ter uvajanje novih organizacijskih modelov in modelov nagrajevanja oziroma motivacije na podlagi pozitivnih učinkov zmanjšanja rabe energije in emisij.

Skupni investicijski stroški za doseganje zgoraj zapisanih ciljev, ki vodijo tudi k doseganju ciljnega scenarija in scenarija trajnostne odličnosti, so ocenjeni na 147 milijonov EUR do leta 2050. Ukrepi bodo sicer predvidoma prinesli za okrog 6 milijonov EUR prihrankov na leto.

Javni in storitveni sektor – obnove stavb kot vzvod varčevanja z energijo

Stopnja obnov obstoječih stavb v lastništvu MOL in v javnem sektorju se mora za doseganje obeh scenarijev do leta 2020 povečati skoraj za dvakrat (z 1,6% oz. 1,5% na 2,7% oz. 2,8%), po tem letu pa ostati na približno enaki ravni. V storitvenem sektorju je za doseganje obeh scenarijev potrebno povečati stopnjo obnov z 1,2% na 1,5% letno.



Slika 27: Delež letno obnovljenih stavb v celotni stavbni površini

Energetsko število (specifična poraba energije za ogrevanje in toplo vodo) obstoječih in novih stavb se bo po predvidevanjih za uresničevanje scenarijev občutno znižalo. Energetska učinkovitost v javnem sektorju lahko postane primer dobre prakse za vse ostale sektorje in ima tako izjemno pomemben demonstracijski učinek.

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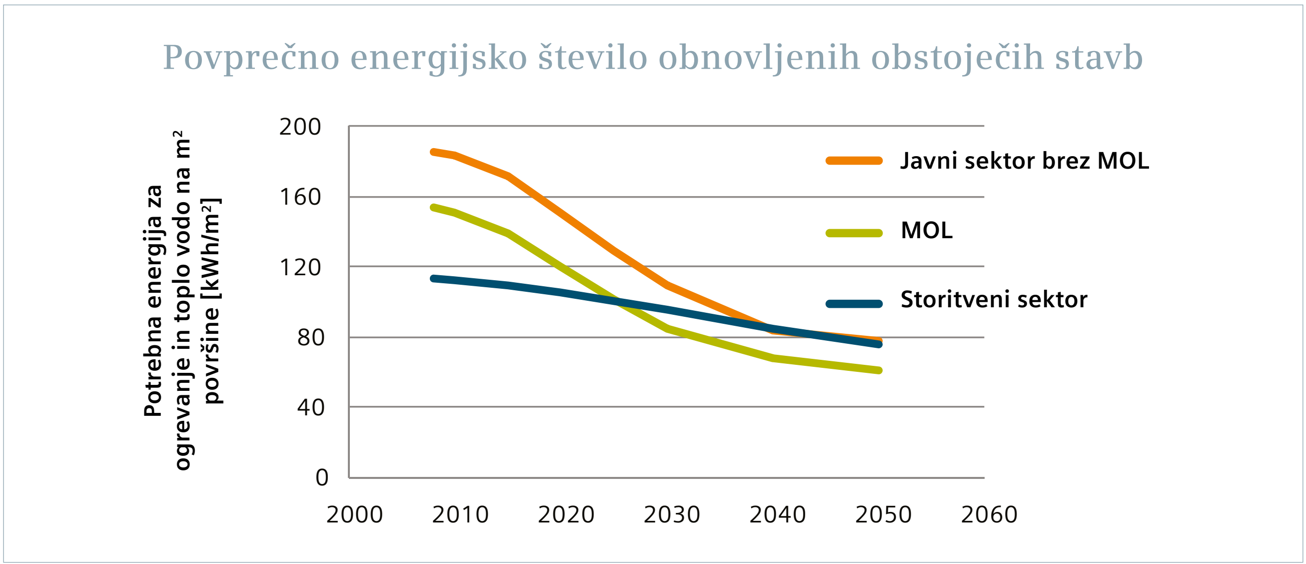
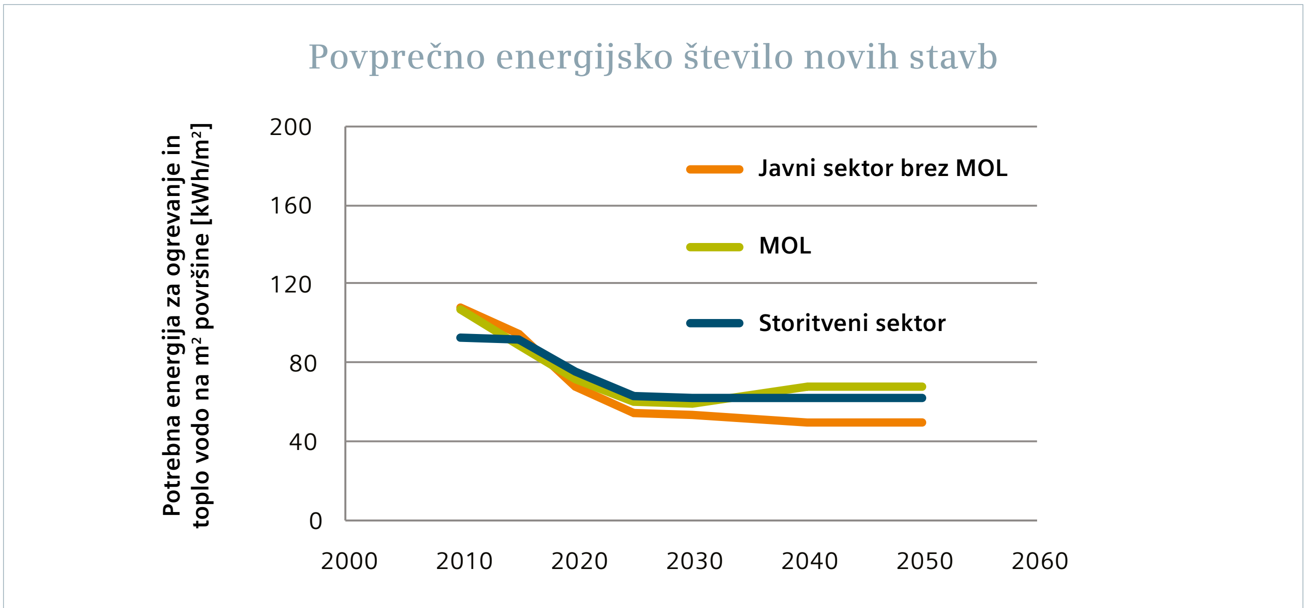


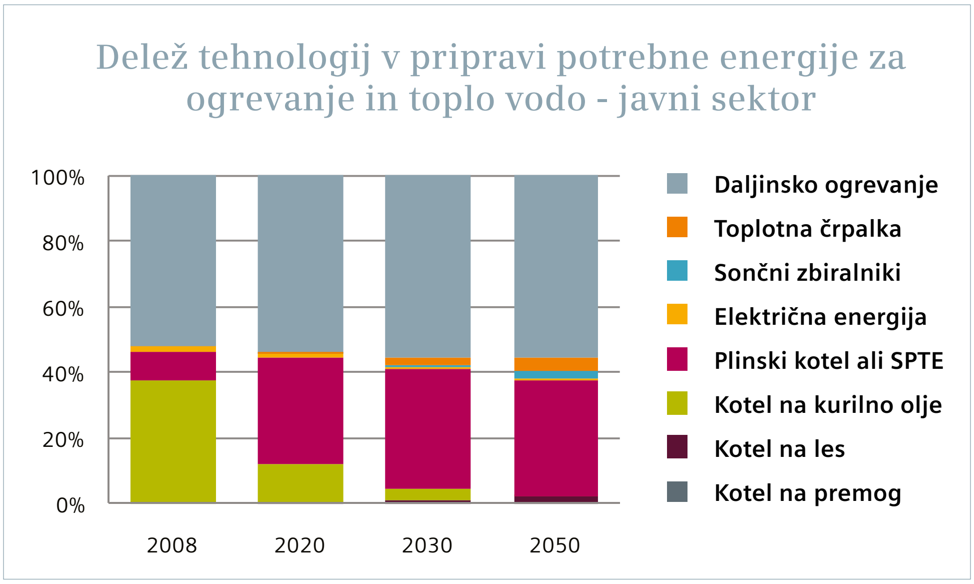
Slika 28: Energetsko število v obstoječih stavbah



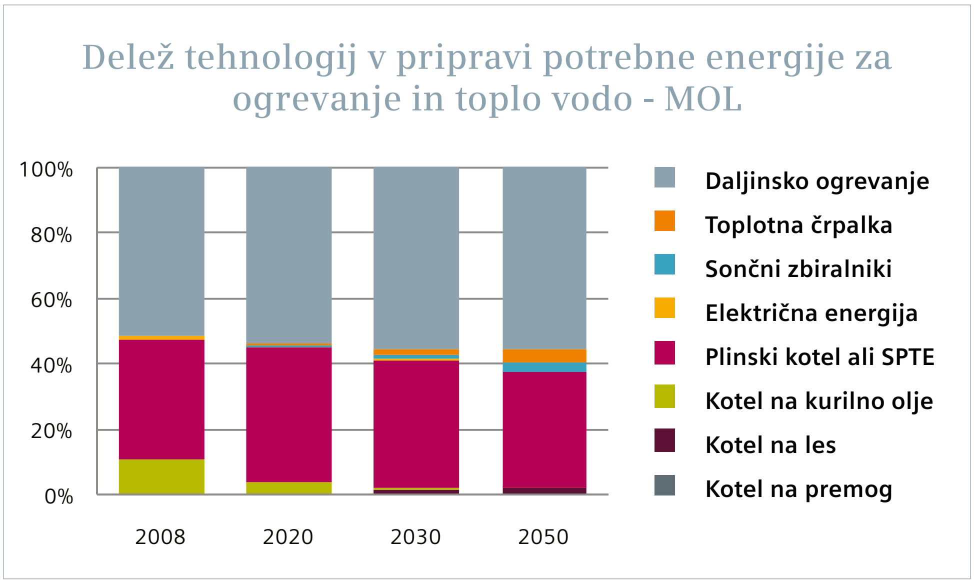
Slika 29: Energetsko število v novih stavbah

Javni in storitveni sektor – tehnologije za pripravo energije za ogrevanje in toplo vodo

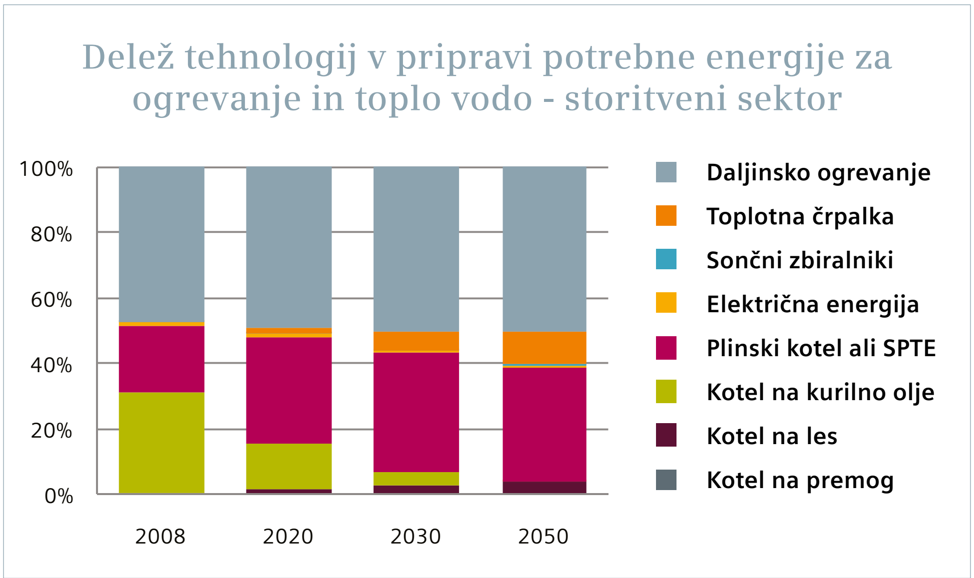
Na rabo končne energije ter zlasti na emisije CO2 pomembno vpliva tudi **zamenjava tehnologij za pripravo toplote za ogrevanje in toplo vodo**. Daljinsko ogrevanje, ki je zelo učinkovit sistem priprave toplote, prevladuje že v letu 2008 v vseh sektorjih, njegov delež pa se bo do leta 2050 še povečal. Kurilnemu olju, ki je trenutno drugi najpomembnejši vir energije v javnem in storitvenem sektorju, se bo delež do leta 2030 močno zmanjšal, do leta 2050 pa padel na nič. Nadomestil ga bo predvsem zemeljski plin, ki se zdaj večinoma uporablja v kotlih, kasneje pa bo zlasti vir v enotah soproizvodnje električne energije in toplote. Med tehnologijami za izkoriščanje obnovljivih virov bodo največji delež do leta 2050 dosegle toplotne črpalke, zlasti v storitvenem sektorju, kjer bodo zastopane z 10% proizvedene energije, medtem ko bo delež v javnem sektorju in stavbah MOL znašal 4%. Ostala vira sta še les in sončna energija, raba le-te je predvidena večinoma v javnem sektorju in MOL, v stavbah, ki potrebujejo večje količine tople vode (npr. bolnice, domovi za starejše, vrtci, športne dvorane, zdravstveni domovi).



Slika 30: Delež tehnologij v pripravi toplote za ogrevanje in toplo vodo v javnem sektorju v letih 2008, 2020, 2030 in 2050



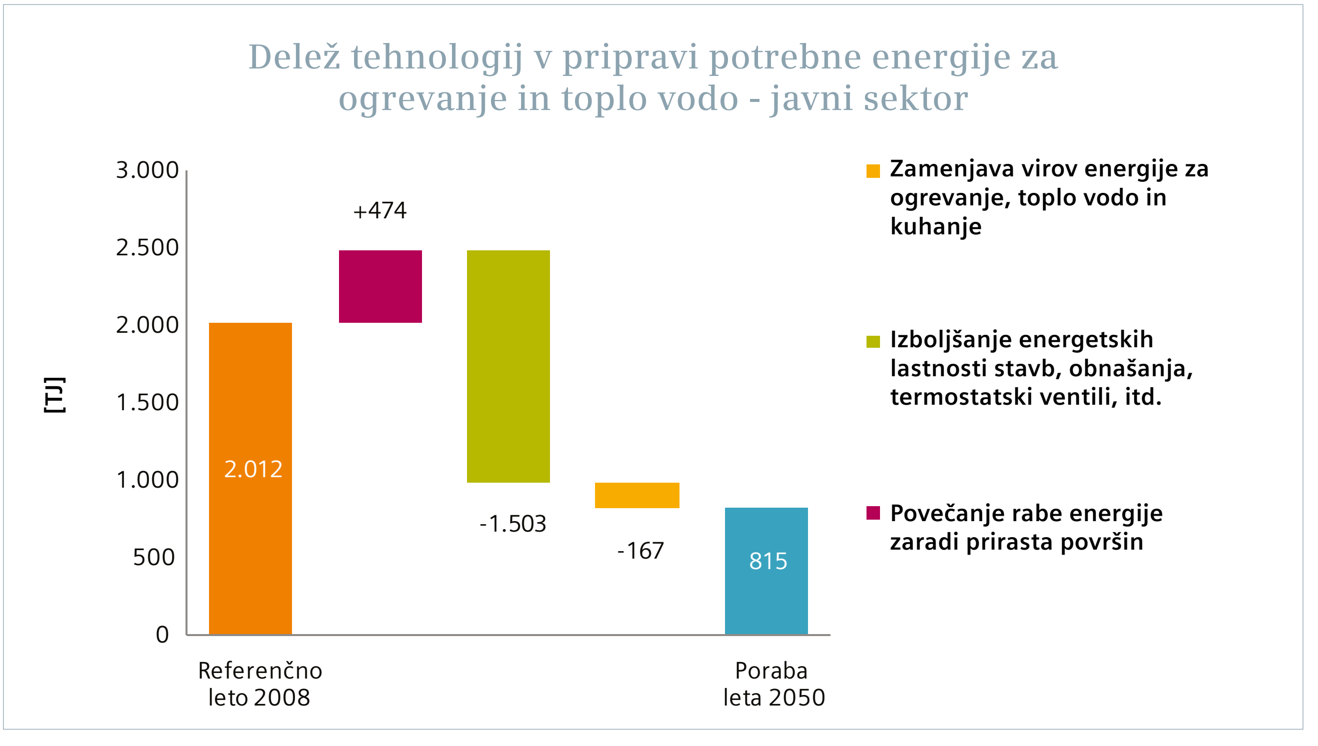
Slika 31: Delež tehnologij v pripravi toplote za ogrevanje in toplo vodo v stavbah MOL v letih 2008, 2020, 2030 in 2050



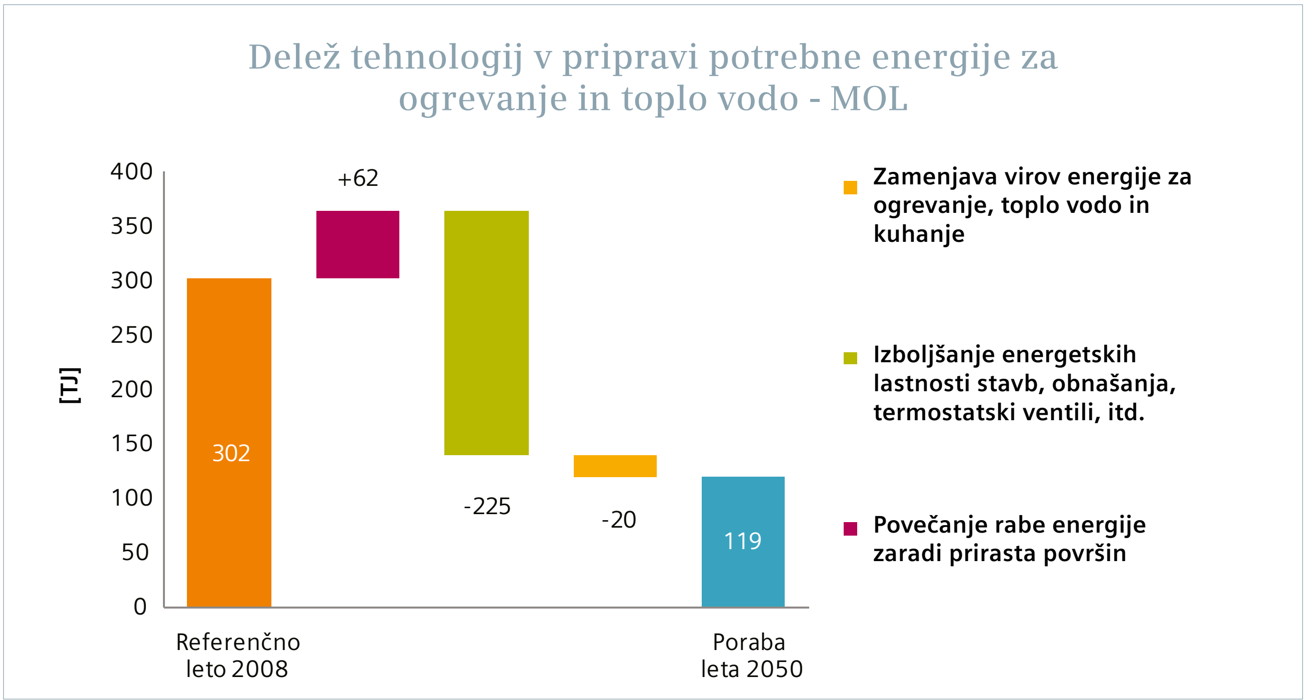
Slika 32: Delež tehnologij v pripravi toplote za ogrevanje in toplo vodo v storitvenem sektorju v letih 2008, 2020, 2030 in 2050

Javni in storitveni sektor – zmanjšanje rabe energije in emisij

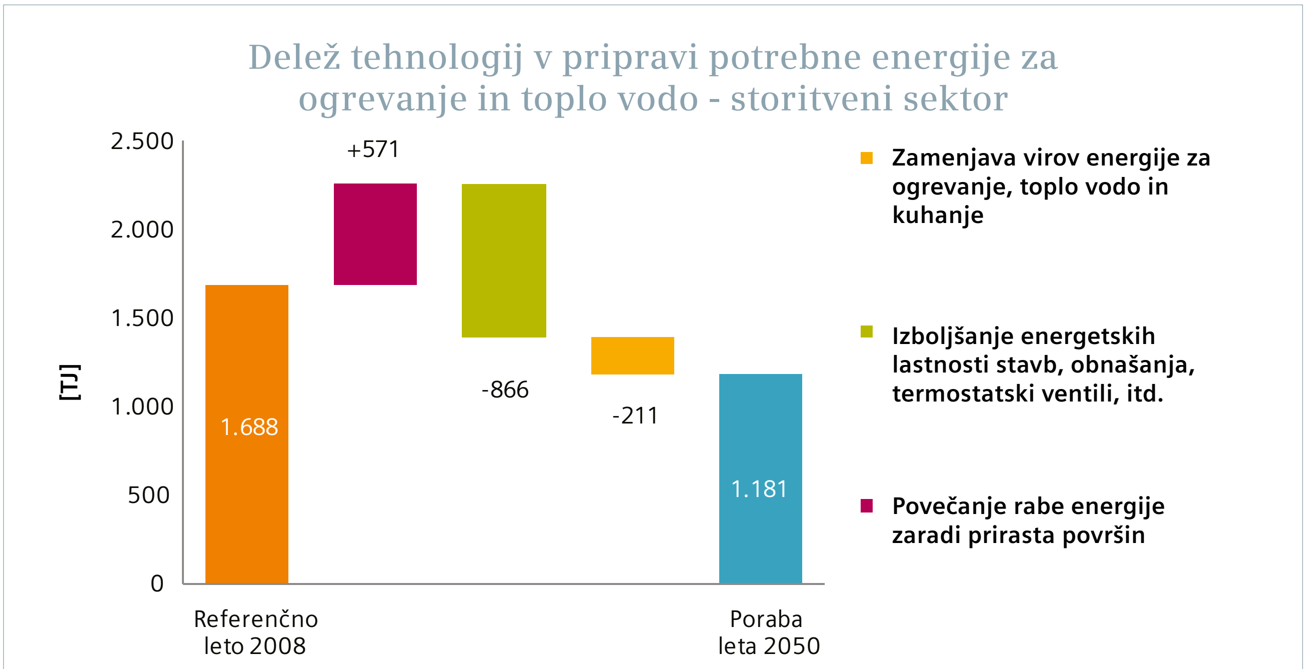
Ključni ukrep, ki največ (v storitvenem sektorju 80%, v javnem sektorju brez MOL 90% in v stavbah MOL 92%) prispeva k zmanjšanju rabe končne energije, je v vseh treh sektorjih izboljšanje energetskih lastnosti stavb, obnašanja uporabnikov ter izboljšanje tehnologij za ogrevanje in toplo vodo (namestitev termostatskih ventilov in hidravličnega uravnoteženja sistema). Preostanek zmanjšanja rabe energije je posledica zamenjave virov energije in tehnologij za pripravo toplote za ogrevanje in toplo vodo.



Slika 33: Primerjava rabe energije pri pripravi toplote za ogrevanje in toplo vodo v javnem sektorju brez MOL leta 2050 glede na 2008



Slika 34: Primerjava rabe energije pri pripravi toplote za ogrevanje in toplo vodo v stavbah v lasti MOL leta 2050 glede na 2008



Slika 35: Primerjava rabe energije pri pripravi toplote za ogrevanje in toplo vodo v storitvenem sektorju leta 2050 glede na 2008

Zmanjšanje emisij CO2 je večje kot zmanjšanje rabe končne energije, saj je v izračunih upoštevana tudi povečana raba obnovljivih virov energije. Skupaj se lahko ob izvajanju ukrepov v javnem in storitvenem sektorju emisije zmanjšajo kar za 77%.

Javni in storitveni sektor – zgodbi o uspehu

Obratovanje bazena Brigittenau

Obratovanje bazena Brigittenau je predstavljalo vedno večji strošek za mesto Dunaj. Zato so se odločili za prenovo v okviru pogodbenega znižanja stroškov za energijo s podjetjem Siemens. Analiza rabe energije je pokazala, da se je največ energije porabilo za ogrevanje vode, pogon prezračevalnih sistemov in razvlaževanje. Ogrevanje vode z daljinskim sistemom so nadomestili s sončnimi zbiralniki, ogrevalni sistem pa vključuje tudi kondenzacijski kotel. Novi

sistem omogoča tudi izrabo toplote iz bazenske vode. Izboljšan je bil pretok vode v in iz bazena s kontrolo vsebnosti klora. Na tuših in pipah so bili nameščeni varčni nastavki za vodo. Hkrati je bil nameščen še sistem upravljanja z energijo, optimizirano pa je bilo tudi prezračevanje. Za natančno spremljanje prihrankov energije je bil izbran sistem DESIGO Insight. Investicija je znašala 1,44 milijona EUR, amortizacijska doba pa znaša 10 let. Z vsemi temi ukrepi se je raba energije zmanjšala za 66%, poraba vode pa za 45%. Emisije CO2 so se zmanjšale za 600 t letno.

Možnosti energetskih prihrankov v ljubljanskih osnovnih šolah

V sklopu projekta Ljubljana, pametno mesto, je bila v letu 2010 opravljena analiza možnih prihrankov energije na dveh ljubljanskih osnovnih šolah. Analiza je pokazala, da imajo javni zavodi še precej rezerve pri svojih izdatkih za energijo in da bi lahko v omenjenih objektih prihranki za energijo znašali vsaj 30.000 EUR letno, investicija v potrebno opremo, s katero bi prihranke dosegli, pa bi se povrnila prej kot v petih letih. Z energetsko prenovo obeh šol bi se zmanjšale tudi emisije CO2, in sicer vsaj za 166 ton letno. Scenariji, po katerih naj bi obe šoli dosegli predvidene prihranke, temeljijo predvsem na investicijah v opremo na področju avtomatizacije stavbe in ne vključujejo investicij v prenovo ovoja stavbe. Priporočeni ukrepi, s katerimi bi lahko dosegali prihranke, so predvsem vgradnja ustreznih sistemov za upravljanje z energijo, vgradnja novih zanesljivih nadzornih sistemov za vse potrebne dele energetskih sistemov stavb, izboljšanje sistema električne razsvetljave ter v primeru OŠ Jožeta Moškriča tudi zamenjava obstoječe energetske opreme.

Promet – ukrepi in učinki za nižanje emisij

Tipični ukrepi energetske politike na področju prometa, ki jih nekatere države že izvajajo, so:

- **ukrepi davčne politike**: obdavčenje goriv in vozil ter dajatve za uporabo cest glede na okoljske kriterije s postopnim povečanjem razpona davčnih stopenj;
- **zmanjševanje specifične porabe novih vozil**: uredba 443/2009 Evropskega parlamenta o določitvi standardov emisijskih vrednosti za nove osebne avtomobile, informiranje kupcev o specifičnih emisijah CO2 pri nakupu novega avtomobila, spodbujanje nakupa hibridnih vozil idr.;
- **spodbude za uvajanje električnih akumulatorskih vozil in vozil na vodik** ter spodbujanje razvoja in izgradnje polnilne infrastrukture za električna vozila;
- **zelena javna naročila**;
- uvajanje **biogoriv** in ostalih obnovljivih virov energije v prometu;
- boljše **vzdrževanje vozil**, redni nadzor nad izpušnimi plini, boljše spremljanje prometa, omejitve hitrosti idr.;
- **informacijske in promocijske akcije** za spodbujanje varčnejše vožnje in trajnostnih oblik prevoza.

Ljubljana lahko doseže ciljni scenarij in scenarij trajnostne odličnosti, če bo pri tem upoštevala naslednje dejavnike, katerih učinke podrobneje opisujemo v nadaljevanju poročila:

- dostopen, učinkovit, cenovno sprejemljiv javni promet in trajnostna prometna infrastruktura (železniška in cestna, ki sta obe investicijsko izjemno zahtevni);
- širjenje omrežja kolesarskih stez in območij za pešce;
- sprememba strukture voznega parka za osebna vozila;
- sprememba strukture voznega parka za avtobuse mestnega prometa;
- sprememba deležev potniških kilometrov.

Promet – struktura potniških kilometrov

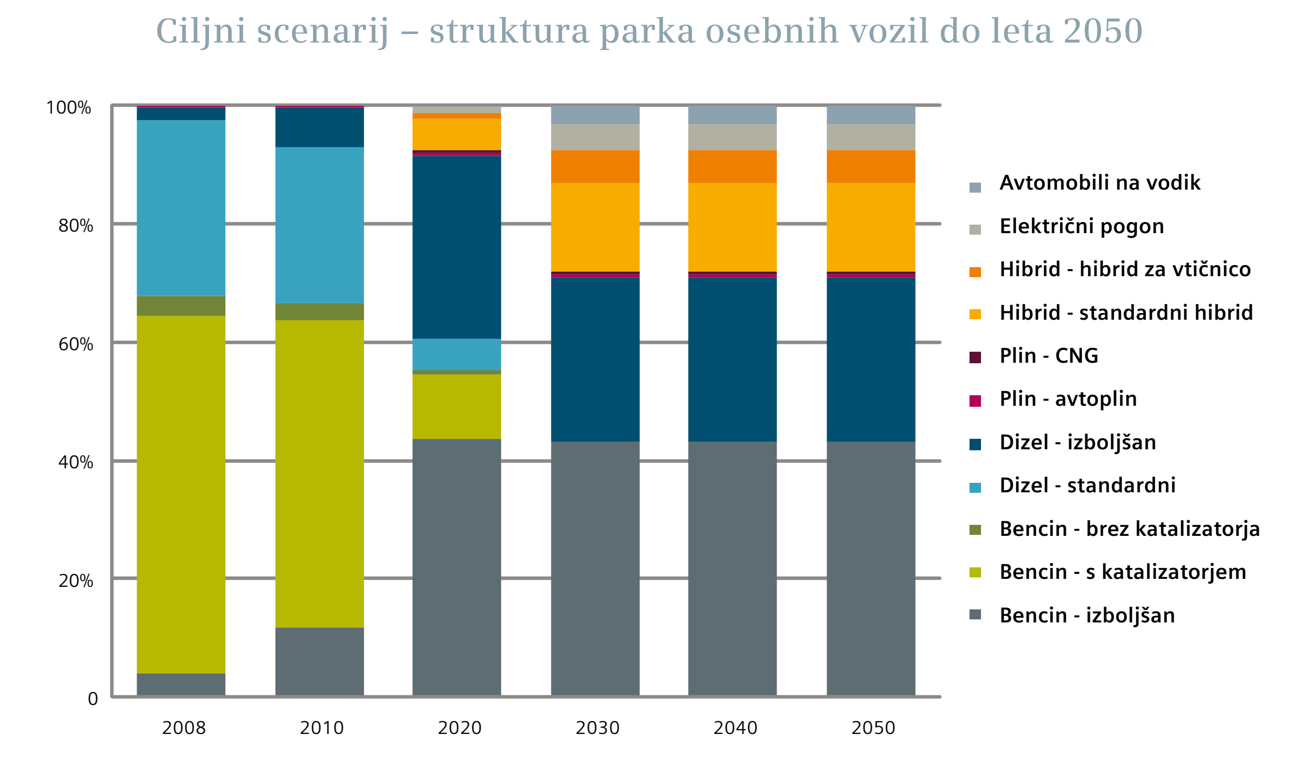
Število potniških kilometrov naj bi se do leta 2050 postopno zmanjševalo, če želi Ljubljana slediti obema razvojnima scenarijema. Za zmanjševanje emisij za 50% oziroma za 80% glede na izhodiščno leto 2008 je bistveno tudi naraščanje kolesarskih potniških kilometrov (za 40% do leta 2050), v manjši meri hoje peš (za 3% do leta 2050), predvidena je znatna rast javnega potniškega prometa, še zlasti v mestnem prometu in železnici.

Potniški km (pkm)	**Enota**	**2008**	**2010**	**2020**	**2030**	**2040**	**2050**
Kolesarji	[milijon pkm]	65	67	79	91	114	137
Pešci	[milijon pkm]	35	35	35	36	36	37
Javni potniški promet	[milijon pkm]	340	348	386	425	488	568
Medkrajevni promet	[milijon pkm]	80	81	89	97	104	112
Mestni promet	[milijon pkm]	197	202	224	247	280	314
Železnica	[milijon pkm]	63	65	73	82	103	142
Osebna motorna vozila	[milijon pkm]	3.485	3.469	3.392	3.315	3.174	3.033
SKUPAJ	**[milijon pkm]**	**3.925**	**3.920**	**3.893**	**3.867**	**3.812**	**3.774**

Tabela 1: Struktura potniških kilometrov do leta 2050

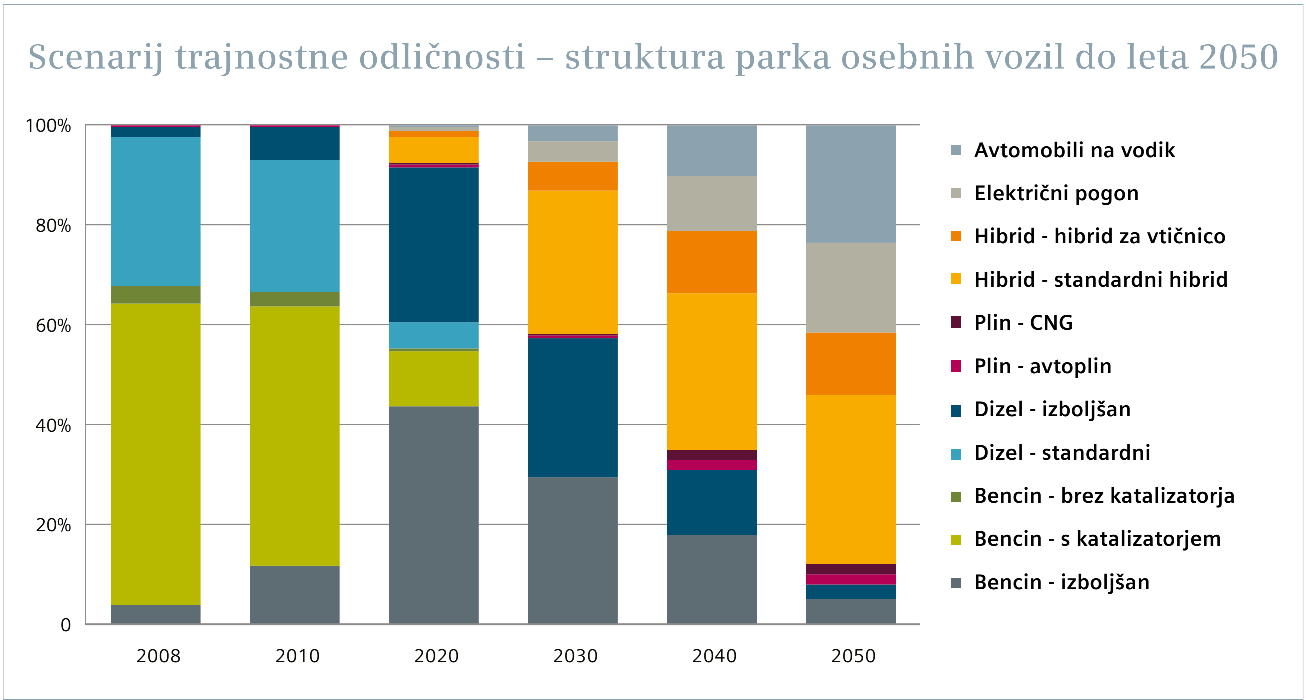
Promet – struktura voznega parka osebnih vozil

Nove tehnologije (in s tem povezana struktura voznega parka) osebnih vozil igrajo ključno vlogo v zmanjševanju emisij v prometu. V ciljnem scenariju smo predvideli uveljavitev bistvenih tehnoloških sprememb okoli leta 2020. V primerjavi z izhodiščnim letom 2008 naj bi se povečal delež izboljšanih vozil na bencinski in dizelski pogon. Po letu 2030 lahko pričakujemo bolj množično uveljavitev standardnih hibridov in hibridov na vtičnico ter uvajanje avtomobilov na vodik.



Slika 36: Ciljni scenarij – struktura parka osebnih vozil do leta 2050

Po scenariju trajnostne odličnosti so ključne tehnološke spremembe predvidene po letu 2030, ko lahko pričakujemo hiter razmah avtomobilov na električni pogon in na vodikove tehnologije. V letu 2050 naj bi bil delež osebnih vozil na bencin in dizelsko gorivo po tem scenariju zelo majhen.

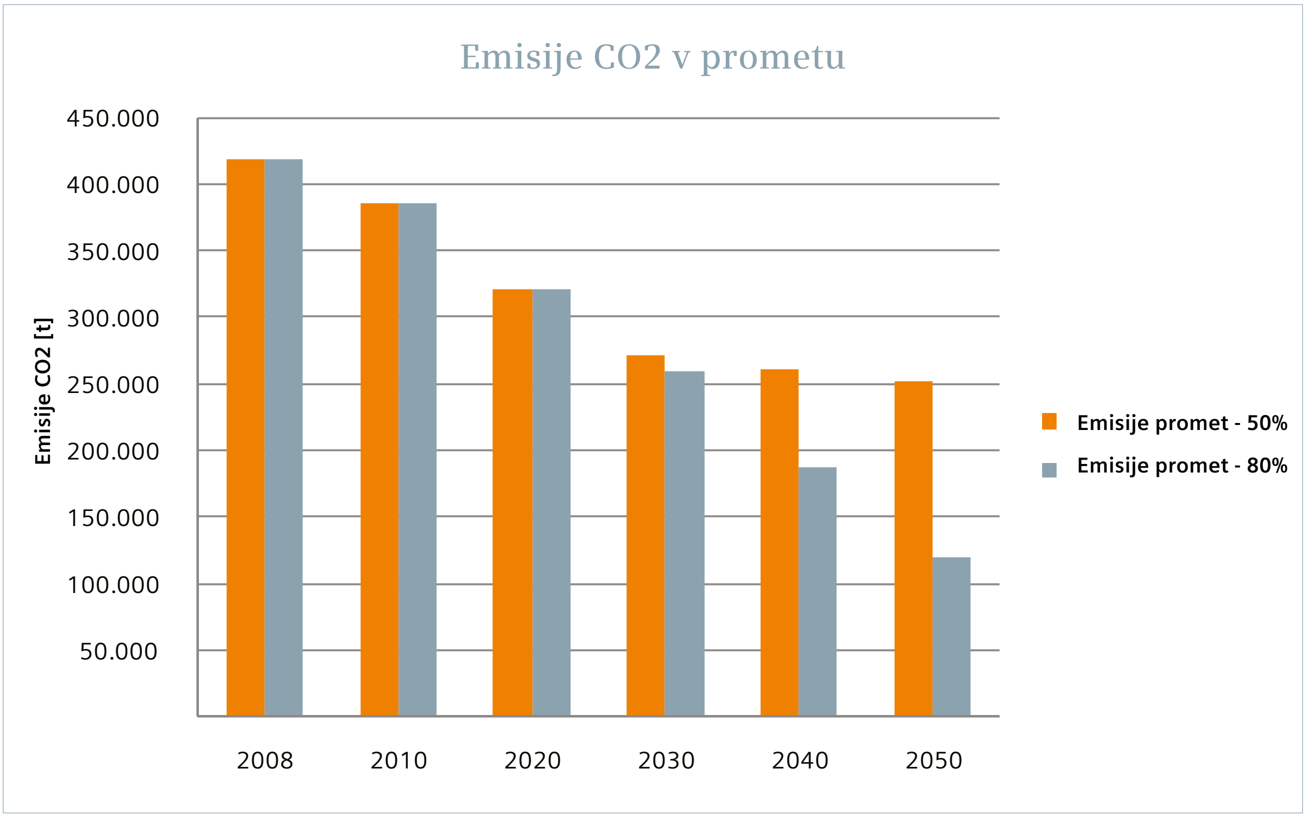


Slika 37: Scenarij trajnostne odličnosti – struktura parka osebnih vozil do leta 2050

Promet – nižanje emisij

Emisije v potniškem prometu se v ciljnem scenariju do leta 2030 znižajo za 35% v primerjavi z letom 2008 in za 40% do leta 2050. Leta 2030 predvidevamo tudi za 33% nižjo rabo energije v prometu, medtem ko naj bi se do leta 2050 znižala za 37% glede na izhodiščno leto.

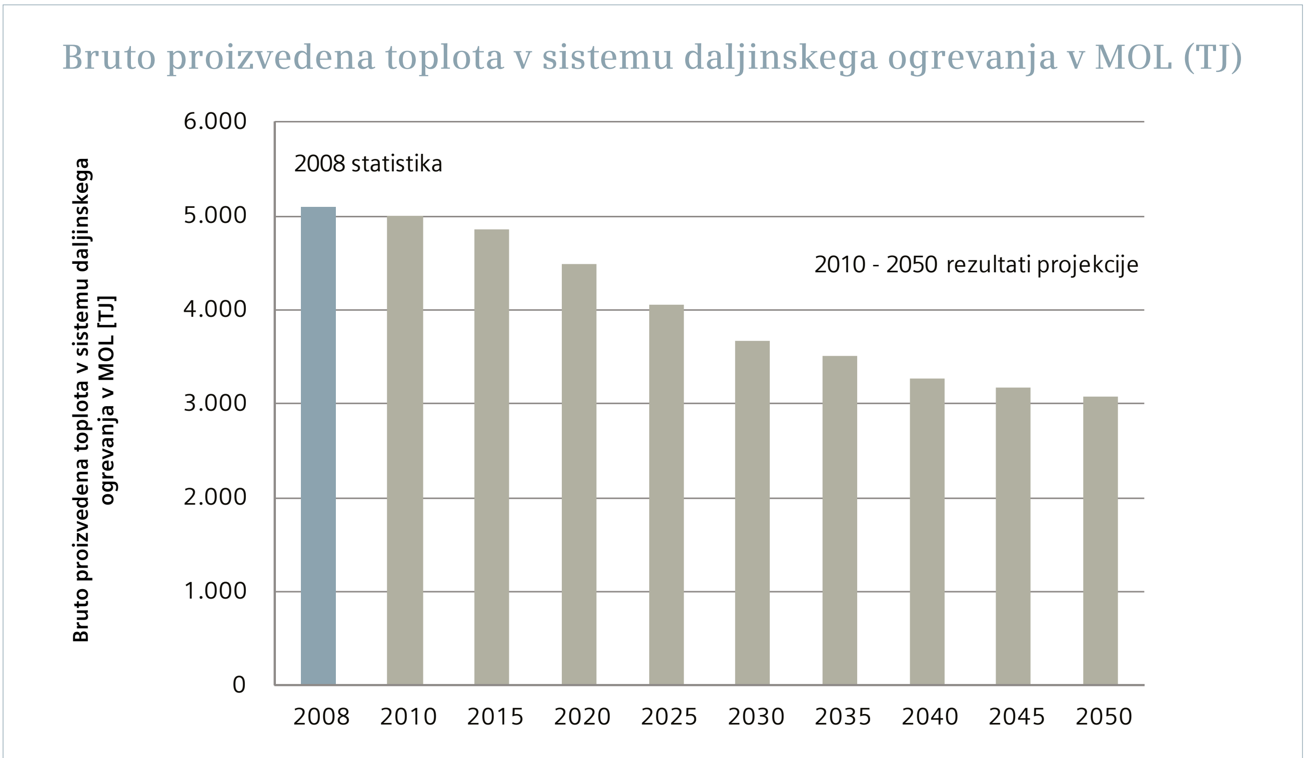
V scenariju trajnostne odličnosti predvidevamo znižanje emisij za 37% do leta 2030 in za 71% do leta 2050 v primerjavi z letom 2008. Raba energije bo do leta 2030 nižja za 35%, do leta 2050 pa za 61%.



Slika 38: Emisije CO2 v prometu

Oskrba s toploto

Za doseganje obeh scenarijev je potreben intenziven razvoj sistema daljinskega ogrevanja in hlajenja, vključno z obsežno obnovo omrežja, ki bo izgube znižala na 7% bruto proizvedene toplote ter omogočila priklop novih odjemalcev. Spremembe so potrebne tudi pri sami proizvodnji toplote, kjer smo predvideli uvajanje zemeljskega plina kot goriva v Termoelektrarni Toplarni Ljubljana in do leta 2050 prehod na obnovljive vire energije. V letu 2050 naj bi kar 30% toplote v Ljubljani pridelali z energetsko izrabo odpadkov, poraba toplote pa se bo zniževala tudi zaradi energetske sanacije objektov.

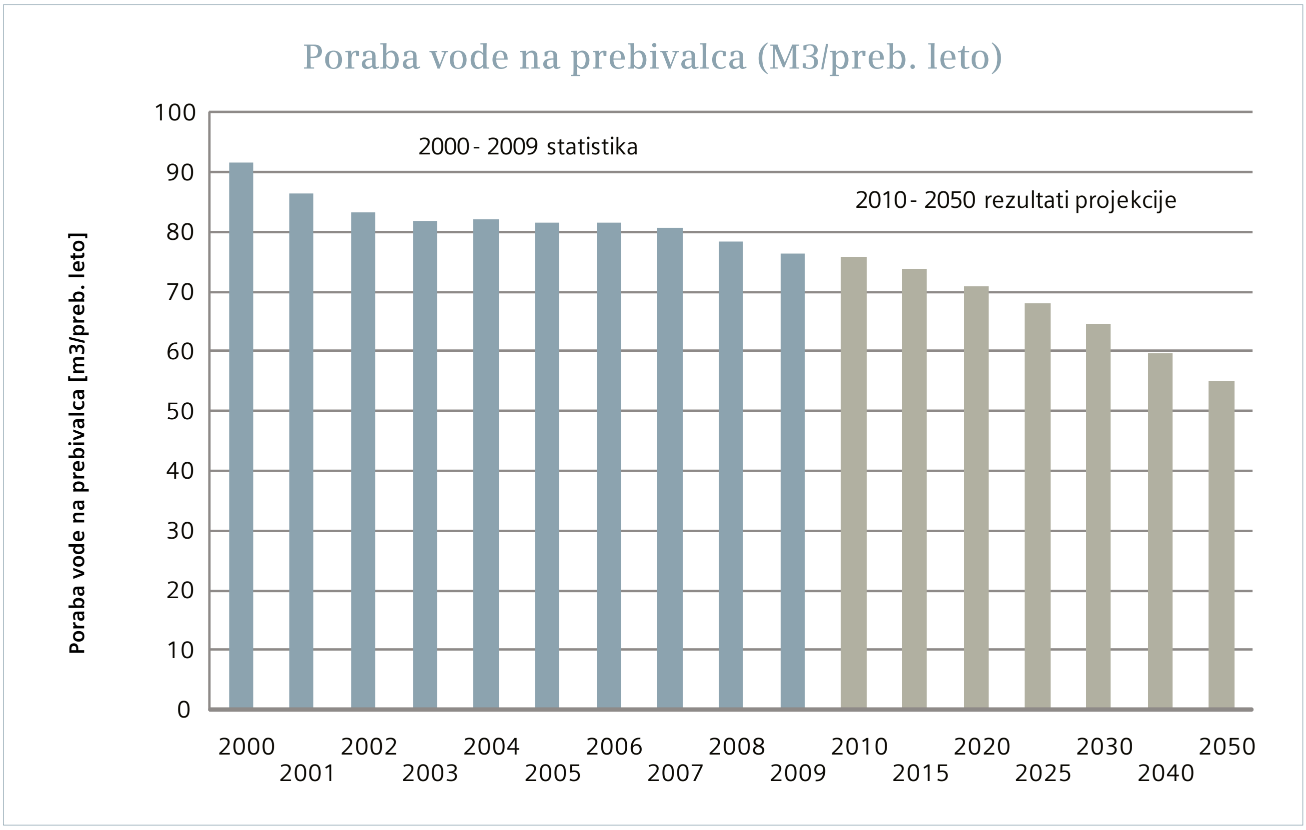


Slika 39: Bruto proizvedena toplota v sistemu daljinskega ogrevanja v MOL (TJ)

Oskrba s pitno vodo

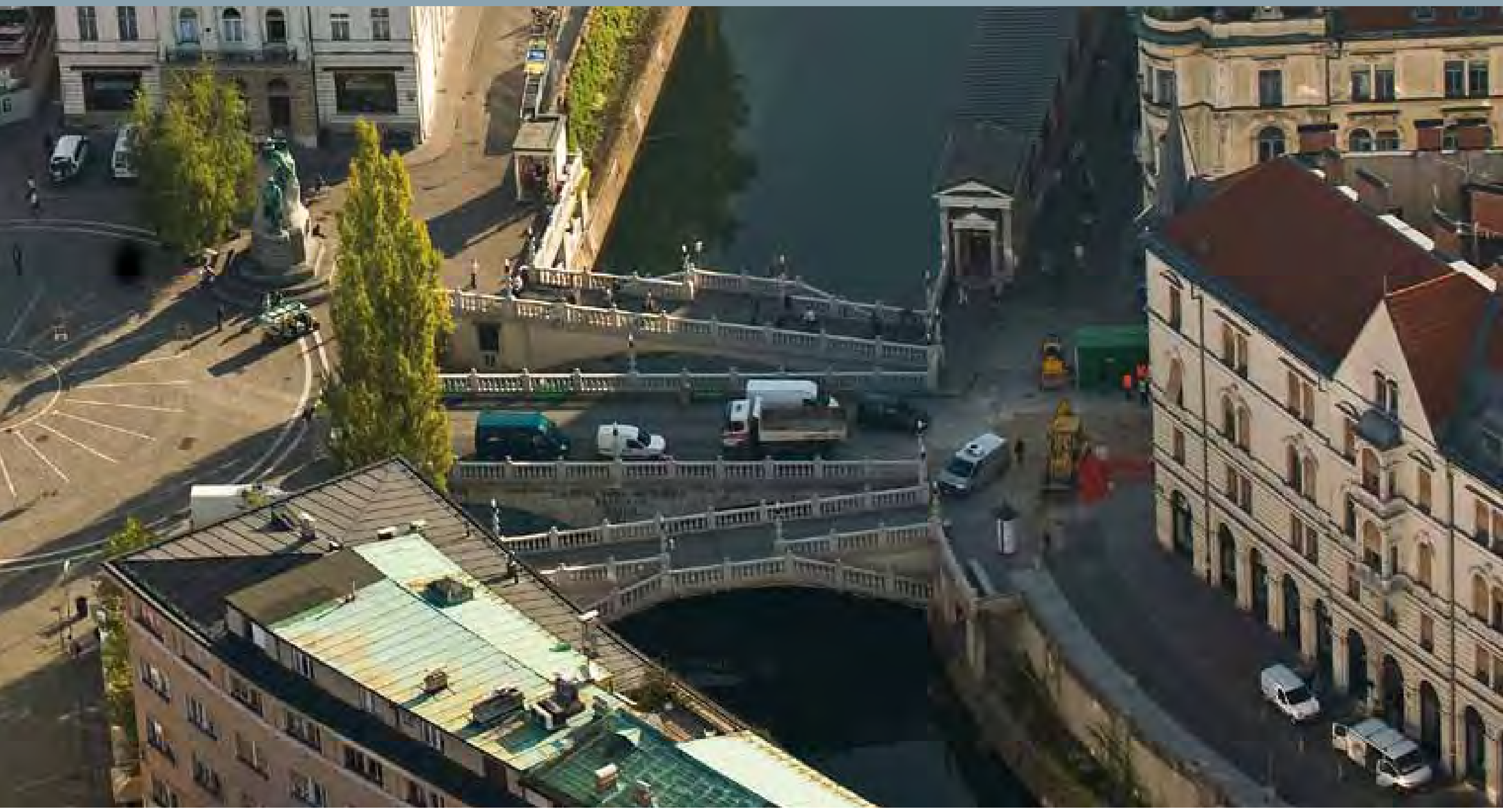
Doseganje obeh scenarijev predvideva zmanjšanje porabe pitne vode. Ta bo rezultat več ukrepov:

- Obsežna prenova vodovodnega omrežja, ki bo prispevala k znižanju izgub na 5% načrpane vode do 2050. Učinek bomo dosegli s pomočjo uvajanja najsodobnejših tehnologij regulacije pretoka in tlaka, ter uvajanja novosti tudi v poslovni model, predvsem z razdelitvijo vodovodnega omrežja na cone, učinkovitim merilnim sistemom ter daljinskim odčitavanjem, s čimer se bodo uporabniki bolj jasno zavedali (finančnih) posledic neracionalne rabe vode.
- Osveščanje in bolj racionalno ravnanje z vodo na strani uporabnikov, ki lahko – ne da bi pri tem trpelo njihovo udobje, omejijo porabo vode za 34% do leta 2050.



Slika 40: Poraba vode na prebivalca (M3/preb. leto)

IV. Ukrepi Mestne občine Ljubljana



Znano je, da imajo mestne oblasti pri doseganju ambicioznih okoljskih ciljev razmeroma omejen vpliv, večji del zaslug za zmanjševanje rabe energije in emisij s svojimi odločitvami nosijo organizacije in posamezniki. V tem poglavju podajamo natančen uvid v prve ukrepe, ki bi jih lahko na področju oskrbe z energijo v stavbah, ki jih ima v lasti, sprejela Mestna občina Ljubljana, analiziramo finančne posledice takšnih odločitev in s tem ustvarjamo zgled, ki mu lahko sledijo druge občine, predvsem pa lastniki in upravniki stavb organizacij zasebnega in javnega sektorja.

Ovire, priložnosti in ukrepi

Na poti učinkovitega upravljanja z energijo stoji več ovir. Tehnološke možnosti niso v celoti izkoriščene, energija pa je s strani uporabnikov prepoznana kot strošek, na katerega imamo zelo omejen vpliv. Sistem stimulacij za racionalno ravnanje z energijo je v pripravi, prav tako formalne zaveze k spoštovanju ciljev skrbnega ravnanja z energijo.

Priložnosti učinkovitega upravljanja z energijo:

- S prehodom v nizkoogljično družbo se vzpostavljajo trgi zelenih produktov, storitev in rešitev, ki so bili na dosedanjo ekonomsko krizo imuni.
- Storitve na področju zelenih tehnologij in učinkovitega upravljanja z energijo so lahko dodaten produkt ali storitev, ki ga na trgu ponujajo javna podjetja v MOL. S tem okrepijo zvestobo strank in ustvarijo dodatne vire prihodkov.
- Z investiranjem v energetsko učinkovitost (Sistem za upravljanje z energijo v objektih MOL) je mogoče že zelo hitro dosegati **visoke prihranke: 708.000 EUR na letni ravni, investicija v potrebno opremo znaša 4,15 milijona EUR in se povrne v 5,5 letih.**

Ukrepi za doseganje učinkov:

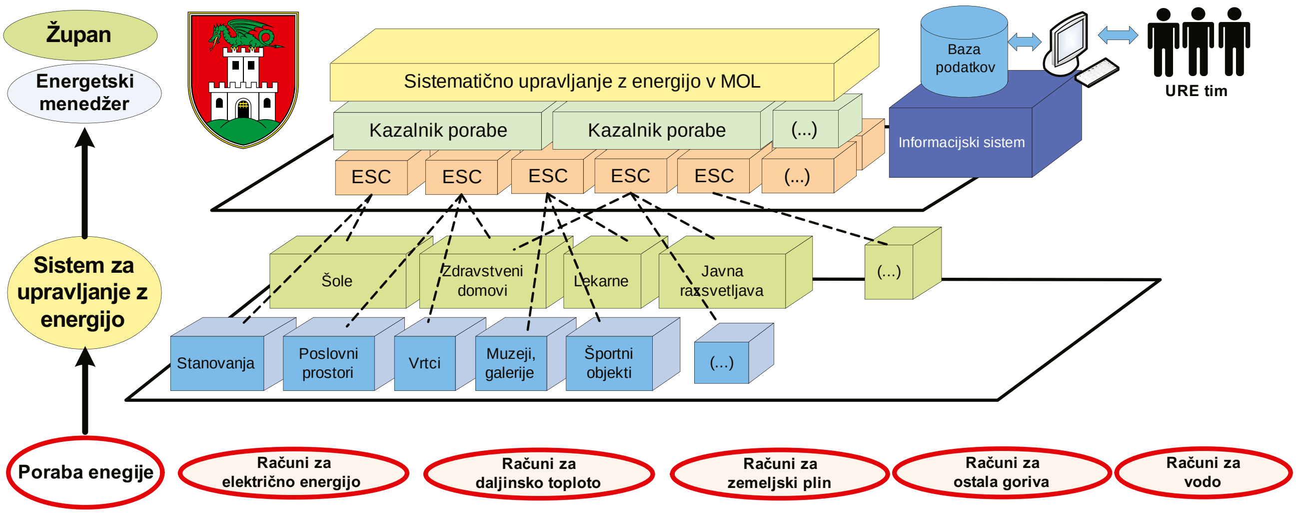
- **Organizacijski ukrepi** (model sistematičnega upravljanja z energijo, uvedba poslovne funkcije, pristojne za upravljanje z energijo).
- **Investicijski ukrepi** (strojna in programska oprema za izvajanje sistematičnega upravljanja z energijo v objektih v lasti MOL, energetska obnova stavb, zamenjava energetskih virov).
- **Ukrepi na področju človeških virov** (prilagoditev politike določanja plač na podlagi uspešnosti in doseganja ciljev, jasen sistem stimuliranja za učinkovitost, ozaveščanje vseh zaposlenih).
- **Vključevanje nabav v sistem upravljanja z energijo.**

Novi organizacijski model

Znotraj MOL obstajajo trenutno še neizkoriščeni potenciali za sinergijsko sodelovanje in povezovanje javnih podjetij iz Javnega holdinga Ljubljana (Energetika Ljubljana, Snaga in Vodovod-Kanalizacija) ter Elektro Ljubljana. Po uspešno izvedenih projektih skrbnega upravljanja z energijo v MOL, ki bi lahko postali primeri dobre prakse energetskega pogodbeništva, lahko zgoraj naštenta podjetja svoje dodatno razvite storitvene dejavnosti ponudijo na širšem slovenskem in regionalnem trgu.

Ključni dejavniki skrbnega upravljanja z energijo v MOL so:

- odgovornost za učinkovito ravnanje z energijo je sprejeta na najvišji ravni v MOL, župan je prvi ambasador takega koncepta;
- izbran je energetski menedžer, katerega plačilo je odvisno od doseganja jasno zastavljenih, merljivih in dokazljivih učinkov;
- določeni so energetski stroškovni centri (ESC), ki imajo prav tako jasno zastavljene cilje na področju učinkovite rabe energije, vsak pa svojega skrbnika, ki nadzira porabo energije in ukrepa;
- inštalirana je strojna in programska oprema za spremljanje in nadzor porabe energije ter obveščanje ob vsakih anomalijah.



Ljubljana, pametno mesto

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V okviru študije smo ocenili, da bi proces vzpostavitve sistema za upravljanje z energijo v MOL trajal štiri leta in potekal v več fazah:

- vzpostavitev organizacijske strukture za sistematično upravljanje z energijo v vseh objektih v lasti MOL;
- vzpostavitev predlaganih energetskih stroškovnih centrov ter določitev kazalnikov za merjenje učinkovitosti;
- vzpostavitev informacijskega sistema za upravljanje z energijo v objektih v lasti MOL;
- implementacija in spremljanje učinkov, morebitne korekcije zastavljenih ciljev;
- usposabljanje in motivacija vseh zaposlenih v MOL;
- komunikacija z zainteresiranimi javnostmi ter ocena napredka.

Stroški zgoraj omenjenih aktivnosti, ki so povezane z vzpostavitvijo sistema za upravljanje z energijo v vseh objetih v lasti MOL, so ocenjeni na **4,15 milijona EUR**. V navedenem znesku so upoštevane naslednje vrste stroškov:

- informacijski sistem za upravljanje z energijo;
- dodatna merilna oprema;
- vzpostavitev sistema;
- izvajanje in spremljanje mehkih ukrepov (npr. pravilna uporaba termostatskih ventilov, uvajanje **koncepta ekološke odgovornosti**, motivacijsko – izobraževalne aktivnosti za zaposlene itn.);
- komuniciranje z javnostmi;
- približno 60% zgoraj omenjenih stroškov predstavljajo stroški nove strojne in programske opreme.

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Sustainable Urban Infrastructure

Ljubljana – A View to 2050

Research project of the City of Ljubljana, Centre for Energy Efficiency at the Jožef Stefan Institute and Siemens

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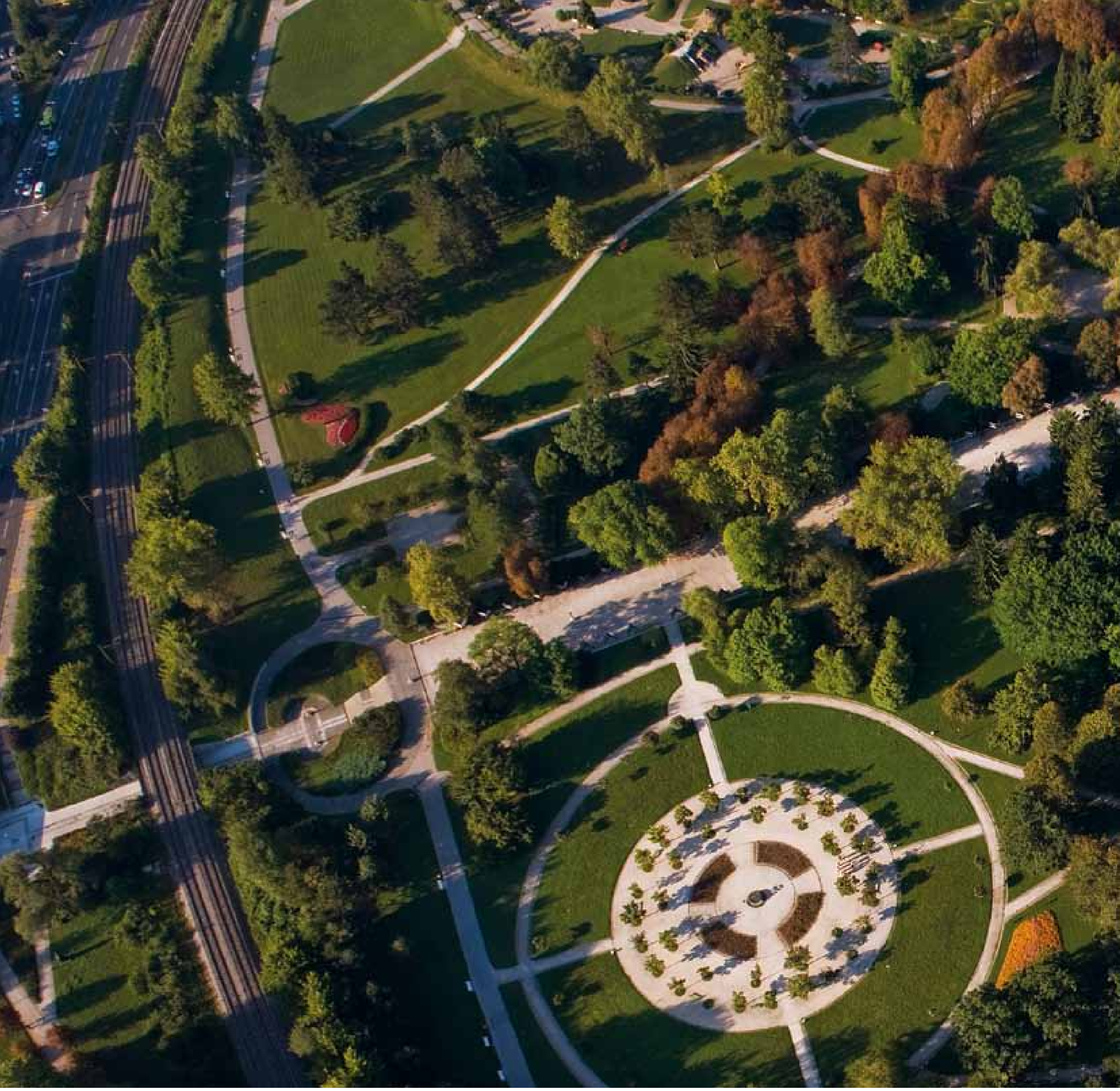

I. Vision and strategic framework

With their environmental impact, cities are an extremely important factor in climate change – both positive and negative. Given their commercial power, they play a decisive part in the economic development of entire countries. Just like commercial organisations, cities operate in a heavily globalised, competitive environment, where they strive for growth and progress through the creation of jobs and good living conditions, and by offering outstanding services to individuals and organisations. The city administration of Ljubljana is striving for sustainable growth and for a constant enhancement of the quality of life. Regardless of the time frame of its mandate, the administration is seeking to implement measures right now that will lay the ground for future generations to enjoy an environment suitable for creativity and living.

Unique nature of the study

No such study has previously been conducted in Slovenia on the city level. Related strategic documents have been set for a shorter perspective: up to 2030 (National Energy Programme) and 2020 (Local Energy Concept).

According to our information, there are few cities that would conduct similar projects of research and analysis. Ljubljana is therefore in the elite company of a few Western European capitals that have decided they wish to embark today on the path of environmental sustainability.

The findings of similar international analytical projects in Munich, London, Dublin and Berlin indeed show that cities have great potential for improving their environmental efficiency – and here, the positive effects even stretch into the areas of urban economics, quality of life and thereby also the international competitiveness of cities.

Context of study

This study has been produced as part of the project Ljubljana, Smart City, in which the City of Ljubljana in cooperation with the Siemens company is developing, communicating and promoting its projects and achievements in the area of environmental efficiency.

Developing a city is a long-term process. The current City of Ljubljana administration is striving for long-term, sustainable development of the city irrespective of the time limitations of its current term in office. The study therefore provides a glimpse of the factors that can influence that development. Projections have been made up to 2050.

Ljubljana accounts for a high proportion of energy consumption and generation of emissions in Slovenia. It will not be possible to achieve the ambitious environmental targets solely through measures implemented by the city authorities. **The transition to sustainable excellence of the capital city cannot therefore be merely an issue for the city, rather it is a national issue**, where solutions will necessarily require the active participation of the state, organisations and individuals.

The investments in technology and infrastructure required to enable the path to a society of sustainable excellence will be high, so there needs to be consensus between city and national structures, organisations and individuals. This study serves as a starting point for dialogue that can lead to such consensus. It offers measures that might lead to achieving the targets.

The city authorities of the Danish capital, Copenhagen, established a plan of environmental efficiency and sustainable development back in 1970, when the oil crisis prompted them to reduce their energy dependence on oil. They set environmental guidelines that they have been pursuing systematically now for decades, and this is yielding rewards. **This study serves as a starting point for establishing long-term environmental policies on the city level**. Through this study the city authorities are demonstrating that their orientation is long-term, strategic and target-based, and above all that they recognise the coming challenges and have addressed them today, even though they may not bear responsibility for ultimately facing them.

Relevance of the study

Energy represents a high cost in the budget of any organisation. Energy saving is an important environmental target, and at the same time an exceptional business opportunity.

In 2008 Slovenia recorded total annual costs of all consumption of primary energy of EUR 1.95 billion (5.2% of gross domestic product).

- Around 80% of the energy is consumed in urban settlements and cities, meaning that urban settlements and cities account for EUR 1.6 billion of the energy costs.
- Reducing energy consumption by 20% on the urban settlement and city level could save around EUR 312 million/ year, or almost 1% of the 2008 GDP.

On the City of Ljubljana level, too, energy consumption is a major item in operational economics:

- The cost of energy in City of Ljubljana buildings and structures in 2008 amounted to EUR 5.9 million (approximately 2% of the city budget for 2008).
- By introducing systematic energy management, we could reduce energy costs on an annual level by EUR 708,000 (this amount compares to the budget item "transfers to unemployed persons" – unemployment benefit – for 2008).
- The investment required to achieve these savings has been estimated at EUR 4.15 million, and its return period is 5.5 years.
- Using the business model of energy contracting, it would be possible for City of Ljubljana not to have to carry out any direct investments to make such savings, and after six years it could "sustain" the achieved energy savings (the life cycle of equipment envisaged for such savings is generally more than 10 years).

Methodology

In this study, the main methodological tool for calculations and projections is the **REES MOL Reference Energy and Ecological Model**:

- this is an array of programmes and tools used to describe mathematically the individual subsystems of the energy system in correlation to the parameters that affect it, and these are then combined together again into a whole;
- it enables consistent modelling of energy consumption on the basis of needs and calculations of emissions, costs and other impacts.

Such application of the methodology has now been made for the first time on the city and wider regional levels.

The projections are based on the currently valid statistics of City of Ljubljana and the national and international statistical offices. In the selection of best practices we made use of a broad range of literature and sources.

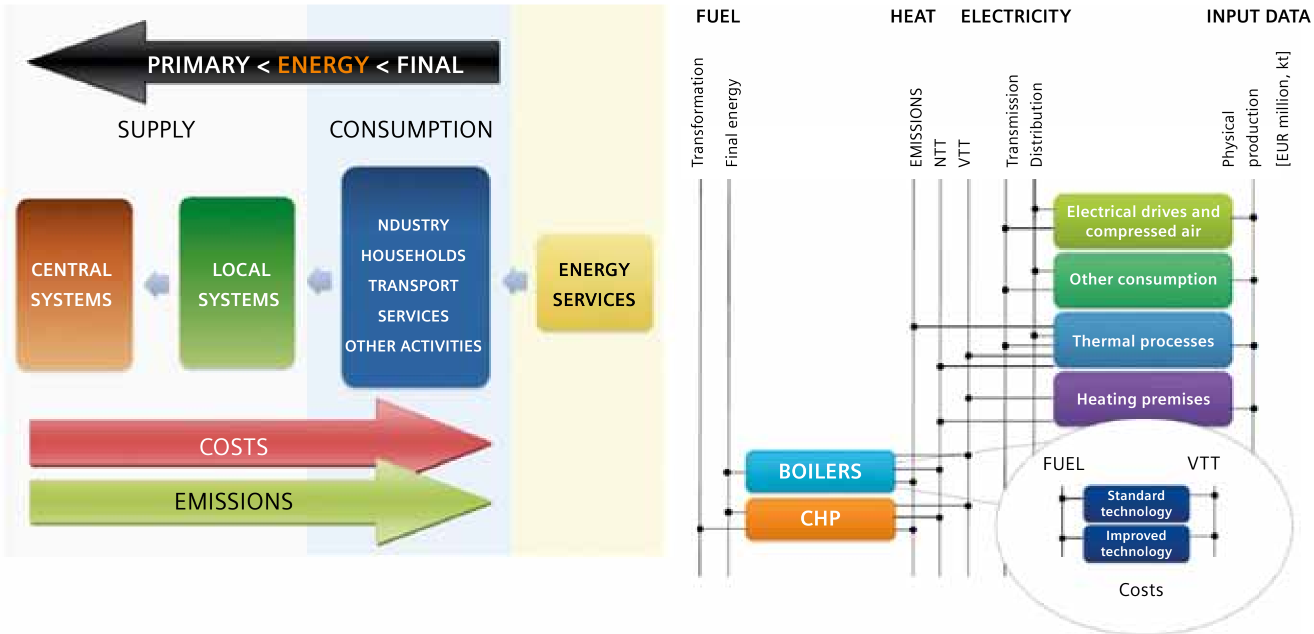

Figure 1: REES MOL Reference Energy and Ecological Model

Summary of key findings

The study analysed two scenarios for reducing emissions relative to the reference year of 2008.

The target scenario envisages a 50% reduction of emissions and represents fulfilment of the requirements already adopted on the EU level. This can be achieved through implementation of the following measures and assumptions:

- a high degree of energy refurbishment of the building stock;
- overhauling the vehicle fleet in use;
- increasing the share of renewable sources in energy supply;
- more efficient energy recovery from waste;
- intensive refurbishment of the water mains system to reduce losses.

The scenario of sustainable excellence envisages a reduction of emissions of 80%, going beyond the adopted targets and commitments and transforming Ljubljana into a sustainably excellent, low-carbon capital city. In addition to the aforementioned measures, fulfilment of this scenario will require the following assumptions:

- that hydrogen is used in industry as a supplemental energy product;
- in energy supply (heat and power generation) and in industry, we start using technology for capturing and storing carbon.

	Households	Services	Industry	Transport	Energy	Water supply and waste management
Scenario of -50%	same for	same for	Exclusively natural gas envisaged for CHP units	Structure of vehicle fleet maintains shares from 2030	No CCS technology envisaged	same for
Scenario of -80%	both	both	Natural gas envisaged for CHP units, after 2015 also hydrogen	Envisaged breakthrough in hybrid and hydrogen technologies	CCS technology envisaged	both

Figure 2: Overview of measures for both scenarios by category

Key findings of the study:

- **Ljubljana has the possibility of achieving by 2050 both scenarios** (target scenario and sustainable excellence scenario), without its residents, organisations and users of city services needing in any way to give up any of the comforts already attained.
- Moreover, **through investment in new technologies** that reduce energy consumption and emissions, the **quality of life and work in Ljubljana can be dramatically improved**. In this way, as a city Ljubljana can become even more competitive in the international environment.
- **The investments involved in achieving the two targets are not slight**, but those that can be made by the city authorities have a **relatively short period of return**. Furthermore, investment in energy efficiency also spurs development in the context of creating new sources of revenue for companies and new jobs.

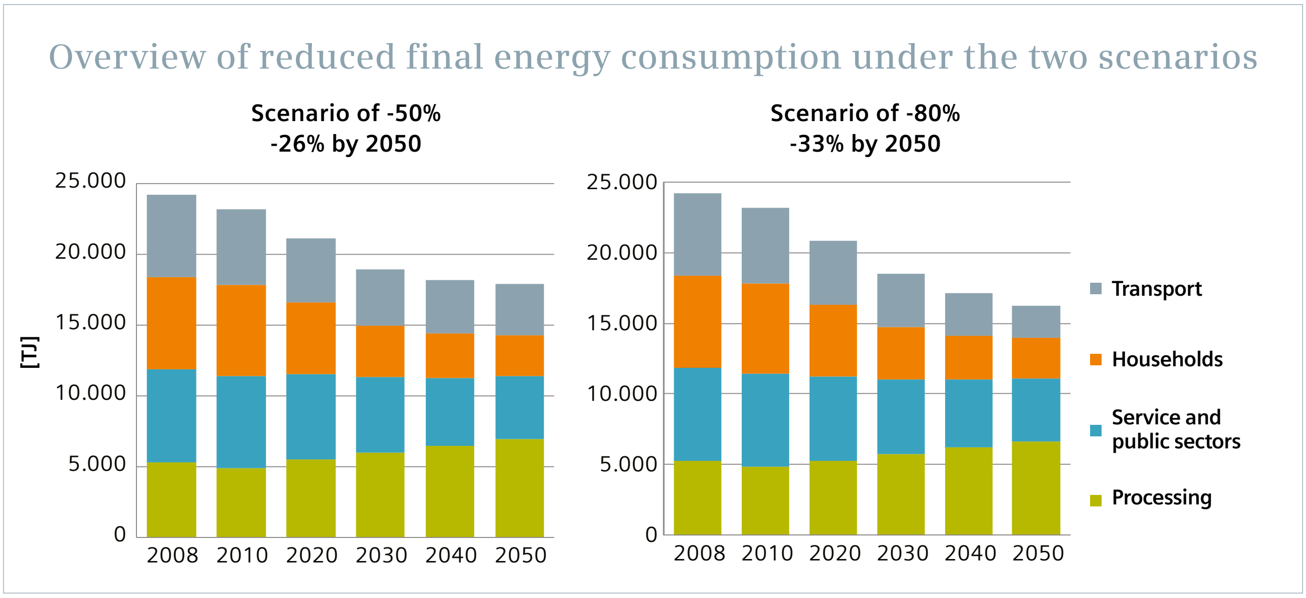

Figure 3: Overview of reduced final energy consumption under the two scenarios

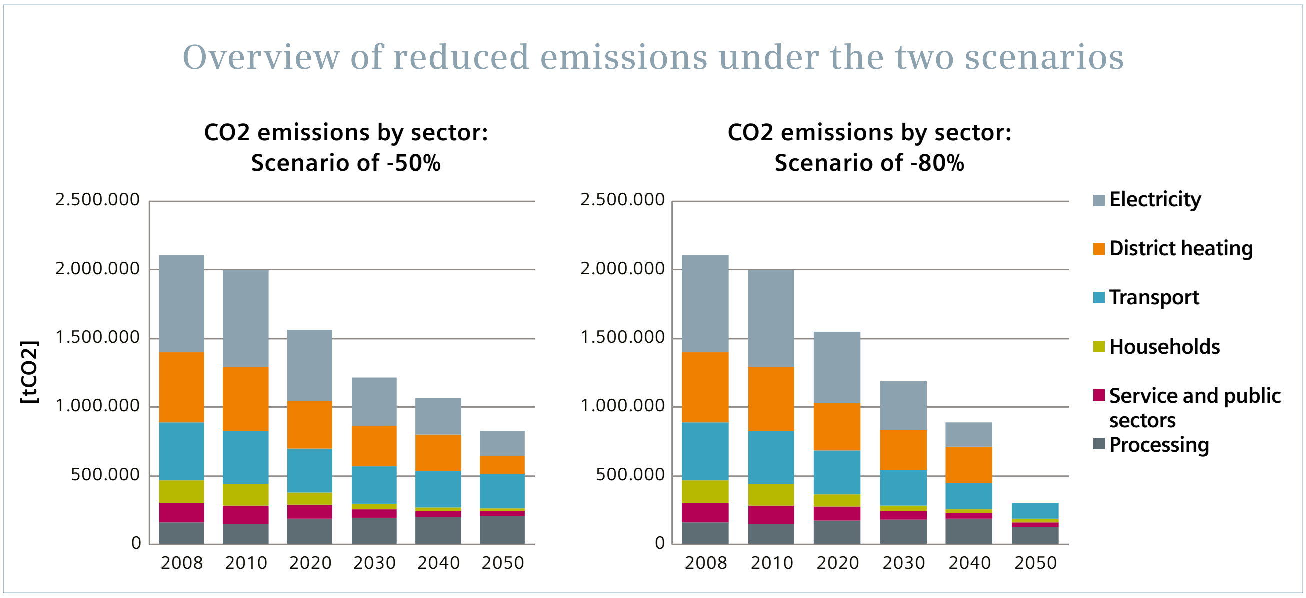

Figure 4: Overview of reduced emissions under the two scenarios

II. Input data and assumptions

At a time of radical change and tough economic conditions, trying to predict the coming decades can be a thankless task. Nevertheless it is better to make use of the data and methodological tools currently available to us than to keep our eyes closed to the future because of its unpredictability. The projections in the material below have been made based on the valid statistics of the Slovenian and international statistical offices, and on an optimistic view that the economic crisis will be transformed into growth. They include well-known visions of anticipated technological change, and describe the conditions needed for Ljubljana to achieve its ambitious environmental targets.

GDP projections to 2050

The calculations up to 2030 take a target scenario of economic development drawn up for the proposed National Energy Programme by experts from the Office of the Republic of Slovenia for Macroeconomic Analysis and Development (OMAD). The projection of economic development to 2050 is based on the assumption of maintaining the absolute value of physical production envisaged for between 2025 and 2030. After a promising start in 2007, when Slovenia achieved record economic growth, the financial crisis and recession in key export markets brought the country to economic crisis. In 2008, economic growth slowed down dramatically, and in 2009 it was distinctly negative (-8.1%) and significantly lower than expectations. In line with the formulated projections of economic growth, the average annual growth of GDP in the target scenario for the period from 2010 to 2050 is set at 2.6%. Owing to conditions in global markets and in the region, forecasts of economic trends at this moment are extremely uncertain.

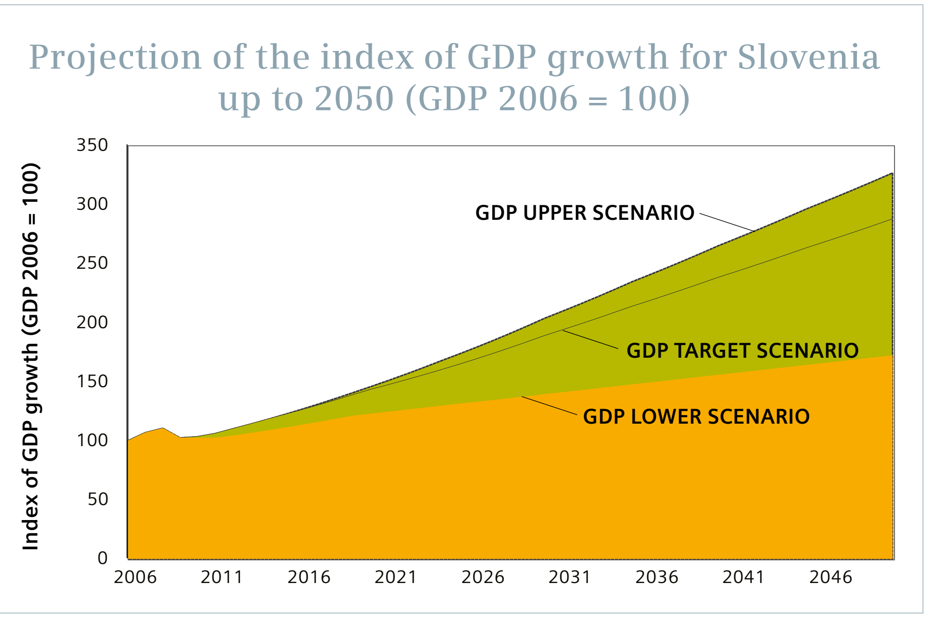

Figure 5: Projection of the index of GDP growth for Slovenia up to 2050 (GDP 2006 = 100)

Projection of energy prices up to 2050

The calculations up to 2030 did not take the projection of energy prices given in the proposed National Energy Programme (intensive scenario in which via regulated activities and fiscal policy, the competent institutions influence prices and create a support environment for the implementation of all profitable EEU, RES and CHP projects and accelerated development in the area of active networks).

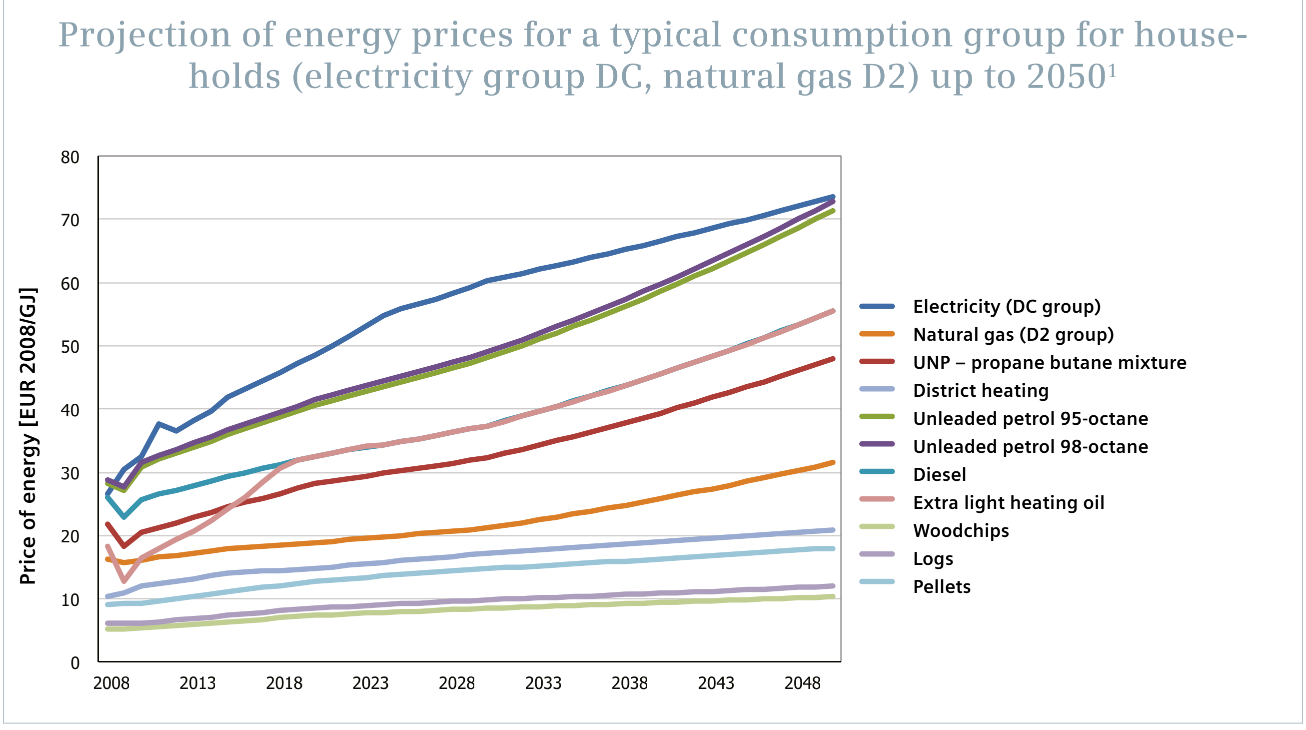

Figure 6: Projection of energy prices for a typical consumption group for households (electricity group DC, natural gas D2) up to 2050[2]

[1] Prices are expressed as constant prices for 2008 (EUR2008) excluding VAT.

[2] E.g. the International Energy Agency: World Energy Outlook 2010; the Eurelectric association: Power Choices – Pathways to Carbon – Neutral Electricity in Europe by 2050; Eurelectric 2010 or WWF in cooperation with Ecofys and OMA (The Office for Metropolitan Architecture): The Energy Report – 100% Renewable Energy by 2050, WWF 2011).

The projection of energy prices up to 2050 is based on assumptions of further technological development and active implementation of measures for the transition to a low-carbon society, drawn from available international studies[1].

Projection of energy prices for a typical consumption group for industry (electricity group IC, natural gas I3) up to 2050[2]

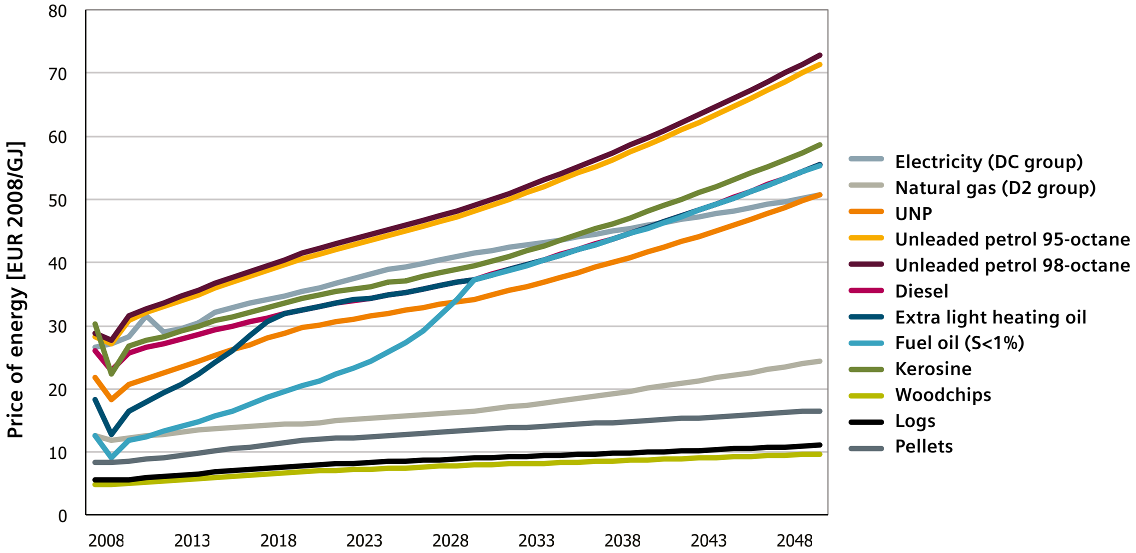

Figure 7: Projection of energy prices for a typical consumption group for industry (electricity group IC, natural gas I3) up to 2050[2]

[1] E.g. the International Energy Agency: World Energy Outlook 2010; the Eurelectric association: Power Choices – Pathways to Carbon – Neutral Electricity in Europe by 2050; Eurelectric 2010 or WWF in cooperation with Ecofys and OMA (The Office for Metropolitan Architecture): The Energy Report – 100% Renewable Energy by 2050, WWF 2011).

[2] Prices are expressed as constant prices for 2008 (EUR2008) excluding VAT.

Share of City of Ljubljana in Slovenian energy consumption

The City of Ljubljana accounts for 13% of final energy consumption in Slovenia. Energy consumption in buildings owned by City of Ljubljana within the public sector accounts for only 14% of that share. This fact confirms that the issues of environmental efficiency of the City of Ljubljana and the Slovenian state are inseparable, since:

- the City of Ljubljana has a high share in overall Slovenian energy consumption,
- as an entity of city administration, the City of Ljubljana has a very small final impact on the energy picture of the city.

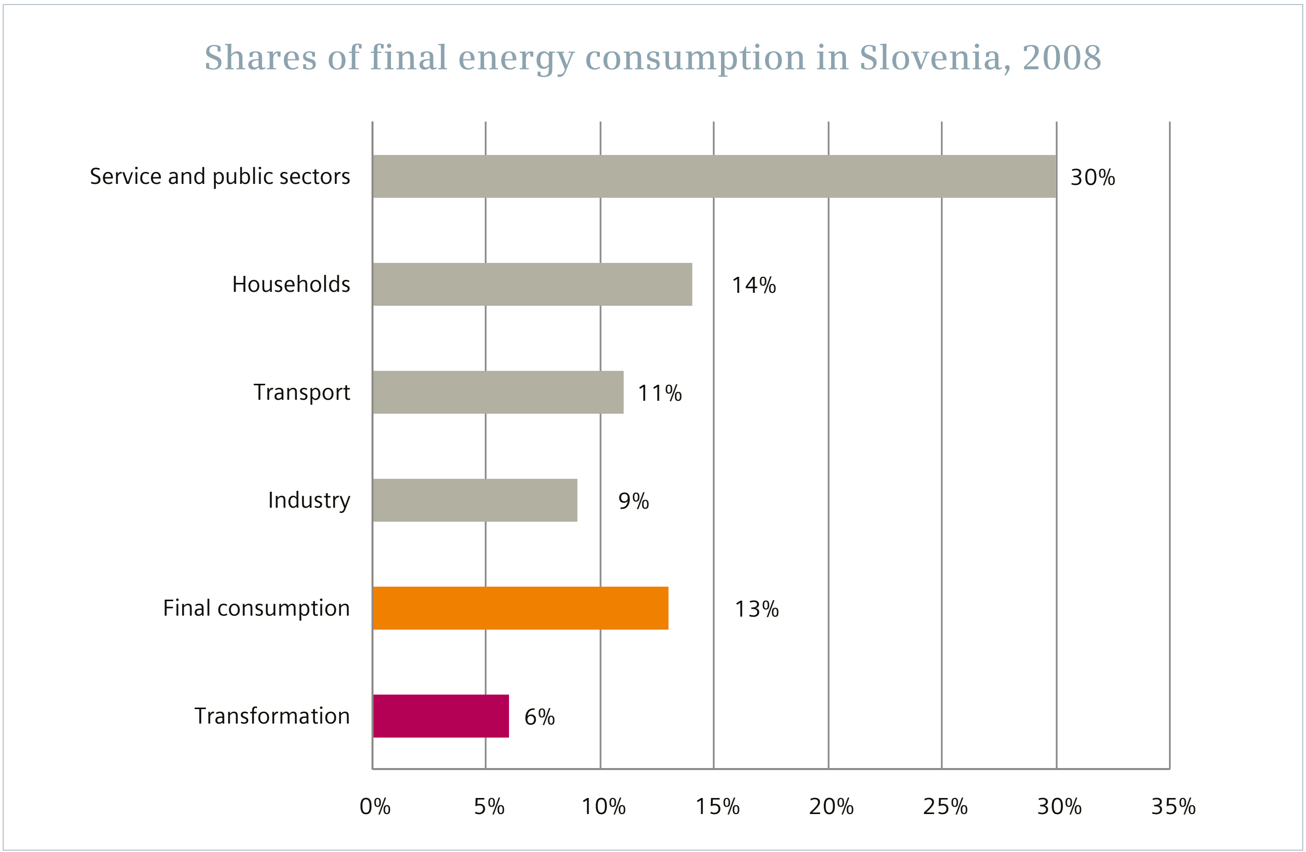

Figure 8: Shares of final energy consumption in Slovenia, 2008

Structure of energy use and costs in buildings owned by City of Ljubljana

In order to achieve the two development scenarios (target scenario and sustainable excellence scenario), Ljubljana's first environmental target must be expanding the district heating and its upgrading to district cooling, as well as strengthening the share of renewables or natural gas (by replacing boilers) in the energy mix at the expense of extra light heating oil. This picture provides a good illustration of the relationship between cost and energy efficiency of individual energy products, and it can be applied to any entity of the administration.

Structure of energy use (left) and costs (right) in buildings owned by City of Ljubljana in 2008[1]

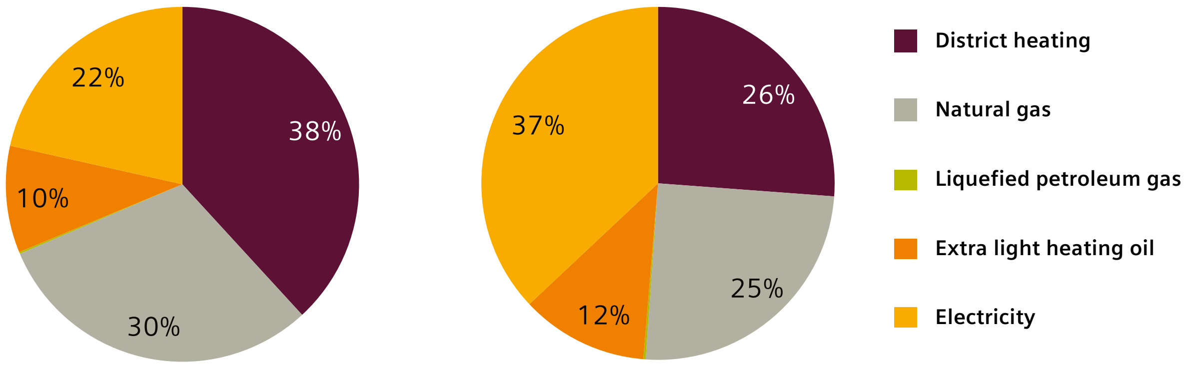

Figure 9: Structure of energy use (left) and costs (right) in buildings owned by City of Ljubljana in 2008[1]

[1] Source: IJS-CEU, URS data, IE-Energis.

Structure of energy use and costs in industry

In our analyses we assumed that **industry would not relocate to other regions**, but would remain in City of Ljubljana and provide jobs and tax revenues, and in this way growth and economic strengthening of the city.

According to predictions, the biggest growth will be in the manufacturing of foodstuffs, chemicals, medicines and non-metallic products. Industry meanwhile has **shown major potential for energy and emission savings**.

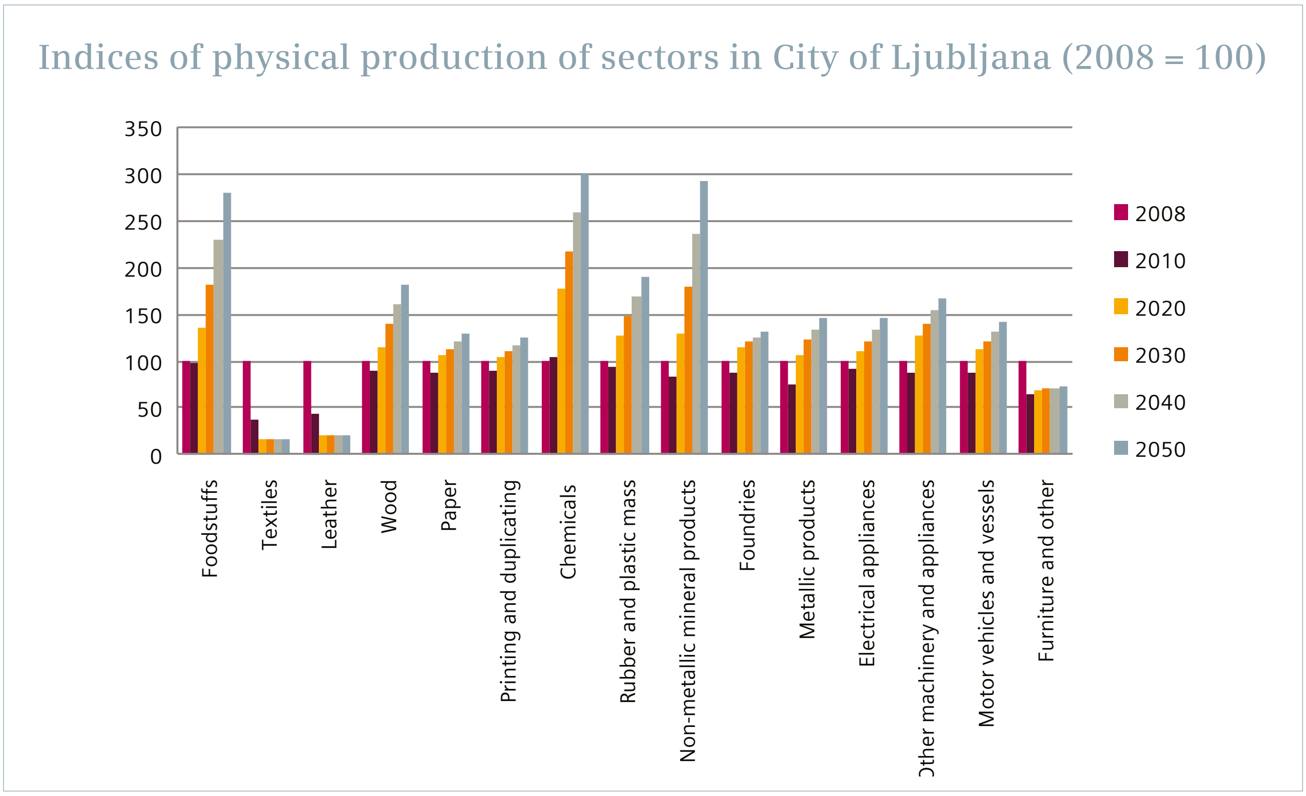

Figure 10: Indices of physical production of sectors in City of Ljubljana (2008 = 100)

Growth in the number of inhabitants and households

According to demographic statistical projections, the number of inhabitants in Ljubljana should increase in the next few years (mainly owing to the ageing population), and then it will remain on a similar level. Households will have fewer and fewer members, while there will be an increase in the number of households. This means that the number of residential units will rise in Ljubljana. The demand for certain services (such as schools) will gently fall, and for others (such as healthcare) it will rise.

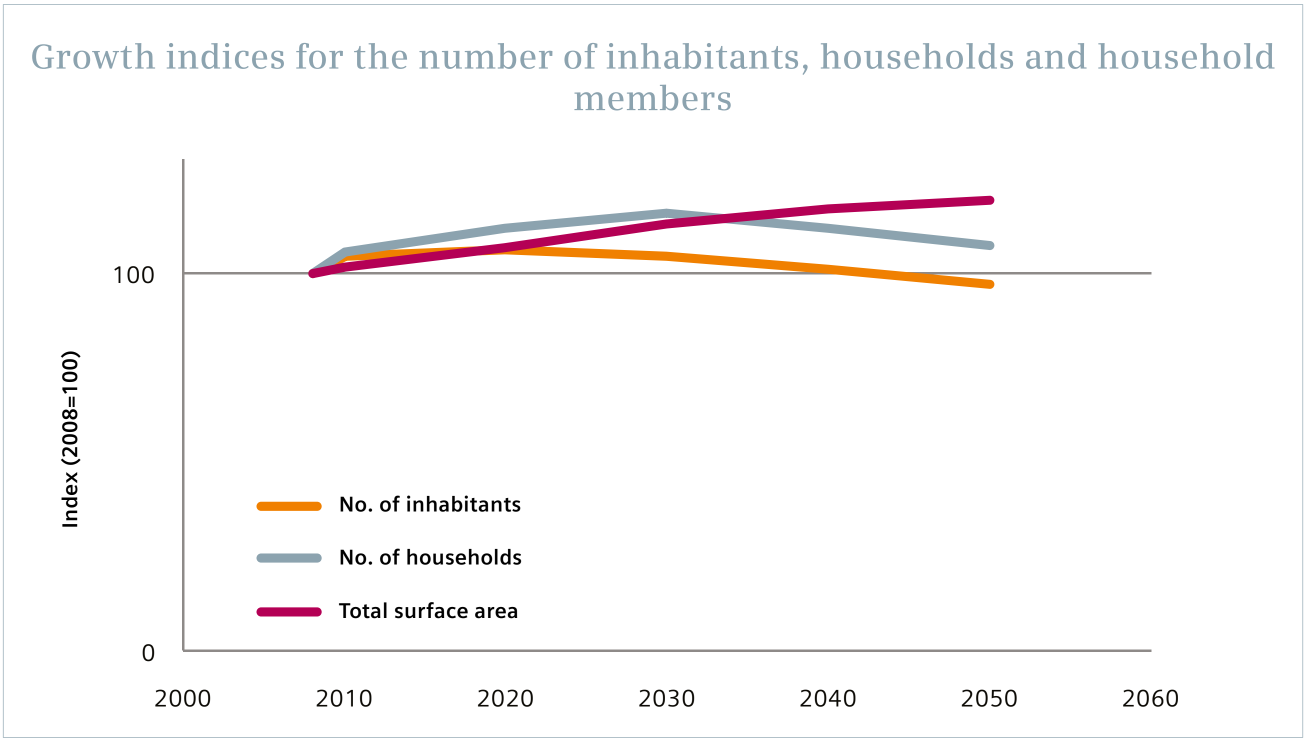

Figure 11: Growth indices for the number of inhabitants, households and household members

Buildings surface area in the public and service sectors

The public and service sectors will expand further in Ljubljana, mainly owing to demographic trends and industrial development trends in the city, so more space will be required. Sectoral growth will have a positive impact on the growth of Ljubljana as a city and on its importance in the wider area.

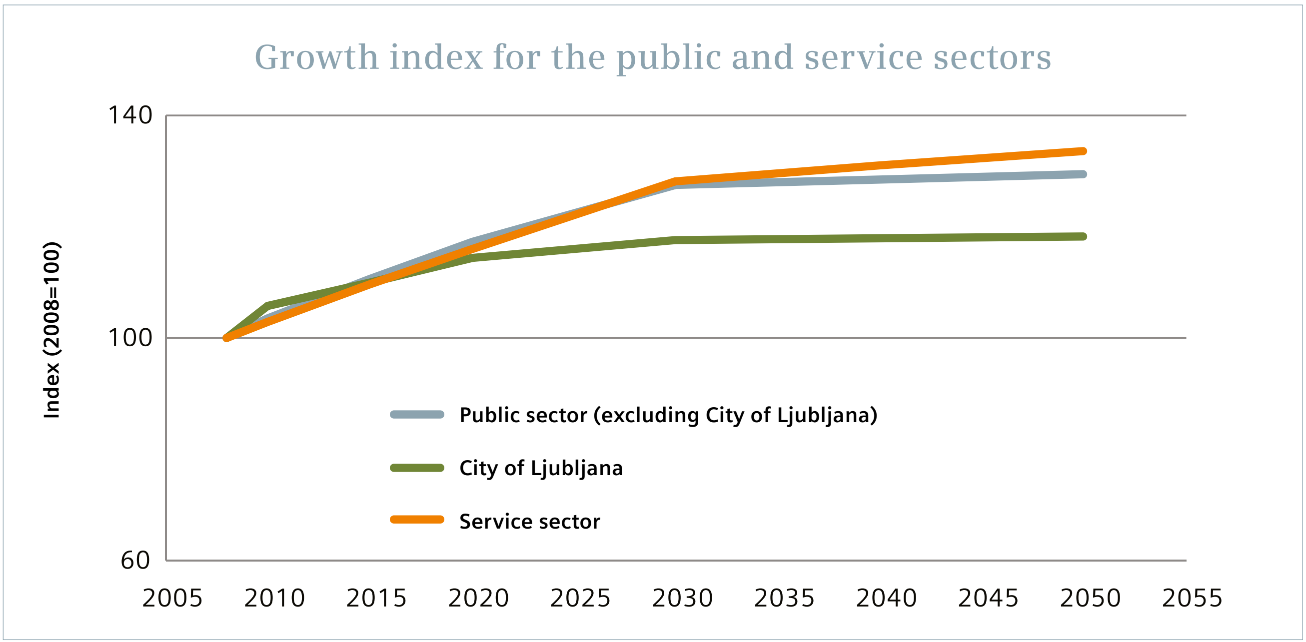

Figure 12: Growth index for the public and service sectors

Transport – consumption per kilometre travelled

Through technological advances, fuel efficiency will continue to improve. By 2020 the average specific consumption by all passenger cars will fall, relative to 2008, by 22%. The reduction will be due mainly to improvements in petrol and diesel vehicle technology (averaging at 18%). Between 2020 and 2050 the average specific consumption by all passenger cars will fall, relative to 2020, by an additional 20%, and this will be attributable almost exclusively to technological breakthroughs.

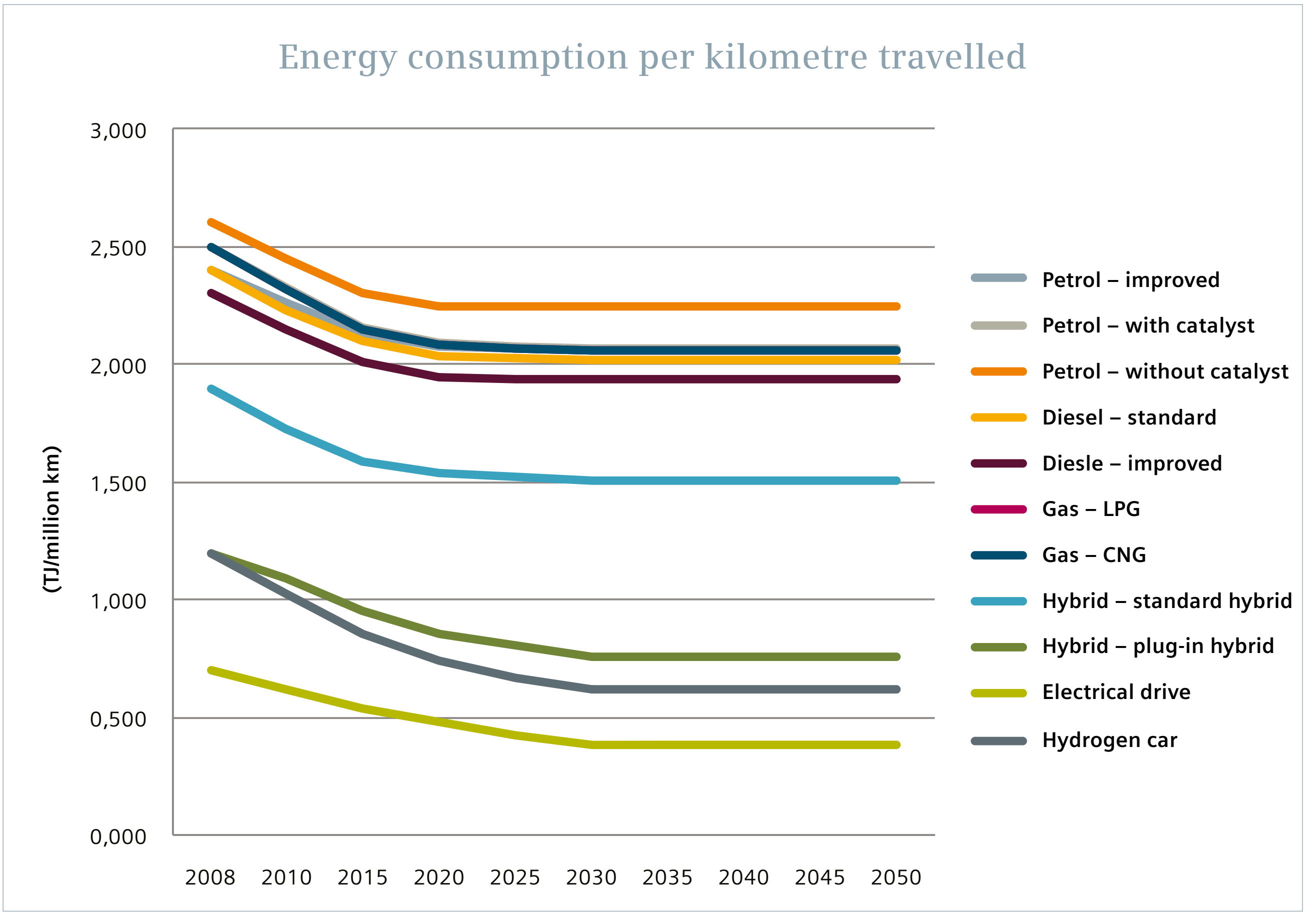

Figure 13: Energy consumption per kilometre travelled

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III. Possibilities for achieving the scenarios

This study analyses two scenarios: the **target scenario**, which envisages a 50% reduction in emissions, and the **sustainable excellence scenario**, in which by 2050 Ljubljana would reduce emissions by 80%. The main focus of attention was on energy supply in industry, households and in the public and service sectors, while the area of transport was also analysed in detail. In this chapter we describe the conditions needed to achieve each of the scenarios in different areas, we analyse the necessary measures and technological changes and, where possible, we assess the financial consequences of fulfilling the specific scenario.

Industry – energy consumption

Energy consumption (especially electricity) will increase in industry. Growth of industrial energy consumption in the City of Ljubljana area is tied directly to the volume of physical output by individual sector.

The target scenario (reducing emissions by 50%) can be achieved through extensive implementation of energy efficiency measures (measures in heat processes and boilers, and electric motor drives), and by increasing the share of RES. The share of gas and district heating must remain on roughly the same level as today (regardless of any other increase in industrial demand).

The sustainable excellence scenario (reducing emissions by 80%) can be achieved in Ljubljana if in addition to the aforementioned energy efficiency measures, manufacturers start investing in technology based on the energy use of hydrogen. The share of other energy products remains in approximately the same proportions as in the target scenario.

Predicted energy consumption in industry up to 2050 under the sustainable excellence scenario (left) and target scenario (right)

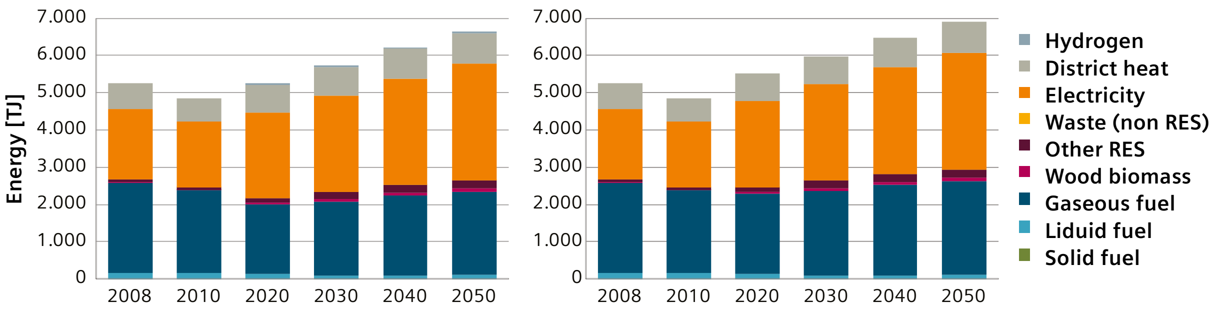


Figure 14: Predicted energy consumption in industry up to 2050 under the sustainable excellence scenario (left) and target scenario (right)

Industry – CO_2 emissions

In the scenario of sustainable excellence (reducing emissions by 80%), industry bears a relatively higher share of responsibility for achieving emission effects, **while the key substantive difference lies in the new energy product (hydrogen) and use of technologies for carbon capture and storage (CCS).**

Predicted CO2 emissions in industry up to 2050 under the target scenario and sustainable excellence scenario

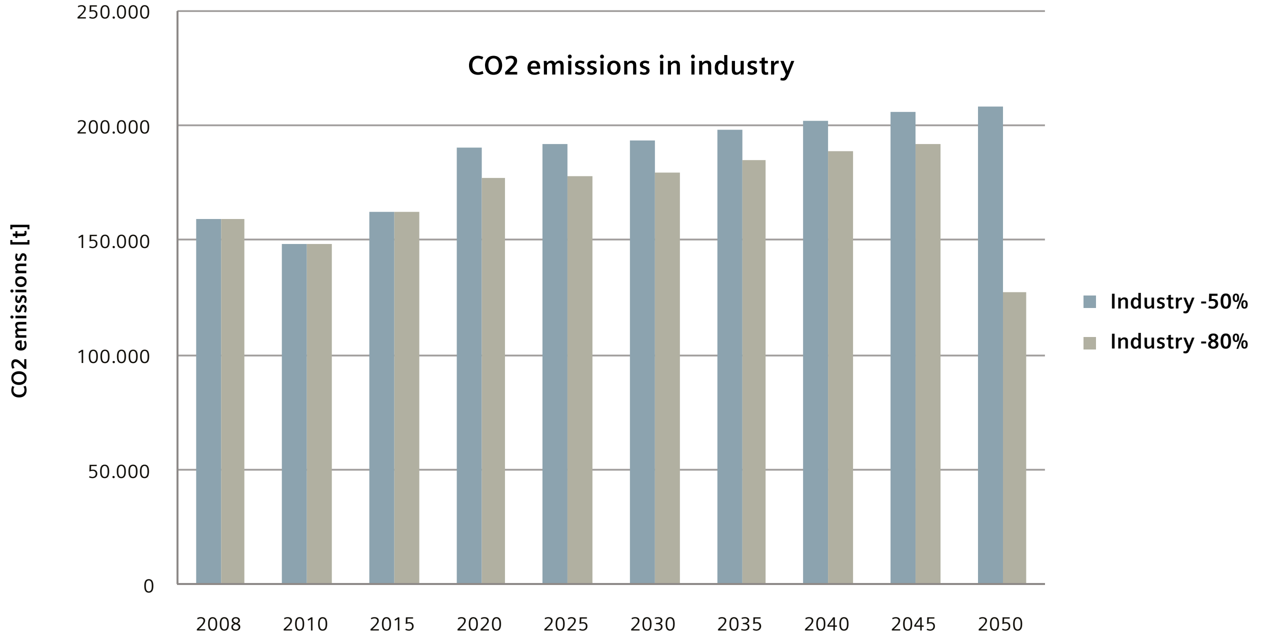


Figure 15: Predicted CO2 emissions in industry up to 2050 under the target scenario and sustainable excellence scenario

Emissions of CO2 in industry in the base year of 2008 amounted to 158,955 t CO2. Up to 2015 there are no significant differences in the attainment of the two scenarios. After 2020, fulfilment of the sustainable excellence scenario envisages a breakthrough in hydrogen technologies in industrial units for combined heat and power generation, which will contribute to additional reductions in emissions relative to the target scenario. As a result of the envisaged use of technologies for carbon capture and storage (CCS), in the sustainable excellence scenario we can achieve a marked reduction in CO2 emissions in 2050, by as much as 20% relative to the base year of 2008 (irrespective of the fact that industry will meanwhile boost operations and consequently its relative consumption of energy).

Industry – measures and their effects

In 2008 industry (the processing sector) in the area of the City of Ljubljana consumed 5,264 TJ of energy. Given the expansion of industry, in the target scenario up to 2050 we envisaged a growth in energy to +93% of baseline consumption (partly on account of the expansion of operations, and partly the non-implementation of efficient energy use measures) and a 62% reduction in consumption relative to the baseline consumption and in view of anticipated growth. The **investments** needed to carry out the measures have been estimated at EUR 22 million up to 2030 and EUR 52 million up to 2050 (cumulative).

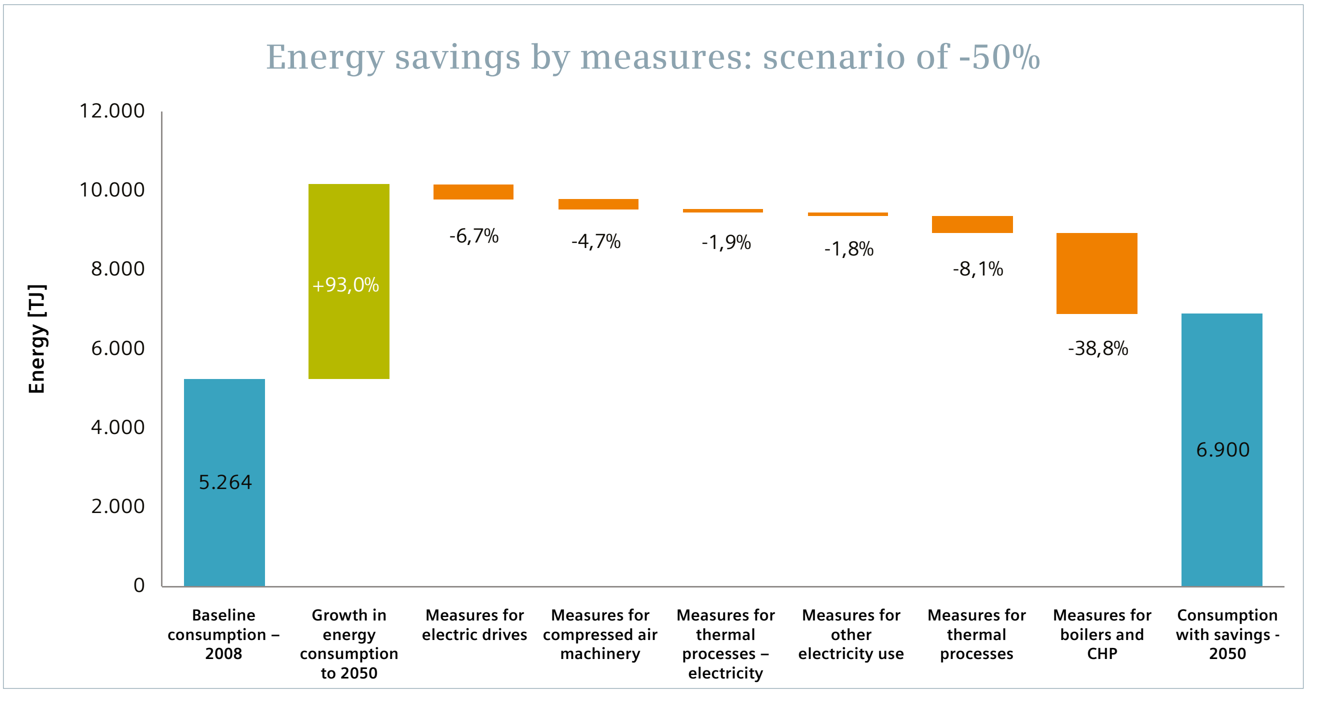


Figure 16: Energy savings by measures in terms of the target scenario

In the sustainable excellence scenario, the percentages for savings do not differ from those in the target scenario, and only the envisaged growth in final energy (88.2%) is lower in 2050 owing to the use of hydrogen, which will replace gas in combined heat and power generation units.

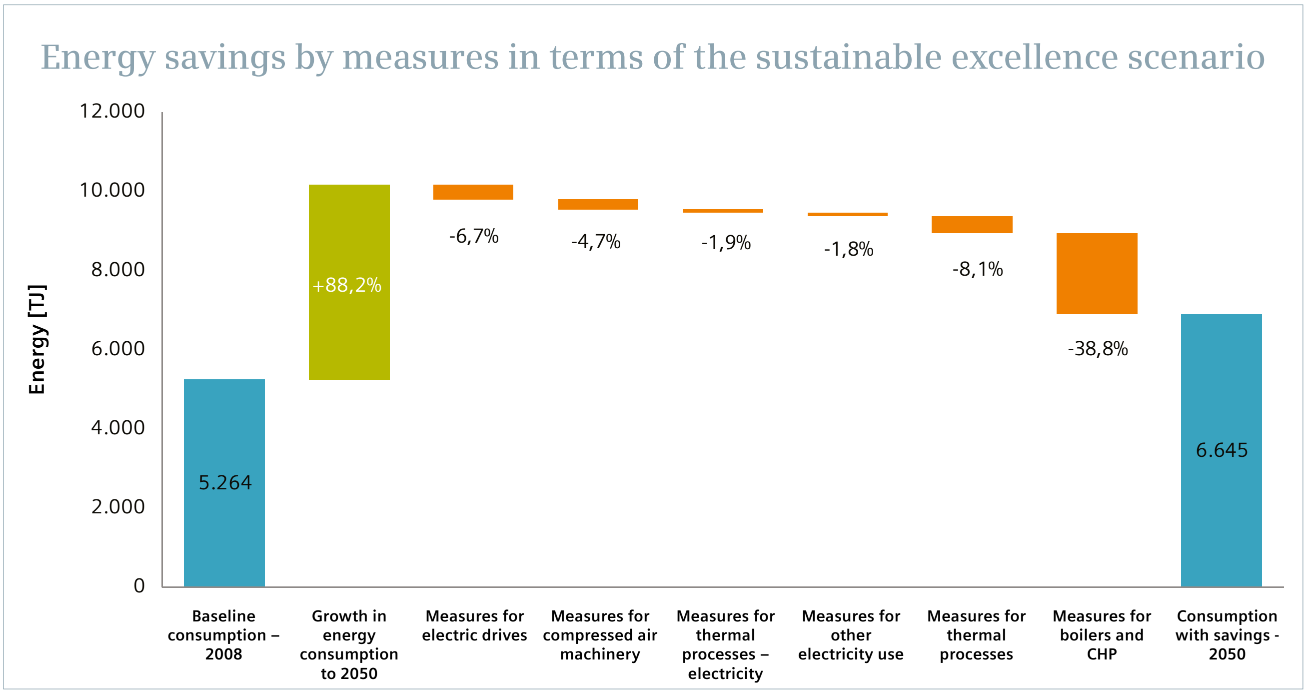


Figure 17: Energy savings by measures in terms of the sustainable excellence scenario

An overview of measures that will contribute to greater environmental efficiency in industry:

- **Measures for electric motor drives: estimated final energy saving of 6.7%** – improving efficiency through the use of frequency regulation of electric drives, using energy-efficient electric motors, pumps and ventilators.
- **Measures for compressed air machinery: estimated final energy saving of 4.7%** – reduced leaks, optimised tubing and optimised regulation for reducing compressed air consumption.
- **Measures for thermal processes (electricity): estimated final energy saving of 1.9%** – introduction of energy accounting and monitoring of consumption, employee training, improved maintenance, replacement and upgrading of equipment (new technology).
- **Measures for other consumption of electricity: estimated final energy saving of 1.8%** – energy-saving lighting, introduction of energy accounting and monitoring of consumption, employee training, improved maintenance, replacement and upgrading of equipment (new technology).
- **Measures for thermal processes (heat): estimated final energy saving of 8.1%** – introduction of energy accounting and monitoring of consumption, employee training, improved maintenance, optimised transport and reducing the need for transport, optimised vehicle fleet (reducing specific use, transfer to other energy products), replacement and upgrading of equipment (new technology).
- **Measures for boilers, CHP and heating appliances: estimated final energy saving of 38.8%** – improvement measures for boilers and replacement and upgrading of equipment (new technology).

Another consequence of efficient energy use will be reduced emissions. Both scenarios anticipate emissions growing by 123,511 t CO2 up to 2050, although in the sustainable excellence scenario, owing to a different mix of technologies, the use of hydrogen and CCS technologies, we can achieve an emission reduction of 155,252 t CO2, representing a full 20% saving relative to the reference year of 2008.

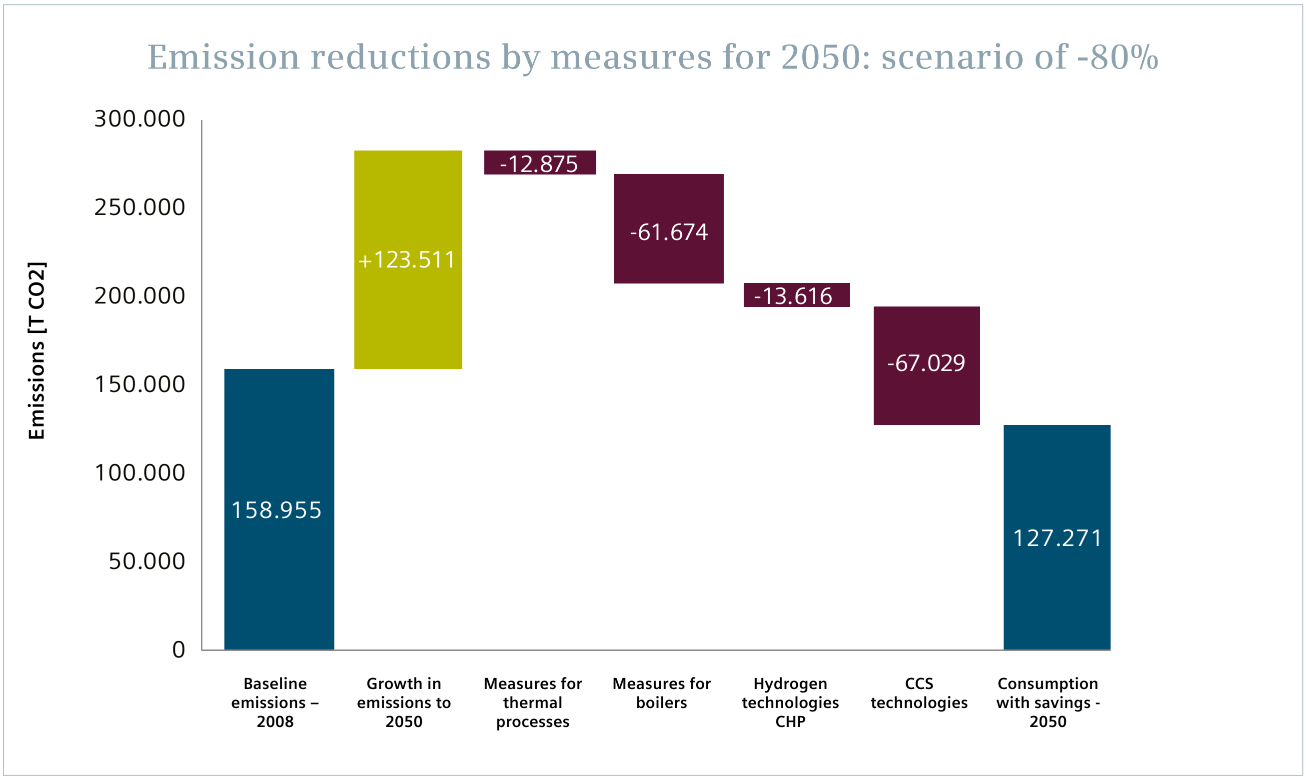


Figure 18: Emission trends by measures in terms of the sustainable excellence scenario

In the target scenario, despite efficient energy use measures (measures for thermal processes and boilers), we record an increase in CO_2 emissions of 48,961 t CO_2.

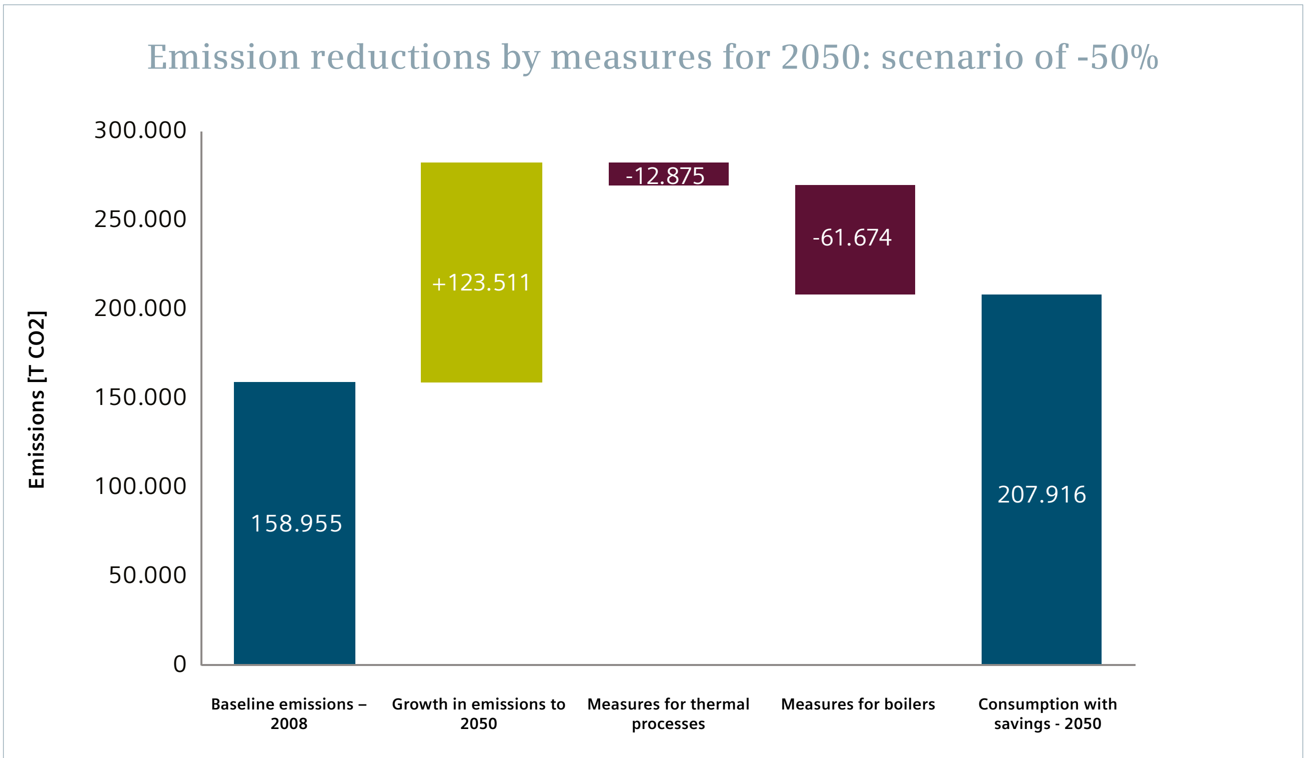


Figure 19: Emission trends by measures in terms of the target scenario

Industry – success story

Energy-efficient paper production

The Papirnica Vevče paper works ranks as one of the oldest industrial plants in Slovenia. It was established in 1842 (so this year it is celebrating its 170th anniversary), and for its operation it has used one of the oldest Slovenian power stations, while today it produces almost 90,000 tons of paper a year for packaging and labels. The paper works has already embarked on the path of energy efficiency.

Frequency converters play a similar role in industry to gears in a car – they enable the motor to be loaded optimally, making production more efficient and flexible. Since the motors are not operating at full capacity 24 hours a day, they use less energy.

"In any event we could start gradually replacing our technology with more energy-efficient equipment, and we are additionally motivated towards this by the possibility of obtaining funds as part of the Ministry of the Economy tender," explains Andrej Smrekar, head of technology at Papirnica Vevče: "Industrial motors are being replaced continuously with more efficient ones, and exclusively to achieve energy savings, last year's output also benefited from the installing of Siemens frequency converters. For the same reason we also partly replaced our lighting – the outside lighting uses LED technology, and inside we use energy-saving bulbs."

The effects were immediate – they are continually monitored and evaluated at Papirnica Vevče – and the savings obtained depend on the type of equipment. "Using tools available on the Siemens website, we calculated that, for instance, our investment in frequency converters pays itself off in 5 to 22 months. Furthermore, we anticipate that in one year from introducing new technologies, we will save 1500 megawatt hours of electricity," adds Smrekar.

Source: Delo, March 30, 2012

Households – energy consumption in buildings

The greatest proportion of household energy is used for heating and hot water, followed by household appliances.

Ljubljana can achieve the target scenario and the sustainable excellence scenario through the energy rehabilitation of buildings, replacement of the sources of heating, hot water and cooking in households and by improving the energy efficiency of appliances and lighting.

By implementing these measures Ljubljana can:

- **reduce by 65% energy consumption** for generation of heat used in heating, hot water and cooking in households;
- **reduce by 85% emissions** produced by energy used in generation of heat for heating, hot water and cooking in;
- greater energy efficiency of household appliances could **additionally reduce energy consumption by 4%** by 2050.

Since such measures cannot be prescribed administratively, an essential factor is added awareness-raising among the population and development of financial products (favourable loans, energy contracting), which can stimulate decision-making by individuals (owners of residential units) and organisations (investors, financial institutions, administrators and other subjects).

Investments in the comprehensive renewal of the housing fund in the household sector up to 2050 have been estimated at EUR 3.1 billion, of which EUR 1.95 billion are for single family homes and EUR 1.15 billion for multi-dwelling buildings.

Households – renovation of buildings as a lever for reducing energy consumption

Today we are renovating an average of 1.6% of residential units a year. In order to attain either scenario, the rate of renovation would have to rise more than twofold, with the majority of the housing stock being renovated by 2030. After this period, we could envisage the rate of renovation falling considerably.

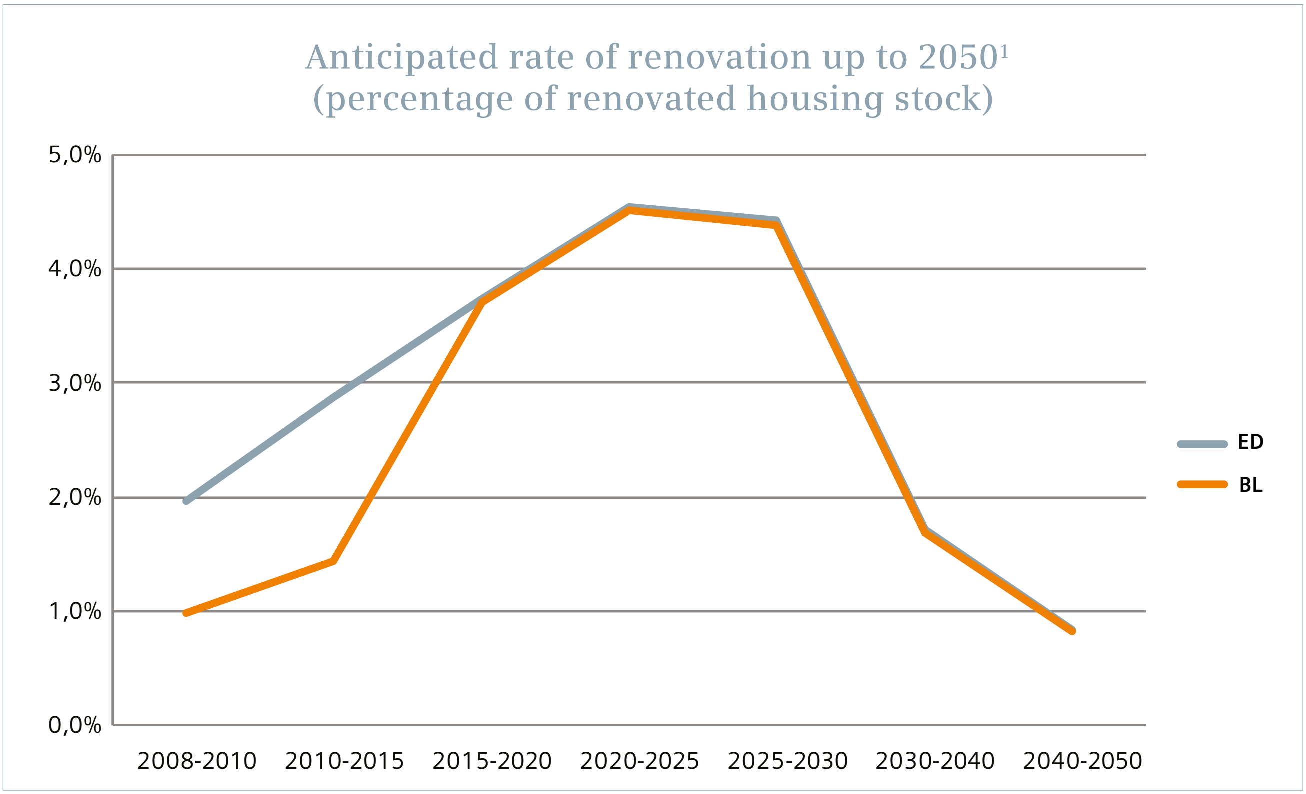


Figure 20: Anticipated rate of renovation up to 2050 (percentage of renovated housing stock)

[1] ED is the abbreviation for single family buildings, and BL for multi-dwelling buildings.

Households – measures and their contribution to reducing energy consumption

Another consequence of increased energy efficiency in buildings will be a reduction in final energy consumption to produce heat for heating, hot water and cooking. The greatest (a full 96%) share in the reduction in energy consumption can be ascribed to improving the energy performance of buildings. **In this sector, energy consumption could fall by 65% up to 2050, and emissions by as much as 85%[1].**

Reduction in finally energy consumption in the generation of heat for heating, hot water and cooking in households

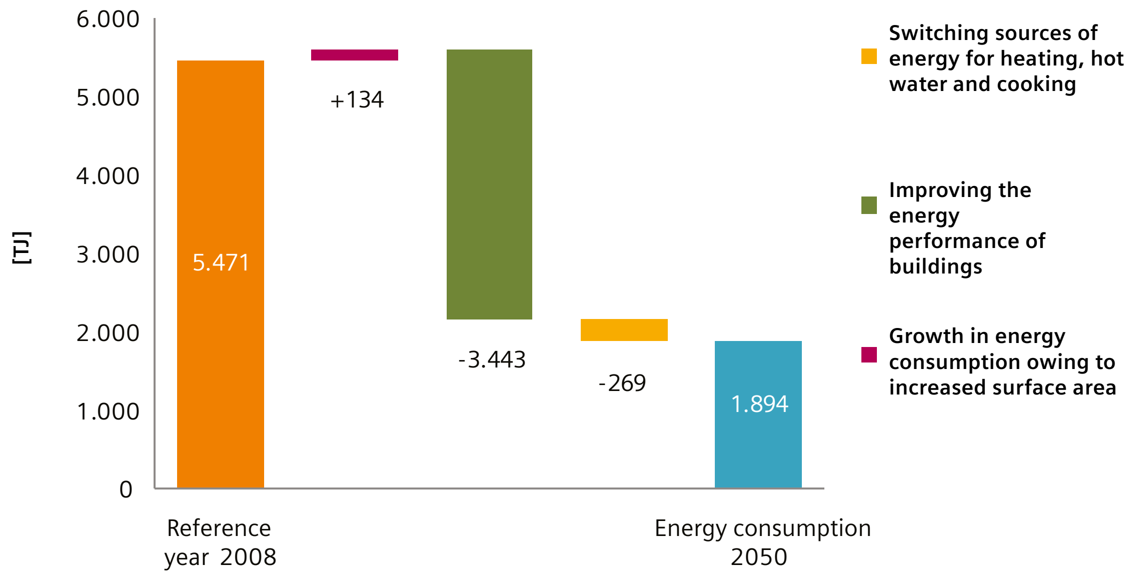


Figure 21: Trend of final energy consumption by measure up to 2050

[1] The calculation of reduced emissions takes into account the effects of a higher share of RES in the energy mix.

Renovated residential units will need an average of **three times less energy than today** for heating. The energy performance of newly constructed buildings will also be improved, principally on the basis of already implemented administrative measures (PURES).

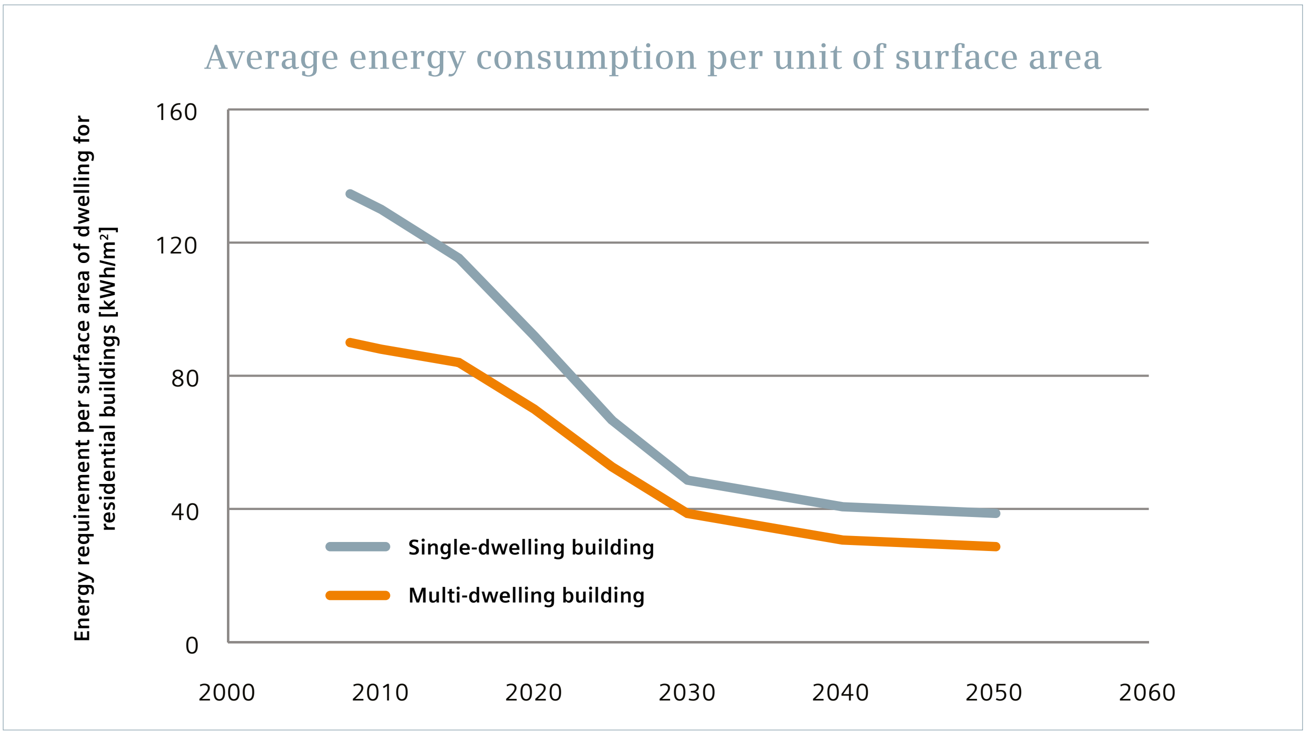


Figure 22: Average energy consumption per unit surface area for households up to 2050

Households – lower emissions

Owing to the use of fossil fuels in the generation of heat for heating, hot water and cooking, CO2 emissions amounted to 163 kt in 2008. **By 2050 these emissions will fall to 24 kt, or by 85% compared to 2008**. The greatest contribution to this reduction will come from improvement to the energy performance of buildings, followed by the replacement of energy sources, where renewables are also taken into account.

Reduction of CO2 emissions in the generation of heat for heating, hot water and cooking in households

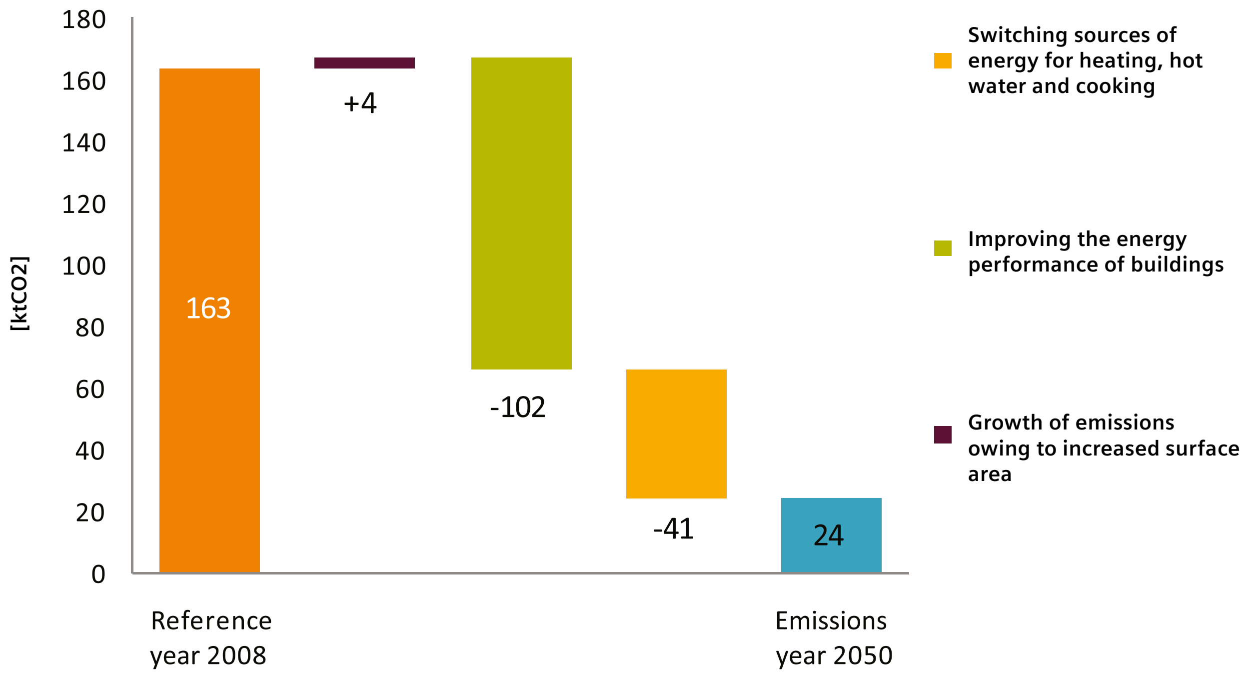


Figure 23: Trend of CO2 emissions in the generation of heat used in heating, hot water and cooking in households by measures up to 2050

Households – technology for heating and hot water

Another important factor in the attainment of the two scenarios is the structure of technologies for heating residential units and production of hot water, where we will witness some fundamental changes. In 2008 district heating has the largest share, and this share will remain the same in the coming periods. The next biggest share is held by gas boilers (fuelled by LPG or natural gas), although despite the fact that this is the most environment-friendly fossil fuel, their use will fall up to 2050, and they will be replaced by micro units for combined heat and power generation.

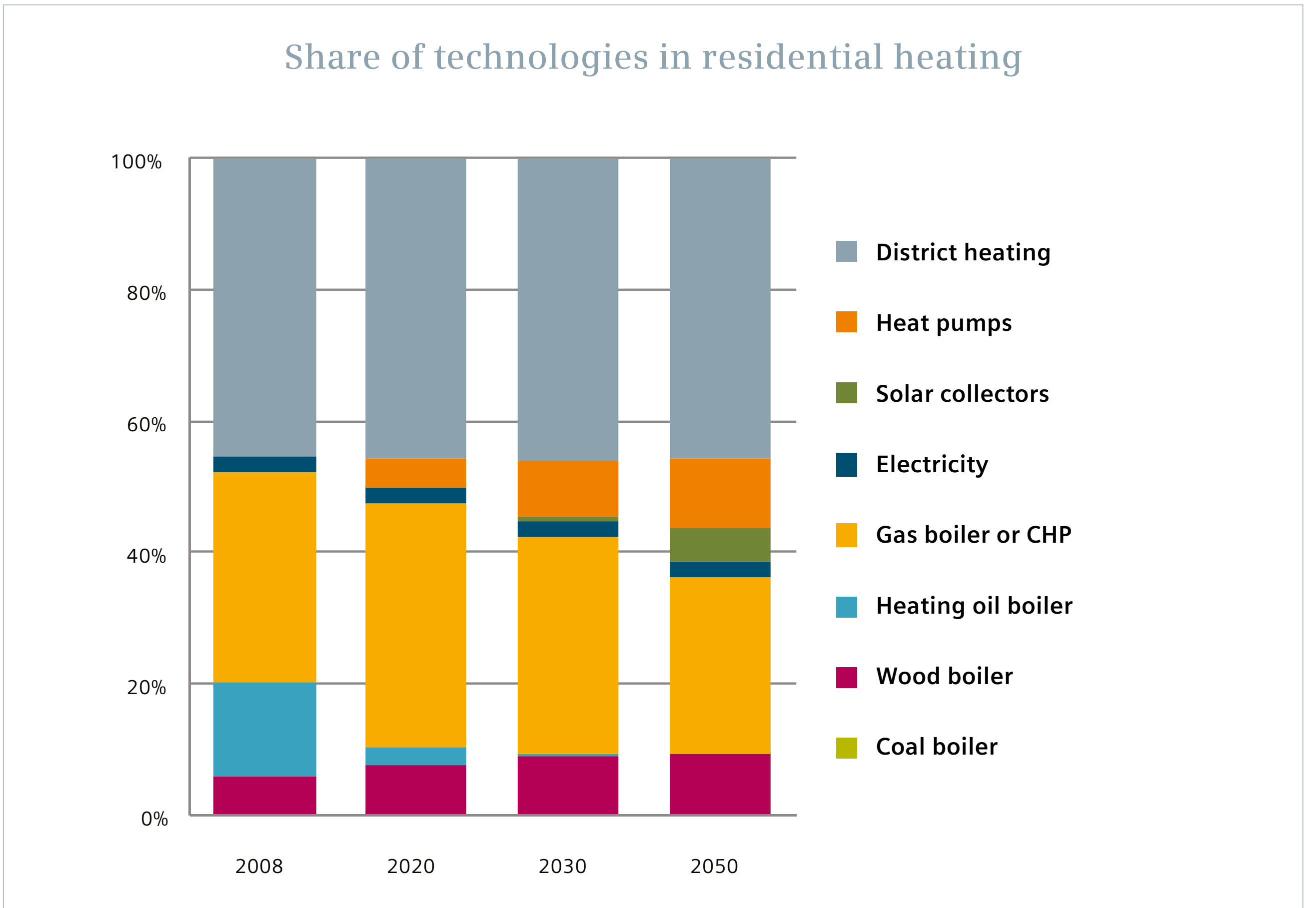


Figure 24: Share of technologies in the preparation of the energy required for heating in 2008, 2020, 2030 and 2050

There will be an even more drastic reduction in the share of heating oil boilers, which will virtually disappear after 2030. There will be an increased share of wood, solar energy and, to the greatest extent, heat pumps.

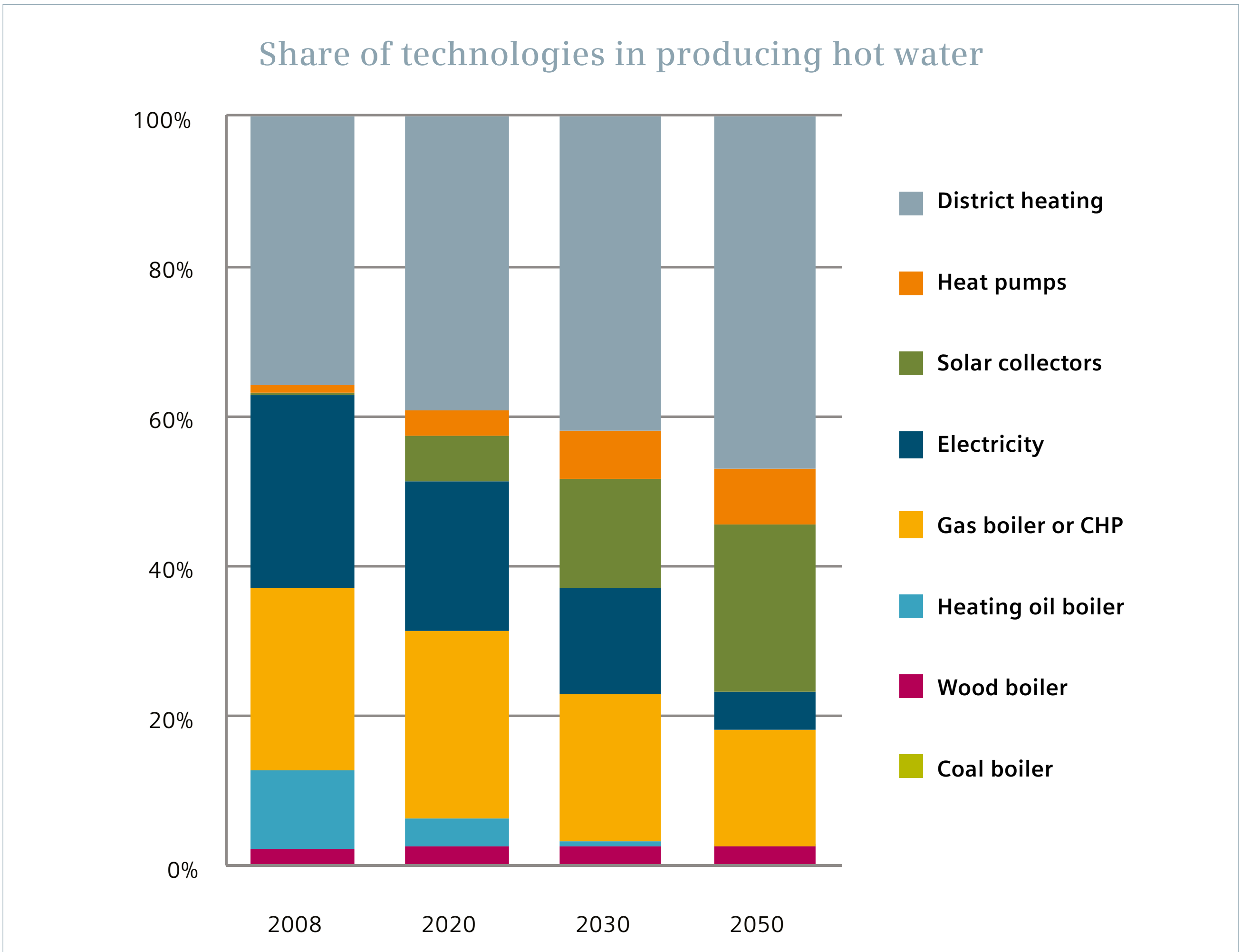


Figure 25: Share of technologies in the preparation of hot water in 2008, 2020, 2030 and 2050

Households – reduced energy consumption for electric appliance operation

Electric household appliances account for a smaller share of energy savings. But new technologies will help render them much more energy-efficient than they are today, with the biggest differences being in the area of freezers and refrigerators.

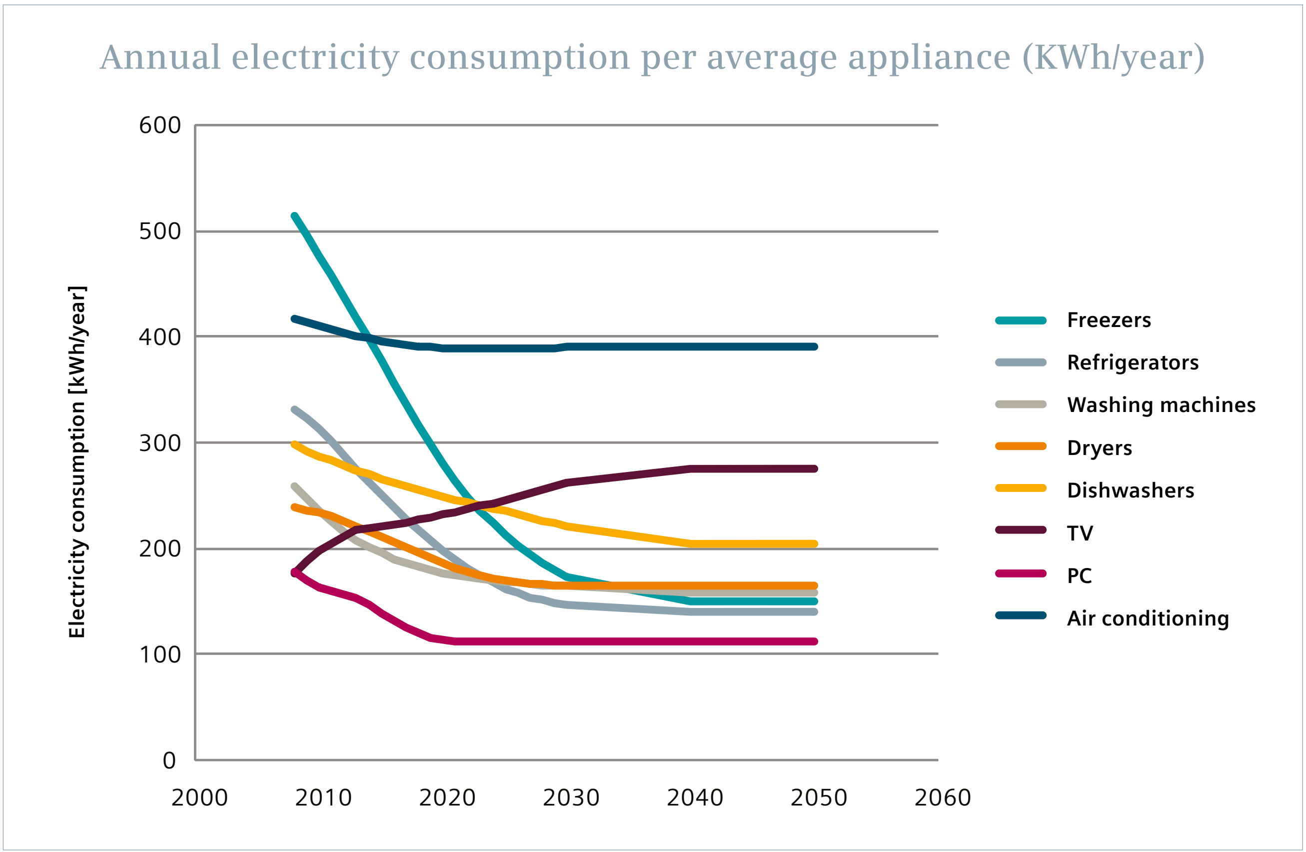


Figure 26: Annual electricity consumption per average appliance (KWh/year)

Households – success story

In 2007 the City of Ljubljana Public Housing Fund renovated two multi-dwelling buildings for the purpose of lowering operating costs while maintaining quality of life. Additional thermal protection was installed in the building shells (exterior walls, basement ceiling, ceiling facing unheated attic, balconies), windows were replaced, shades were installed and a system of mechanical ventilation with heat exchanging was installed. Prior to rehabilitation, the energy consumption for heating alone was between 75 and 85 kWh/m^2, while after rehabilitation this was supposedly reduced by at least 80%[1]. Actual measurements of energy consumption showed that consumption in fact fell to 50 kWh/m^2, representing a 38% reduction[2]. The difference between the anticipated and achieved reduction was a consequence chiefly of non-use of the mechanical ventilation system, since in winter the predominant method was still to ventilate by opening windows. It follows from this that in order to achieve the full potential of the measures, users of dwellings will need to be additionally advised and made aware of the use of all the systems installed in their dwellings.

[1] source: Energijska sanacija večstanovanjskih stavb [Energy Rehabilitation of Multi-dwelling Buildings]; Slovenian Chamber of Engineers, accessible at: http://www.izs.si/dobra-praksa/primeri-dobre-prakse/stanovanjski-objekti/energijska-sanacija-vecstanovanjskih-stavb/

[2] source: Zmanjšanje porabe energije za ogrevanje v prenovljenih stanovanjih JSS MOL [Reducing energy consumption for heating in renovated dwellings of the City of Ljubljana PHF], Ljubljana Smart City, accessible at: http://www.ljubljanapametnomesto.si/aktualno/arhiv/clanek?aid=127

Public and service sectors – energy consumption in buildings

The greatest proportion of household energy use in the public and service sectors is also for heating and hot water, followed by electricity for appliances and lighting.

The target scenario and the scenario of sustainable excellence can be achieved through the following measures:

- energy-efficient renovation of buildings;
- measures for heating systems;
- switching sources for heating and hot water;
- improving the energy efficiency of lighting and electrical appliances.

By implementing these measures we can achieve several positive effects:

- **reducing energy consumption for heat used in heating and hot water** (in the public sector excluding buildings owned by City of Ljubljana, the reduction could be 59%, in City of Ljubljana buildings 61% and in the service sector 30%);
- **reducing emissions** (in the public sector excluding buildings owned by City of Ljubljana, the emissions reduction could be 82%, in City of Ljubljana buildings 80% and in the service sector 70%);
- **reducing electricity consumption for other purposes** (not including heating and hot water) despite the obvious increase in activities, in the public sector (excluding City of Ljubljana buildings) the increase could be limited to just 4%, while it could be reduced in City of Ljubljana buildings (by 13%) and in the service sector (by 13%).

Since this involves public buildings, users do not feel the consequences of irrational practices on their own wallet. For this reason it is extremely important to provide awareness-raising and to introduce new patterns and models for rewards and motivation based on the positive effects of reducing energy consumption and emissions.

The total investment costs for achieving the above targets, which will also lead to attaining the target scenario and the sustainable excellence scenario, have been estimated at EUR 147 million up to 2050. These measures should yield around EUR 6 million in savings each year.

Public and service sectors – renovation of buildings as a lever for energy saving

The rate of renovation on existing buildings owned by City of Ljubljana and in the public sector must increase almost twofold (from 1.6% and 1.5% to 2.7% and 2.8%) in order to achieve the two scenarios by 2020, and after that year must remain on approximately the same level. In the service sector, the rate of renovation will need to increase from 1.2% to 1.5% a year to achieve the two scenarios.

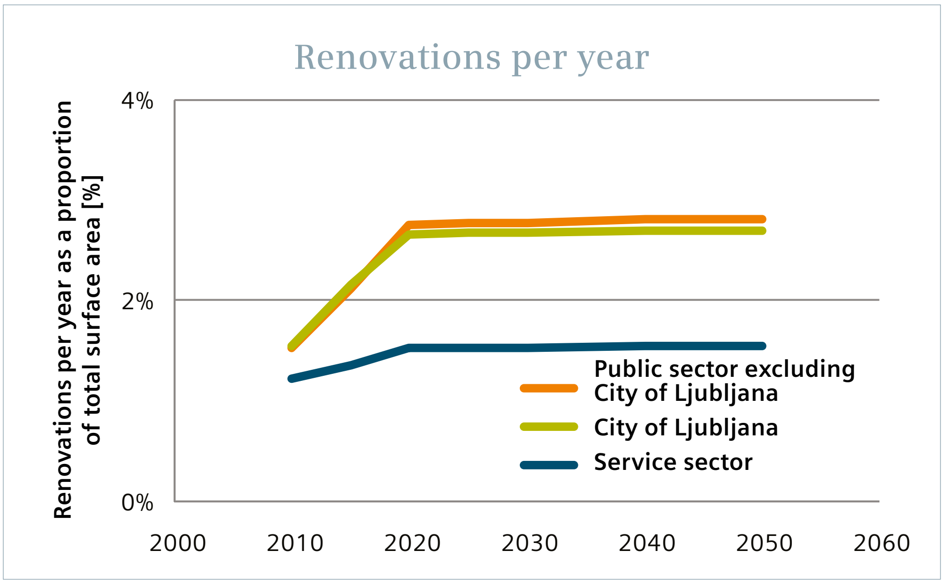


Figure 27: Proportion of buildings renovation each year in the total buildings surface area

According to predictions for achieving the scenarios, the energy figure (specific consumption of energy for heating and hot water) for existing and new buildings will fall markedly. Energy efficiency in the public sector can become an example of best practices for all other sectors, and in this way it has an extremely important demonstrative effect.

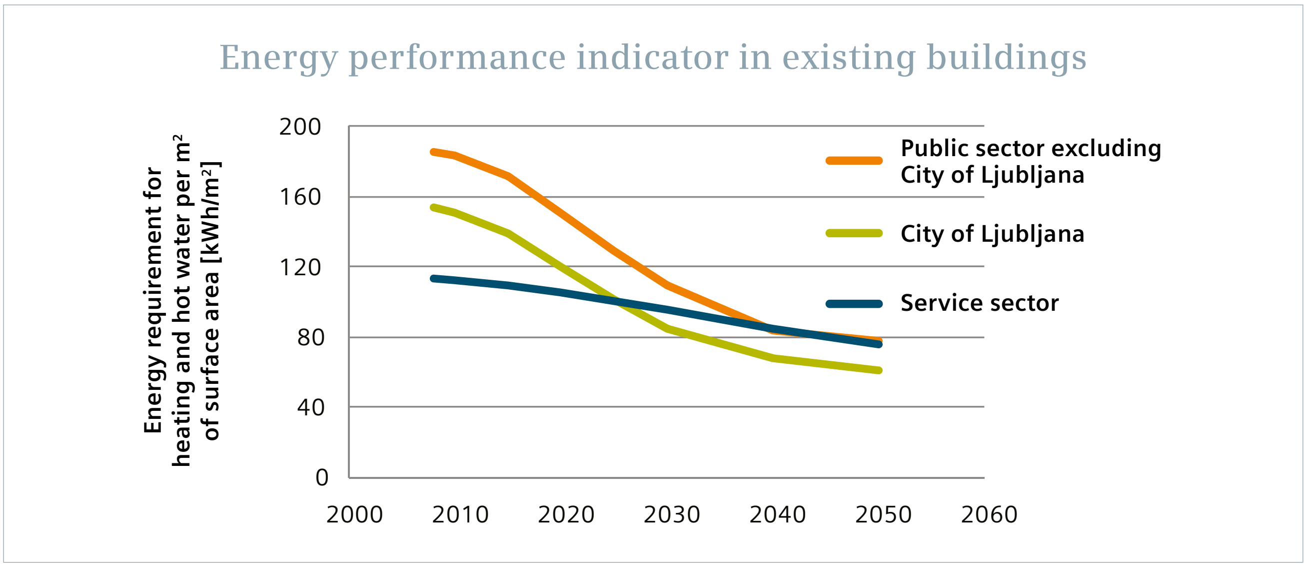


Figure 28: Energy performance indicator in existing buildings

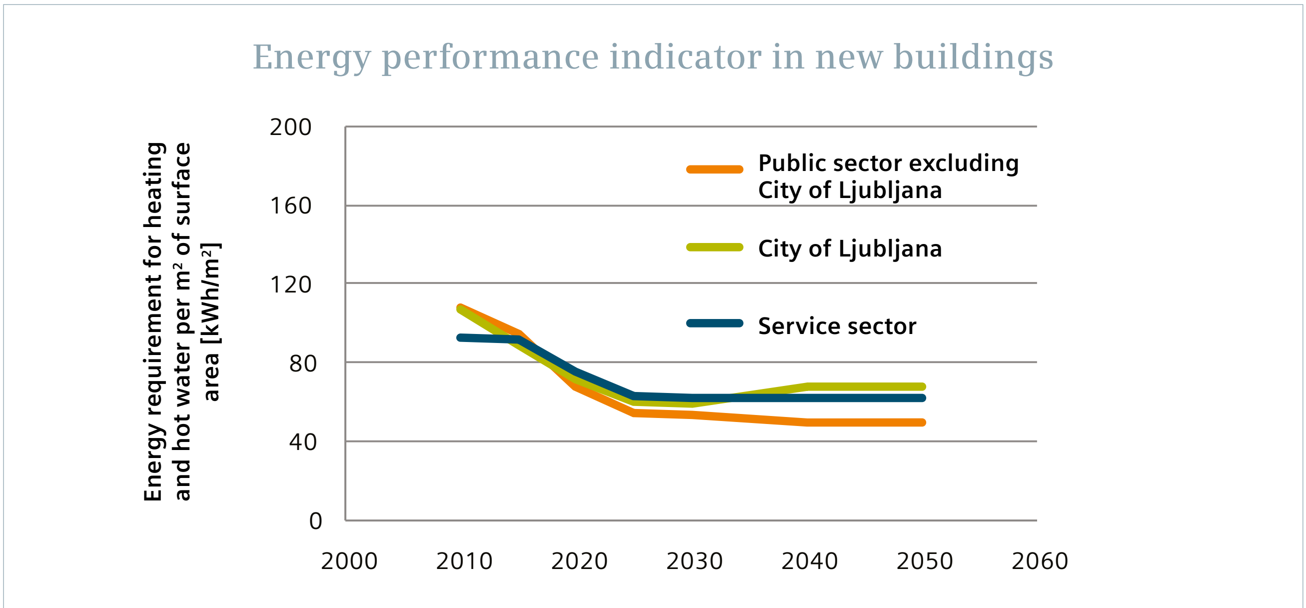


Figure 29: Energy performance indicator new buildings

Public and service sectors – technologies for generating energy for heating and hot water

Final energy consumption and particularly emissions of CO_2 are significantly influenced by **switching technologies for generating heat for heating and hot water**. District heating, which is a highly efficient system for obtaining heat, was already predominant in 2008 in all sectors, and its share will increase further up to 2050. The share of heating oil, which is currently the second biggest source of energy in the public and service sectors, will fall dramatically by 2030, and by 2050 will drop to zero. It will be replaced primarily by natural gas, which is now used mainly in boilers, and later will become chiefly a source in combined heat and power generating units. Among the technologies for exploiting renewable energy sources, by 2050 the largest share will be held by heat pumps, especially in the service sector, where it will account for 10% of energy produced, while its share in the public sector and in City of Ljubljana buildings will amount to 4%. The other sources are wood and solar energy, with the use of the latter envisaged primarily in the public sector and in City of Ljubljana, in buildings that require major quantities of hot water (such as hospitals, homes for the elderly, kindergartens, sports halls and health centres).

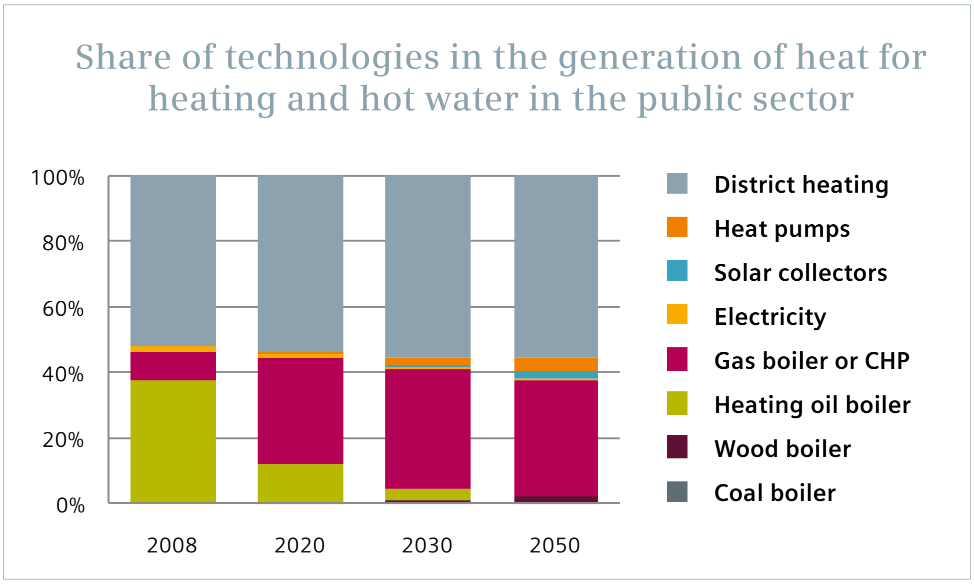


Figure 30: Share of technologies in the generation of heat for heating and hot water in the public sector in 2008, 2020, 2030 and 2050

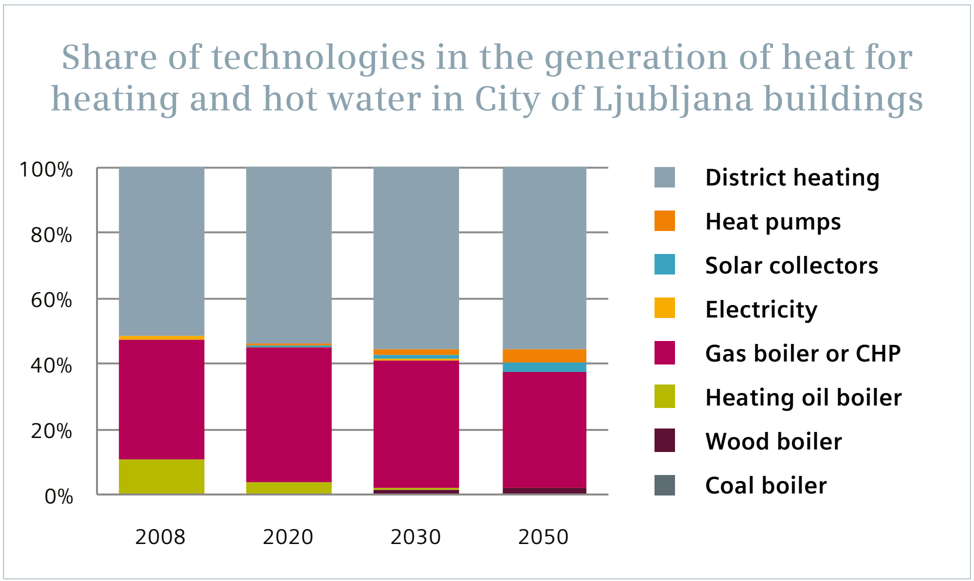


Figure 31: Share of technologies in the generation of heat for heating and hot water in City of Ljubljana buildings in 2008, 2020, 2030 and 2050

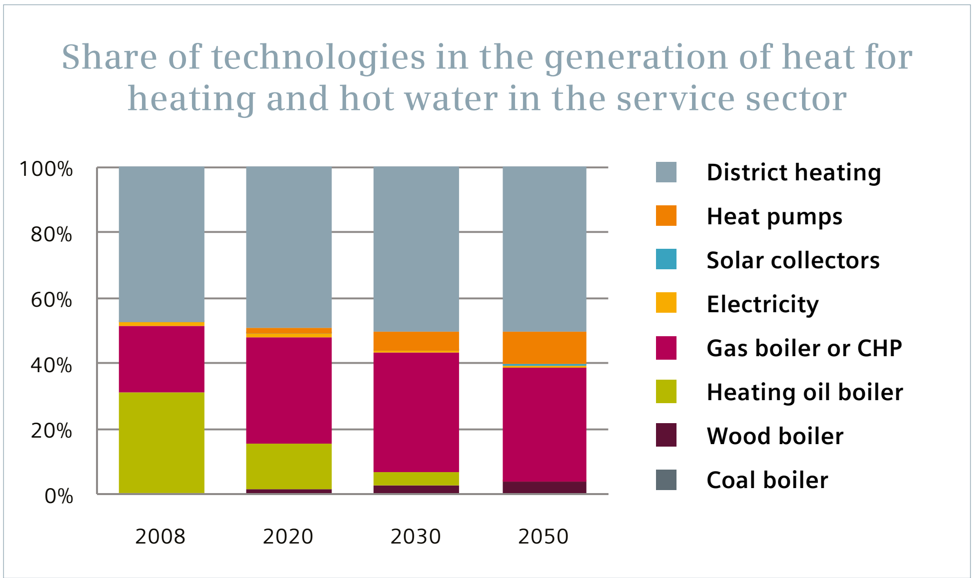


Figure 32: Share of technologies in the generation of heat for heating and hot water in the service sector in 2008, 2020, 2030 and 2050

Public and service sectors – reduced energy consumption and emissions

The key measure that contributes most (80% in the service sector, 90% in the public sector excluding City of Ljubljana and 92% in City of Ljubljana buildings) to reducing final energy consumption in all three sectors, is improving the energy performance of buildings, user behaviour and improving technologies for heating and hot water (installing thermostat valves and hydraulic balancing of the system). The remaining reduction in energy consumption is the result of replacing sources of energy and technologies for generating heat for heating and hot water.

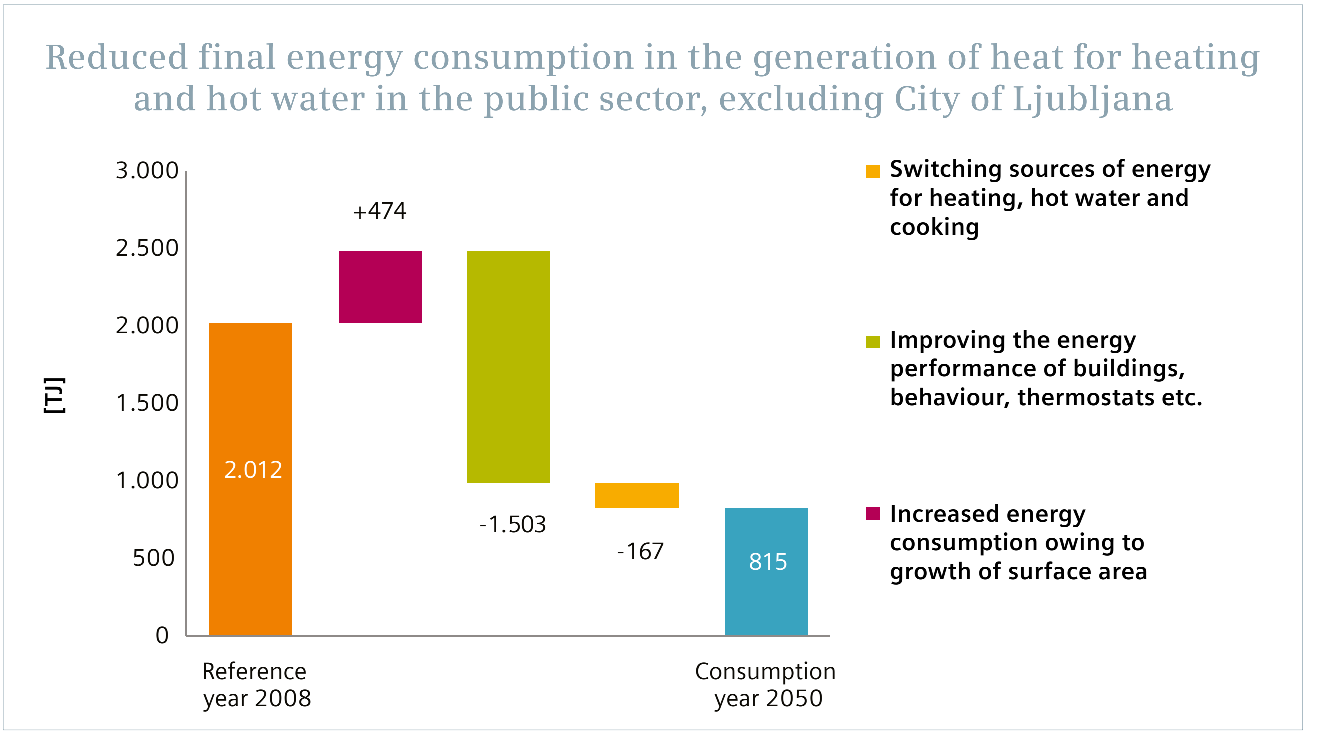


Figure 33: Comparison of energy consumption in the generation of heat for heating and hot water in the public sector excluding City of Ljubljana in 2050 relative to 2008

SIEMENS

Ljubljana, pametno mesto

Reduced final energy consumption in the generation of heat for heating and hot water in buildings owned by City of Ljubljana

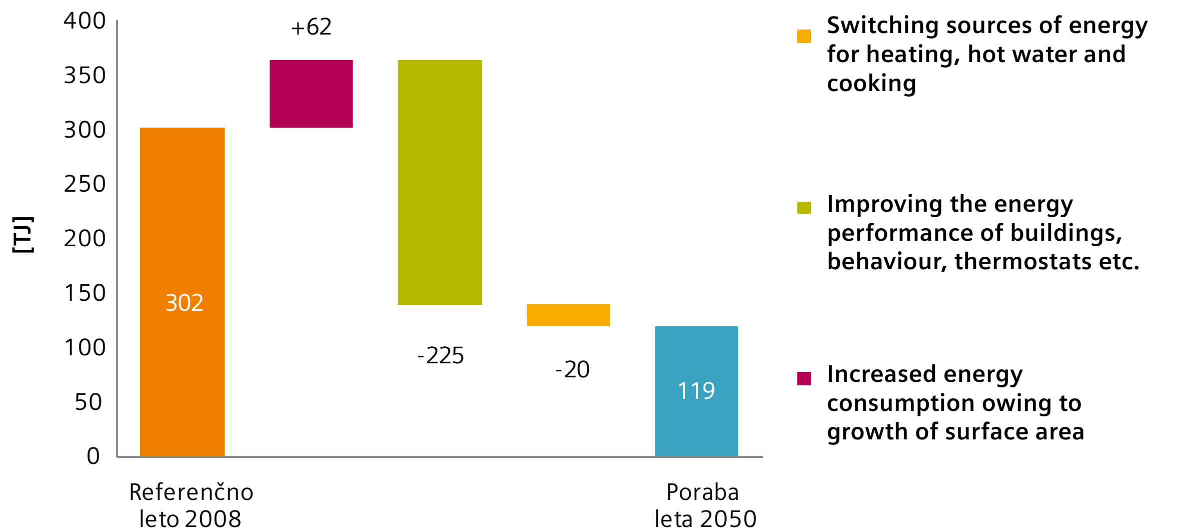


Figure 34: Comparison of energy consumption in the generation of heat for heating and hot water in buildings owned by City of Ljubljana in 2050 relative to 2008

Reduced final energy consumption in the generation of heat for heating and hot water in the service sector

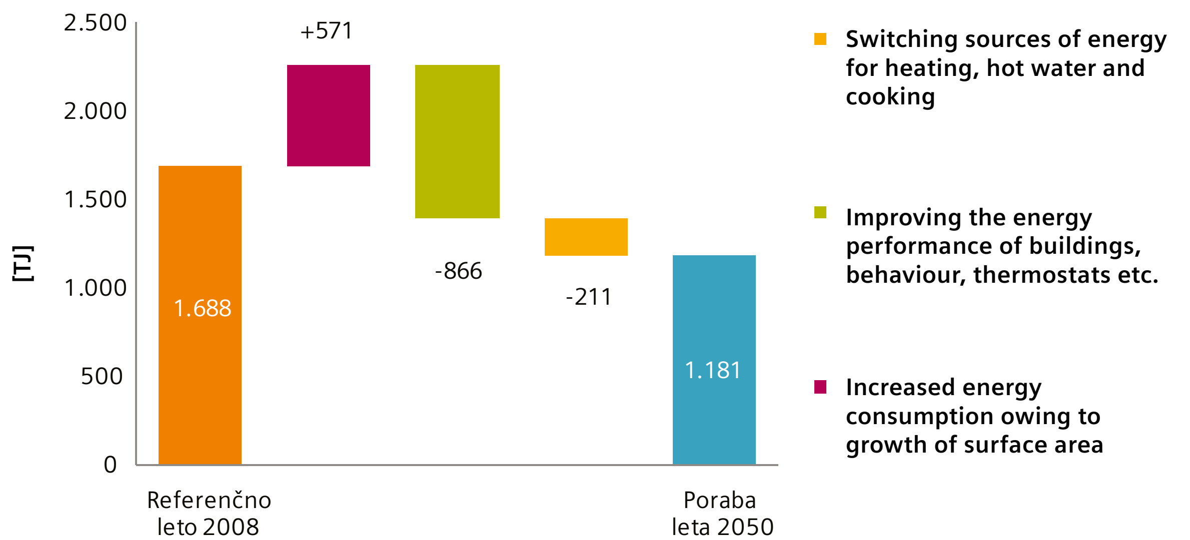


Figure 35: Comparison of energy consumption in the generation of heat for heating and hot water in the service sector in 2050 relative to 2008

The **reduction of CO2 emissions** is greater than the reduction of final energy consumption, since the calculations also take into account the increased use of renewable energy sources. Together, with the implementation of measures in the public and service sectors, emissions can be reduced by as much as 77%.

Public and service sectors – success stories

Operation of the Brigittenau swimming pool

Operation of the Brigittenau swimming pool represented an increasing cost for the city of Vienna. The decision was therefore made to refurbish it as part of a contractual lowering of energy costs with the Siemens company. Analysis of energy consumption showed that the greatest amount of energy was used on heating water, on driving the ventilation systems and dehumidifying. Water heating from the district system was replaced with the

use of solar panels, and the heating system also includes a condensing boiler. The new system also enables the exploitation of heat from the pool water. The flow of water into and out of the pool was improved with the control of the chlorine content. Water-saving controls were installed on the showers and taps. At the same time an energy management system was installed, and the ventilation was optimised. The DESIGO Insight system was selected for precise monitoring of energy savings. The investment amounted to EUR 1.44 million, and the amortisation period is set at 10 years. With all these measures, energy consumption has been reduced by 66% and water consumption by 45%. CO_2 emissions have been reduced by 600 t a year.

Possibilities for energy savings in Ljubljana primary schools

As part of the project Ljubljana, Smart City, an analysis was made in 2010 of possible energy savings at two Ljubljana primary schools. The analysis showed that public institutions have considerable reserves in their energy expenditure, and that in the aforementioned facilities energy savings could amount to at least EUR 30,000 a year, while the investment in the necessary equipment that would achieve the savings would be returned sooner than in five years. The energy rehabilitation of the two schools would also reduce CO_2 emissions by at least 166 tons a year. The scenarios under which the two schools would achieve the envisaged savings are based primarily on investments in equipment in the area of automating the buildings, and do not involve investments in renovating the building shells. The recommended measures that would serve to achieve the savings involve mainly the installing of appropriate energy management systems, installing of new, reliable control systems for all the necessary parts of the building energy systems, improving the system of electric lighting and in the case of the Jože Moškrič Primary School, replacing the existing energy equipment.

Transport – measures and effects for reducing emissions

The typical measures of energy policy in the area of transport that some countries are already implementing are as follows:

- **fiscal policy measures**: taxing fuels and vehicles and fees for the use of roads in terms of environmental criteria, with a gradual increase in the range of tax rates;
- **reducing the specific consumption of new vehicles**: Regulation (EC) No 443/2009 of the European Parliament and of the Council setting emission performance standards for new passenger cars, informing buyers of specific CO2 emissions when they purchase new cars, promoting the purchase of hybrid vehicles and so forth;
- **incentives for introducing electric battery cars and hydrogen-powered cars** and promoting the development and construction of charging facilities for electric cars;
- **green public procurement;**
- introducing **biofuels** and other RES in transport;
- better **vehicle maintenance**, regular monitoring of exhaust gases, better monitoring of traffic, speed limits etc.;
- **information and promotion campaigns** to promote more economical driving and sustainable forms of transport.

Ljubljana can achieve the target scenario and the sustainable excellence scenario if it observes the following factors, whose effects we describe in greater detail later in this report:

- accessible, efficient, affordable public transport and sustainable transport infrastructure (rail and road, which both demand major investment);
- expanding the network of cycle paths and pedestrian zones;
- altering the structure of the fleet of passenger cars;
- altering the structure of the city bus fleet;
- changing the share of passenger kilometres.

Transport – structure of passenger kilometres

The number of passenger kilometres should gradually fall up to 2050, if Ljubljana seeks to pursue the two development scenarios. To reduce emissions by 50% or 80% relative to the baseline year of 2008, it will be essential to increase the number of cycling passenger kilometres (by 40% up to 2050), to a lesser extent walking kilometres (by 3% up to 2050), and we envisage a major growth in public transport, especially urban transport and rail.

Passenger km (pkm)	Unit	2008	2010	2020	2030	2040	2050
Cyclists	[million pkm]	65	67	79	91	114	137
Pedestrians	[million pkm]	35	35	35	36	36	37
Public transport	[million pkm]	340	348	386	425	488	568
Long-distance transport	[million pkm]	80	81	89	97	104	112
Urban transport	[million pkm]	197	202	224	247	280	314
Rail	[million pkm]	63	65	73	82	103	142
Passenger cars	[million pkm]	3.485	3.469	3.392	3.315	3.174	3.033
TOTAL	**[million pkm]**	**3.925**	**3.920**	**3.893**	**3.867**	**3.812**	**3.774**

Table 1: Structure of passenger kilometres up to 2050

Transport – structure of passenger car fleet

New technologies (and the related structure of the vehicle fleet) for passenger cars play a key role in reducing emissions in transport. In the target scenario we envisaged the implementation of major technological changes in around 2020. Compared to the baseline year of 2008, there should be a rise in the proportion of enhanced petrol and diesel vehicles. After 2030 we can expect more widespread use of standard hybrids and plug-in hybrids, as well as the use of hydrogen vehicles.

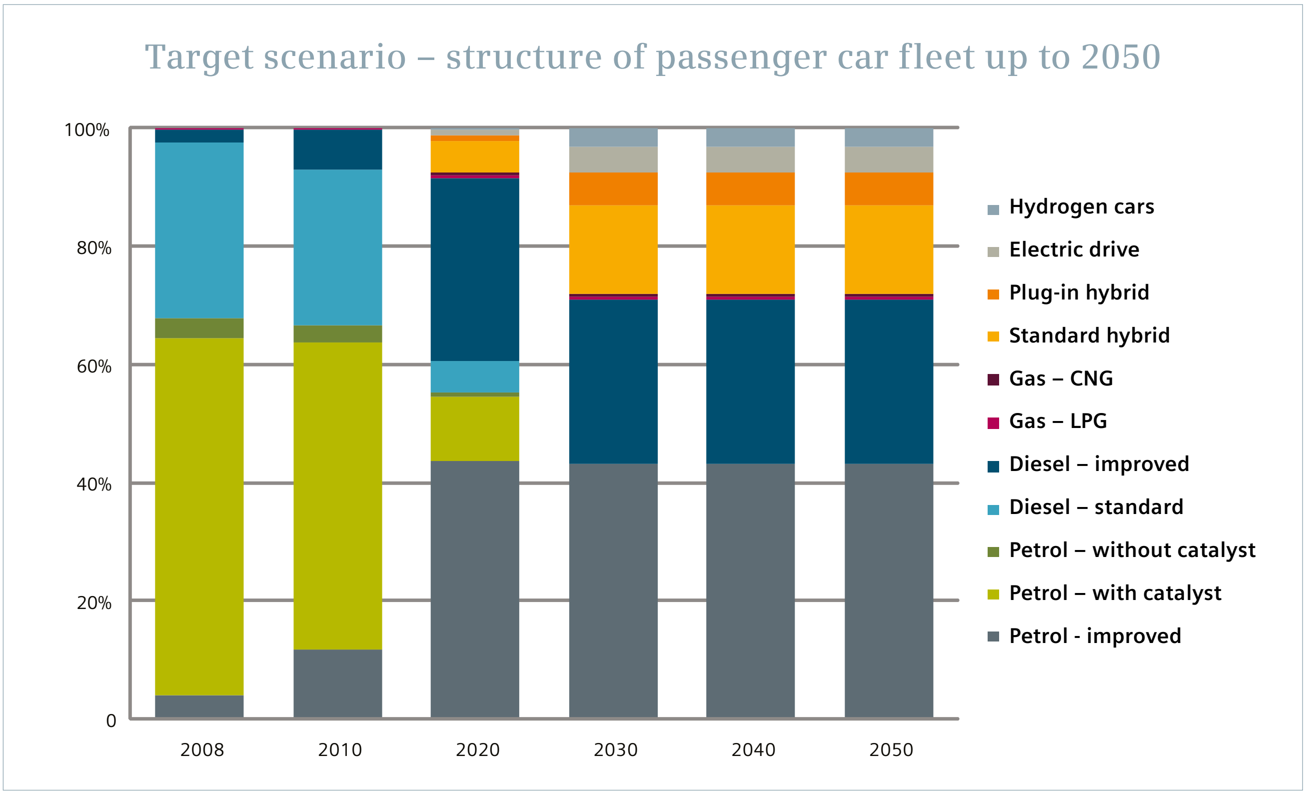


Figure 36: Target scenario – structure of passenger car fleet up to 2050

Under the sustainable excellence scenario the key technological changes are envisaged for after 2030, when we can expect the rapid spread of electric and hydrogen-powered cars. In 2050 the share of passenger cars fuelled by petrol and diesel under this scenario should be very small.

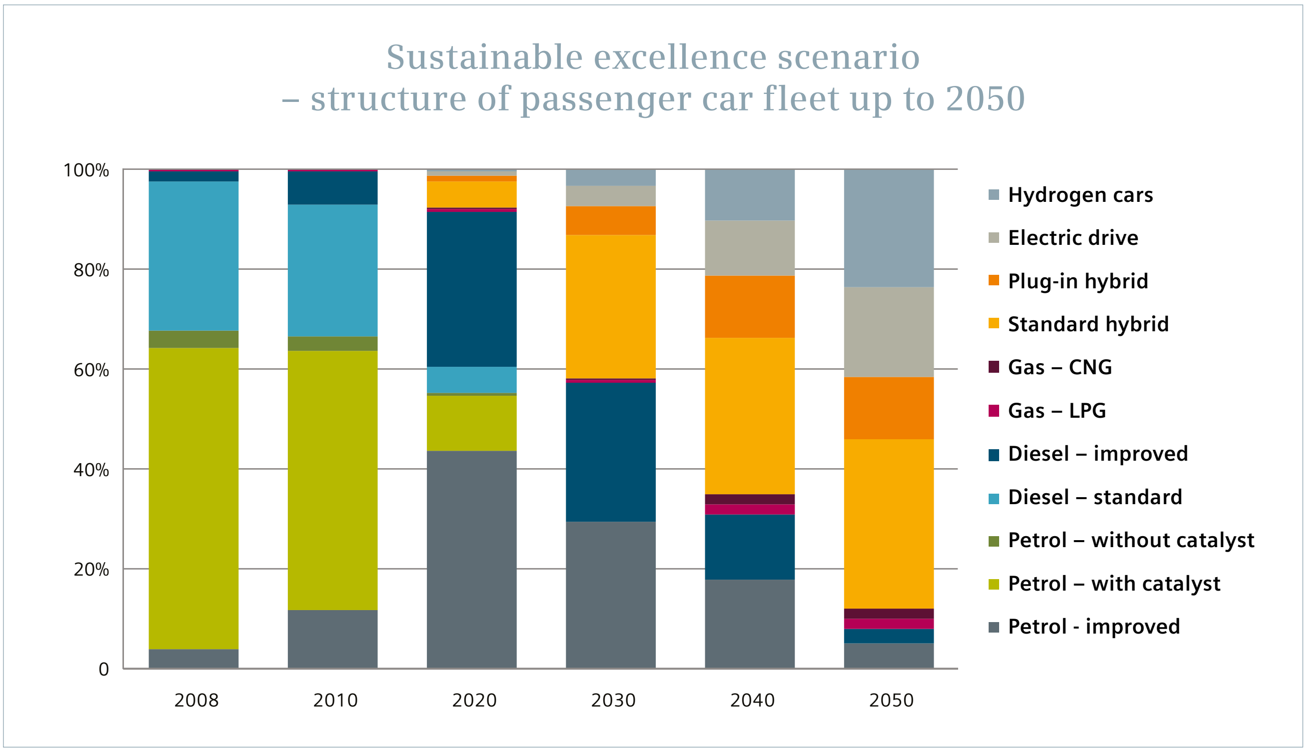


Figure 37: Sustainable excellence scenario – structure of passenger car fleet up to 2050

Transport – lower emissions

Under the target scenario, emissions in passenger transport will fall by 35% by 2030 relative to 2008 and by 40% by 2050. In 2030 we also envisage a 33% reduction in energy consumption for transport, and by 2050 this should fall by 37% relative to the baseline year. Under the sustainable excellence scenario, we envisage emissions falling by 37% by 2030 and 71% by 2050 relative to 2008. Energy consumption will be 35% lower by 2030, and 61% lower by 2050.

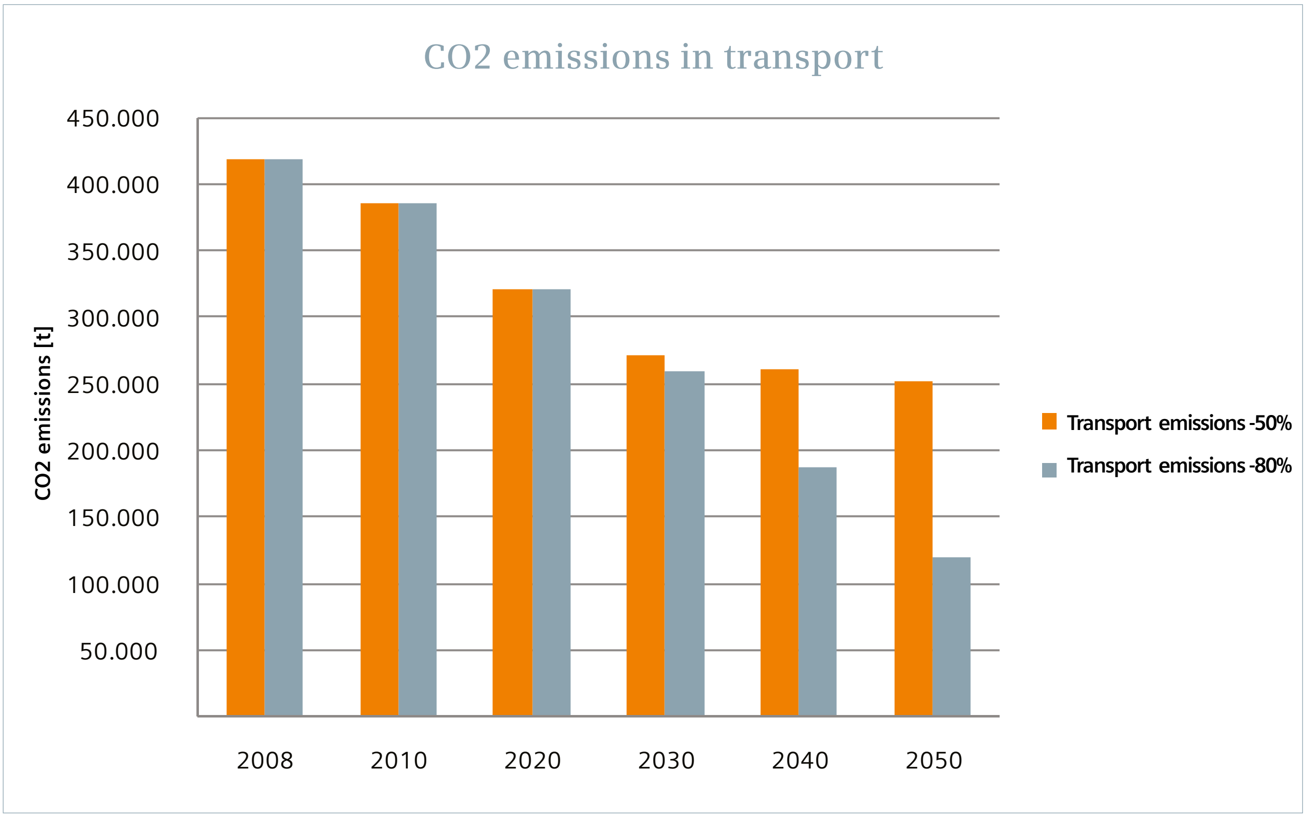


Figure 38: CO2 emissions in transport

Heat supply

Achieving the two scenarios will require intensive development of the district heating and cooling system, including extensive refurbishment of the network, which will reduce losses to 7% of gross heat produced and will enable the connection of new consumers. Changes will also be needed in the actual generation of heat, where we have envisaged the introduction of natural gas as a fuel at the Ljubljana Thermal Heat and Power Station, and the transition to renewable energy sources by 2050. In 2050 as much as 30% of the heat in Ljubljana should be generated through energy recovery from waste, while the consumption of heat should be reduced through the energy rehabilitation of buildings.

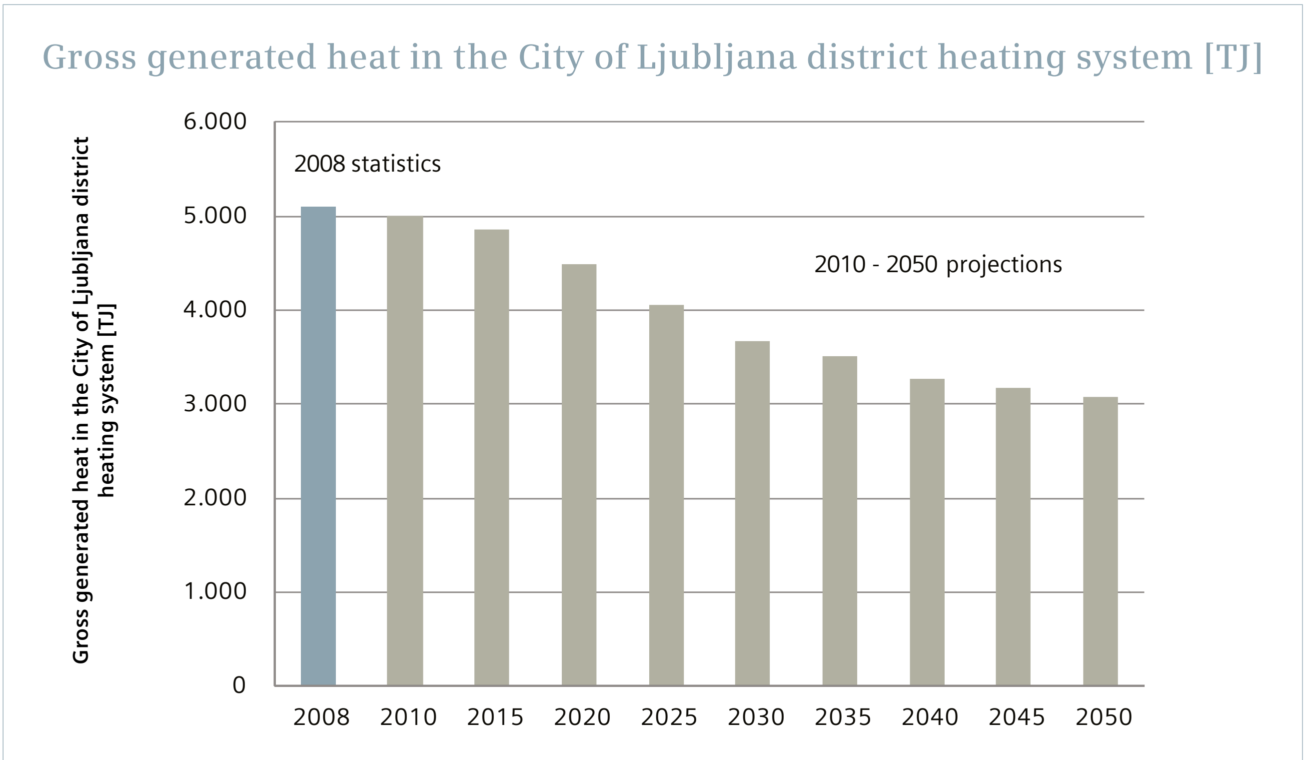


Figure 39: Gross generated heat in the City of Ljubljana district heating system (TJ)

Drinking water supply

Achieving the two scenarios envisages a reduction in the consumption of drinking water. This will result from several measures:

- Extensive refurbishment of the mains water network, which will contribute to reducing losses to 5% of pumped water by 2050. This effect will be achieved by introducing state-of-the-art technologies for regulating flow and pressure, and by introducing new features into the business model, especially through the division of the mains network into zones, an efficient measuring system and remote meter reading, whereby users will have a clearer awareness of the (financial) consequences of irrational water use.
- Awareness-raising and more rational use of water on the part of users, which could – without compromising their comfort – limit water consumption by 34% by 2050.

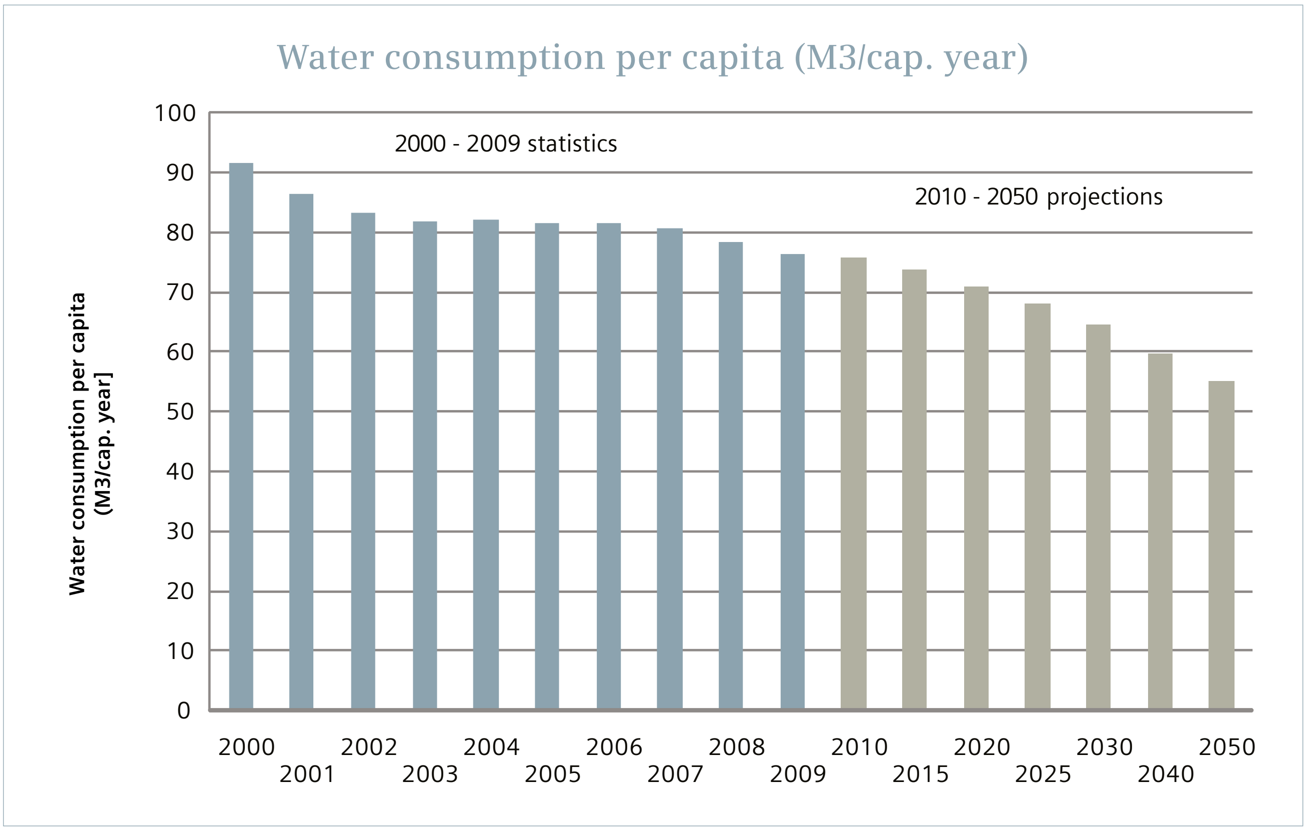


Figure 40: Water consumption per capita (M3/cap. year)


H&M

IV. Measures in City of Ljubljana

It is well-known that the city authorities have relatively limited influence in achieving the ambitious environmental targets, with a greater part in reducing energy consumption and emissions being played by organisations and individuals through their own choices. This chapter offers a detailed insight into the first steps that could be taken by the City of Ljubljana in the area of energy supply in buildings that it owns, it shows a precise analysis of the financial consequences of such decisions and in this way creates a model that could be followed by other municipalities, and particularly by the owners and managers of buildings in the private and public sectors.

Efficient energy management in City of Ljubljana – barriers, opportunities and measures

There are several barriers along the path to efficient energy management. The technological possibilities are not being entirely exploited, and energy is identified as a cost over which we have very little influence. The system of incentives to pursue rational energy use is in preparation, as well as formal objectives of careful energy use.

Opportunities for efficient energy management:

- The transition to a low-carbon society has seen the establishing of markets for green products, services and solutions that have been immune this far to the economic crisis.
- Services in the area of green technology and efficient energy management can be an additional product/service offered in the market by public companies in City of Ljubljana. This will serve to bolster customer loyalty and create additional sources of income.
- By investing in energy efficiency (Energy Management System in City of Ljubljana buildings) it will be possible very quickly to achieve **major savings: EUR 708,000 on an annual basis, with investment in the necessary equipment amounting to EUR 4.15 million and the return period being 5.5 years.**

Measures for achievement of the effects:

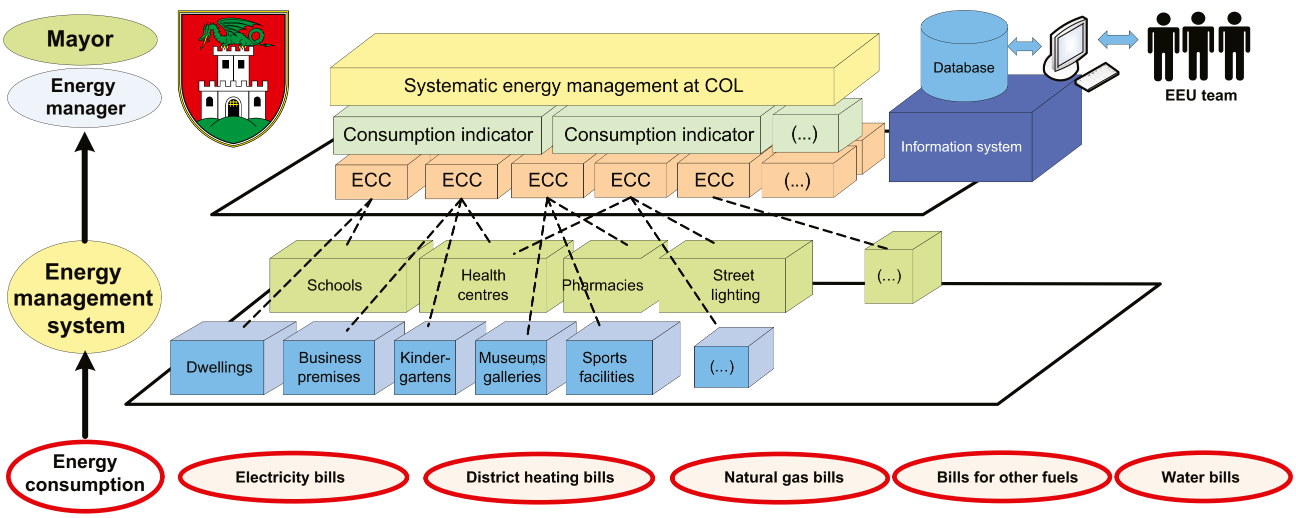
- **Organisational measures** (model of systematic energy management, introduction of the business position of energy manager).
- **Investment measures** (hardware and software for implementing systematic energy management in buildings owned by City of Ljubljana, energy renovation of buildings, replacing energy sources).
- **Human resources measures** (adjusting the pay scale policy based on performance and achievement of targets, a clear system of incentives for efficiency, awareness-raising among all employees).
- **Including procurement in the energy management system.**

Efficient energy management in City of Ljubljana – new organisational model

Currently within City of Ljubljana there is still considerable unexploited potential for cooperative synergy and for the linking up of public companies from Ljubljana Public Holding (Energetika Ljubljana, Snaga and the Vodovod-Kanalizacija water company) and Elektro Ljubljana. Following successfully concluded projects of careful energy management in City of Ljubljana, which could become examples of best practices in energy contracting, the above companies could offer their additionally developed service activities in the wider Slovenian and regional markets.

Key factors of careful energy management in City of Ljubljana are as follows:

- responsibility for efficient energy management is accepted at the highest level in City of Ljubljana, and the mayor is the principal ambassador of this concept;
- an energy manager is recruited, and his or her salary depends on the attainment of clearly set, measurable and demonstrable effects;
- energy cost centres (ECC) are identified; these also have clearly defined targets in the area of efficient energy use, and each has its own administrator who oversees the use of energy and takes appropriate action;
- hardware and software are installed for monitoring and controlling energy consumption and notification of any anomalies.



As part of the study we estimated that the process of setting up the energy management system in City of Ljubljana would take four years and be implemented in several phases:

- establishing an organisational structure for systematic energy management in all buildings owned by City of Ljubljana;
- establishing the proposed energy cost centres and determining the indicators for measuring efficiency;
- setting up an information system for energy management in buildings owned by City of Ljubljana;
- implementation and monitoring of effects, possible correction of set targets;
- training and motivation of all City of Ljubljana employees;
- communication with stakeholders and evaluation of progress.

The costs of these activities, which are associated with establishing an energy management system in all buildings owned by City of Ljubljana, have been estimated at **EUR 4.15 million**. This amount includes the following types of cost:

- the information system for energy management;
- additional measuring equipment;
- system deployment;
- implementing and monitoring soft measures (e.g. correct use of thermostat valves, introducing the concept of ecological responsibility, motivational and training activities for employees etc.);
- communication with the public;
- approximately 60% of the above costs represent the cost of new hardware and software.