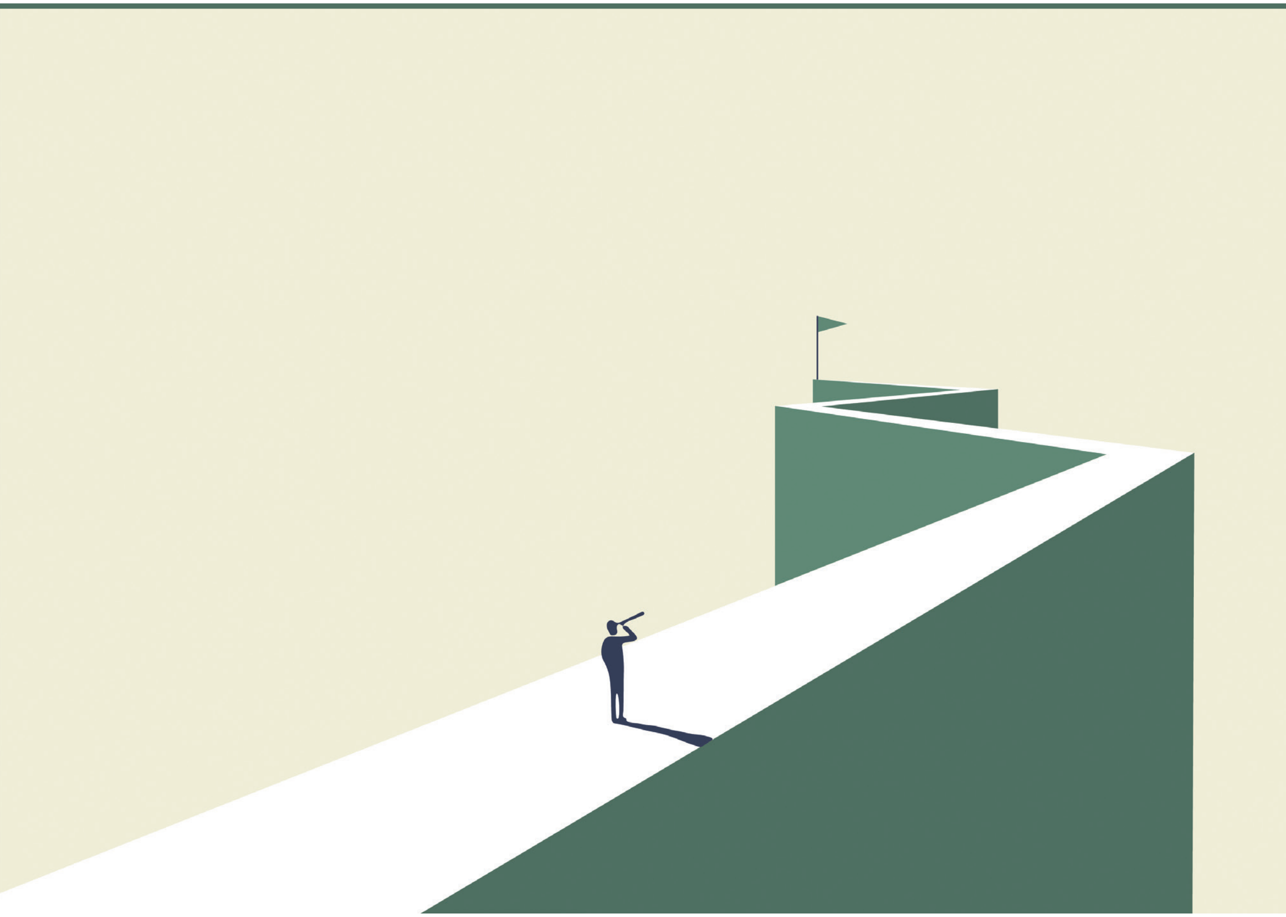
RĪGAS TEHNISKĀ UNIVERSITĀTE

Anda Jēkabsone

ENERGOPĀRVALDĪBAS LOMA KLIMATNEITRALITĀTES MĒRĶU SASNIEGŠANĀ PAŠVALDĪBĀS EIROPĀ

Promocijas darbs



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RĪGAS TEHNISKĀ UNIVERSITĀTE
Elektrotehnikas un vides inženierzinātņu fakultāte
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ENERGOPĀRVALDĪBAS LOMA KLIMATNEITRALITĀTES MĒRĶU SASNIEGŠANĀ PAŠVALDĪBĀS EIROPĀ

Promocijas darbs

Zinātniskie vadītāji:
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ANOTĀCIJA

Viena no Eiropas Savienības politikas prioritātēm pēdējā dekādē nepārprotami ir bijusi klimatu pārmaiņu mazināšana. Saskaņā ar Parīzes klimata nolīgumu pasaules valstu mērķis ir ierobežot globālo sasilšanas līmeni vidēji zem 1,5 °C vai vismaz zem 2 °C, salīdzinot ar pirms industriālo līmeni. Tikmēr Klimata pārmaiņu starpvaldību padomes (*IPCC*) jaunākajā ziņojumā norādīts, ka līdzšinējā klimata pārmaiņu mazināšanas un pielāgošanās politika ir nepietiekama, un, visticamāk, 1,5 °C globālās sasilšanas slieksnis tiks sasniegts jau 21. gadsimtā. Tāpēc ilgtspējīga plānošana pašvaldībās ir ļoti būtiska, lai samazinātu ekonomiskos, sociālos un vides riskus un palīdzētu sasniegt globālos mērķus. Tomēr pārejai uz klimatneitralitāti ir jābūt taisnīgai un proporcionālai dažādām sabiedrības grupām, un tā nedrīkst veicināt enerģētisko nabadzību un iedzīvotāju neaizsargātību pret klimata izraisītiem riskiem. Kopš 2015. gada Pilsētu Mēru pakta metodoloģiskā pieeja ilgtspējīgas enerģētikas un klimata rīcības plāniem ir paplašināta, iekļaujot trīs galvenās jomas: klimata pārmaiņu mazināšana, pielāgošanās klimata pārmaiņām un enerģētiskās nabadzības mazināšana. Līdz ar to nepieciešams ne tikai izstrādāt plānus, kas pievēršas visiem trim aspektiem, bet jāspēj arī iesaistīt plašu ieinteresēto personu loku gan izstrādes, gan ieviešanas procesos, un sistemātiski strādāt, lai plānu īstenotu. Daudzas Eiropas pašvaldības ir izstrādājušas rīcības plānus vai stratēģijas, lai ilgtermiņā virzītos uz klimatneitralitāti un klimatnoturību, taču šo plānu īstenošana bieži nenotiek kā iecerēts. Energopārvaldības sistēmas ieviešana pašvaldībās veiksmīgi palīdz institucionalizēt sistemātisku rīcību energoefektivitātes uzlabošanai pašvaldību infrastruktūrā, un šī pieeja ir jāpaplašina un tās elementi jāizmanto, lai sasniegtu pašvaldību klimatneitralitātes un klimatnoturības mērķus.

Šī promocijas darba mērķis ir izstrādāt metodiku un rekomendācijas, sistemātiskas pieejas ieviešanai pašvaldību enerģētikas un klimata jomu pārvaldībā, lai nodrošinātu pašvaldību skaidru virzību uz klimatneitralitātes mērķu sasniegšanu, uzsverot energopārvaldības sistēmas lomu konkrētu rīcību ieviešanā.

Promocijas darbs ir balstīts uz sešām doktorantūras studiju laikā izstrādātām zinātniskajām publikācijām. Zinātniskie raksti publicēti vairākos zinātnisko rakstu žurnālos, indeksētas *Scopus* un *Web of Science* datubāzēs, un ir pieejami šo žurnālu interneta vietnēs.

Promocijas darba ievadā ir aprakstīta tēmas aktualitāte un praktiskā vērtība, skaidrots darba mērķis, uzdevumi un hipotēze. Pirmajā nodaļā veikta literatūras analīze, kurā apskatīta pieejamā informācija par ilgtspējīgas enerģētikas un klimata rīcības plānu ieviešanu pašvaldībās, pielāgošanās klimata pārmaiņām aspektu integrāciju šajos plānos, energopārvaldības sistēmas ieviešanu pašvaldībās, kā arī uzvedības maiņas pasākumu ietekmi uz enerģijas patēriņu un *COVID-19* pandēmijas ietekmi uz enerģijas patēriņu. Otrajā nodaļā apskatītas pētījumu veikšanā izmantotās metodes. Trešajā nodaļā aprakstīti pētījumos iegūtie rezultāti, un noslēgumā doti secinājumi un rekomendācijas ilgtspējīgas plānošanas veicināšanai pašvaldībās.

ANNOTATION

In the last decade, one of the priorities of the European Union has been to mitigate climate change. According to the Paris Agreement, the goal is to limit global warming to below 1.5°C or at least below 2°C compared to pre-industrial levels. However, the latest report from the Intergovernmental Panel on Climate Change (IPCC) suggests that existing climate change mitigation and adaptation policies are insufficient, and it is likely that the 1.5°C global warming threshold will be reached by the 21st century. Therefore, sustainable planning in municipalities is critical for reducing economic, social, and environmental risks and helping to achieve global goals. However, the transition to climate neutrality must be fair and proportionate to different societal groups and must not promote energy poverty and vulnerability to climate risks. Adaptation to climate change is a relatively new concept in municipal planning, especially in countries that have not been affected by climate disasters with serious consequences. Since 2015, the Covenant of Mayors' methodological approach to sustainable energy and climate action plans has been expanded to include three main areas: climate change mitigation, adaptation to climate change, and reduction of energy poverty. As a result, a wide range of competencies is needed to develop a plan that addresses all three aspects, as well as the ability to engage a wide range of stakeholders in both the development and implementation processes, and the ability to work systematically to implement the plan. Many municipalities in Europe have developed action plans or strategies to move towards climate neutrality and resilience, but the implementation of these plans often falls short of expectations. Introduction of an energy management system in municipalities successfully helps to institutionalise systematic action to improve energy efficiency, and this approach needs to be expanded and its elements used to achieve local government climate neutrality and climate resilience objectives.

The objective of this Doctoral Thesis is to develop a methodology and recommendations for the implementation systematic approach in municipal energy and climate management, to ensure clear progress towards achieving climate neutrality goals, highlighting the role of energy management system in initiating specific actions.

The Thesis is based on 6 scientific publications developed during PhD studies. Scientific articles have been published in several scientific journals and are available on the websites of these journals.

The introduction to the Thesis describes the practical value of the topic, explains the purpose, tasks and hypothesis of the work. The first chapter provides a literature analysis looking at available information on the implementation of sustainable energy and climate action plans in municipalities, the integration of climate change adaptation aspects into these plans, the introduction of an energy management system in municipalities, as well as the impact of change in behaviour on energy consumption and the impact of the COVID-19 pandemic on energy consumption. The second chapter discusses the methods used for the research. Chapter three describes the results obtained from the studies and concludes with conclusions and recommendations for promoting sustainable planning in local governments.

PATEICĪBAS

Izsaku lielu pateicību saviem promocijas darba vadītājiem profesorei Dr. sc. ing. Marikai Rošā un asociētajam profesoram Dr. sc. ing. Agrim Kamenderam par viņu veltīto laiku, iedrošinājumu, un nenovērtējami lielo atbalstu darba tapšanas procesā. Viņu pieredze, pacietība un iesaiste ideju veidošanā ir bijis būtisks virzītājspēks manā akadēmiskajā attīstībā un šī darba izstrādē. Izsaku pateicību arī par ieguldījumu visiem publikāciju līdzautoriem un projektu partneriem, bez kuru iesaistes un palīdzības šādi pētījumi nevarētu tapt, kā arī visam Rīgas Tehniskās universitātes Vides aizsardzības un siltuma sistēmas kolektīvam par atbalstu.

Izsaku pateicību arī saviem vecākiem par to, ka viņi manī ir ieaudzinājuši mīlestību pret mācīšanos, vēlmi izzināt un attīstīties. Bez viņu atbalsta un iedrošinājuma dažādos dzīvos posmos es nebūtu tur, kur esmu šodien.

Tā pat, esmu pateicīga visiem draugiem un radiem par sapratni un iedrošinājumi. Esmu īpaši pateicīga savam dzīvesbiedram Andžam, par neizsakāmo pacietību būt blakus, atbalstīt, iedrošināt un neļaut padoties arī grūtākajos brīžos.

SATURS

Darbā izmantotie saīsinājumi

AER	Atjaunojamie energoresursi
ANO	Apvienoto Nāciju Organizācija
BMS	Ēku pārvaldības sistēma (*Building management system*)
CO_2	Oglekļa dioksīds
CSS	Centralizētās siltumapgādes sistēma
ES	Eiropas Savienība
EPS	Energopārvaldības sistēma
EUR	eiro
GWh	gigavatstunda
h	stunda
IERP	Ilgtspējīgas enerģētikas rīcības plāns
IEKRP	Ilgtspējīgas enerģētikas un klimata rīcības plāns
IKP	iekšzemes kopprodukts
IPCC	ANO Klimata pārmaiņu starpvaldības padome (*ANO Intergovernmental Panel on Climate Change*)
km	kilometrs
MWh	megavatstunda
m^2	kvadrātmetrs
NEKP2030	Nacionālais enerģētikas un klimata plāns 2030. gadam
SEG	siltumnīcefektu izraisošās gāzes
t	tonna
°C	Celsija grādi

IEVADS

Viena no Eiropas Savienības politikas prioritātēm pēdējā dekādē nepārprotami ir bijusi klimatu pārmaiņu mazināšana. Saskaņā ar Parīzes klimata nolīgumu pasaules valstu mērķis ir ierobežot globālo sasilšanas līmeni vidēji zem 1,5 °C vai vismaz zem 2 °C, salīdzinot ar pirms industriālo līmeni [1]. ANO Klimata pārmaiņu starpvaldību padomes novērtējuma ziņojumā (*AR6*) ir secināts, ka esošā klimata pārmaiņu mazināšanas un pielāgošanās politika nav pietiekama un ir iespējams, ka 1,5 °C globālās sasilšanas slieksnis tiks sasniegts jau 21. gadsimtā [2]. Jau šobrīd sasniegtais globālās sasilšanas līmenis (vidējā gaisa temperatūra paaugstinājusies par 1,1 °C 2011.–2020. gadā, salīdzinot ar vidējo līmeni 1850.–1900. gadā) ir palielinājis dažādu ekstrēmu klimata parādību biežumu, radot būtiskus apdraudējumus gan cilvēkiem, gan dabai [2]. Tieši pilsētas un tām piegulošās teritorijas, kurās koncentrējas lielākā daļa pasaules iedzīvotāju, būs ievainojamākās teritorijas klimata pārmaiņu radīto risku kontekstā [3], [4]. Tāpēc ilgtspējīga plānošana pašvaldībās ir kritiski svarīga ekonomisko, sociālo un vides risku mazināšanai un globālo mērķu sasniegšanai. Taču vienlaikus ir skaidrs, ka virzībai uz klimatneitralitāti jābūt godīgai un samērīgai attiecībā uz dažādām sabiedrības grupām un tā nedrīkst veicināt enerģētisko nabadzību un palielināt dažādu mazaizsargāto sociālo grupu ievainojamību pret klimata riskiem [5].

Pielāgošanās klimata pārmaiņām ir samērā jauns koncepts pašvaldību plānošanā, īpaši valstīs, ko nav skārušas klimata katastrofas ar nopietnām sekām. Taču apzinoties, ka klimata pārmaiņas ir neizbēgamas, pielāgošanās klimata pārmaiņām ir nekavējoši jāintegrē visos plānošanas līmeņos. Kopš 2015. gada arī Pilsētu mēru pakta (turpmāk tekstā Mēru pakts) metodiskā pieeja pašvaldību Ilgtspējīgas enerģētikas un klimata rīcības plāniem ir paplašināta un iekļauj trīs galvenos virzienus – klimata pārmaiņu mazināšana, pielāgošanās klimata pārmaiņām un enerģētiskās nabadzības mazināšana [6]. Rezultātā, lai pašvaldībā izstrādātu un īstenotu plānu, kas iekļauj visus trīs aspektus, ir nepieciešamas atbilstošas kompetences, spēja iesaistīt dažādas ieinteresētās puses gan izstrādes, gan ieviešanas procesā, kā arī kapacitāte plānveidīgi strādāt pie plāna ieviešanas un uzraudzības.

Daudzas pašvaldības Eiropā ir izstrādājušas rīcības plānus vai stratēģijas, lai virzītos uz klimatneitralitāti un klimatnoturību, tomēr šo plānu ieviešana bieži nesokas tik veiksmīgi, kā iecerēts [7]–[10]. Literatūrā ir identificēti ārējie un iekšējie šķēršļi, piemēram, kompetenču un zināšanu trūkums, pašvaldības darbinieku nepietiekama iesaiste un savstarpējā komunikācija [11], [12], kas kavē šo plānu ieviešanu, taču efektīvi risinājumi joprojām tiek meklēti. Standartizētas pieejas ieviešana klimatneitralitātes un klimatnoturības mērķu sasniegšanai var palīdzēt pārvarēt šos šķēršļus.

Starptautiskais standarts *ISO 50001* "Energopārvaldības sistēma" sniedz vadlīnijas, kā uzņēmumiem sistemātiski uzlabot energoefektivitāti, samazinot enerģijas patēriņu un izmaksas, kā arī mazināt organizācijas ietekmi uz vidi. Standarts nosaka prasības sistēmas izveidošanai, ieviešanai, uzturēšanai un nepārtrauktai uzlabošanai [13]. Tajā tiek īpaši uzsvērta nepieciešamība noteikt regulārus īstermiņa enerģijas samazināšanas mērķus, ieviest energoefektivitātes pasākumus, kas neprasa investīcijas vai prasa minimālas investīcijas, un veikt pastāvīgu enerģijas patēriņa monitoringu. *ISO 50001* standartu lielākoties ievieš rūpniecības uzņēmumi [14], taču standarts ir piemērots jebkura veida organizācijām un viegli piemērojams pašvaldību infrastruktūras objektiem [15].

Redzot, ka energopārvaldības sistēmas (EPS) ieviešana pašvaldībās veiksmīgi palīdz institucionalizēt sistemātisku rīcību energoefektivitātes uzlabošanai, šo pieeju nepieciešams paplašināt un tās elementus izmantot pašvaldību klimatneitralitātes un klimatnoturības mērķu sasniegšanā. Sistemātiska un cikliska rīcība, skaidra atbildību sadale un precīzas procedūras ir galvenie principi, ko nepieciešams integrēt pašvaldību enerģētikas un pielāgošanās klimata pārmaiņām pārvaldībā.

Promocijas darba aktualitāte

Eiropas Zaļais kurss (*EU Green Deal*), kas ir visaptverošs plāns ilgtspējīgākai Eiropas Savienības ekonomikai, šobrīd ir viena no nozīmīgākajām ES politikām. Šajā plānā ietverti mērķi samazināt SEG emisijas, palielināt atjaunojamās enerģijas īpatsvaru, uzlabot energoefektivitāti un pāriet uz aprites ekonomiku. Arī Latvijā ir izstrādāts "Latvijas Nacionālais Enerģētikas un klimata plāns 2021.–2030. gadam" (NEKP2030), kura mērķis ir virzīties uz klimatneitralitāti godīgā un samērīgā veidā pret visām sabiedrības grupām. Šis mērķis ir būtisks ne tikai klimata, bet arī ekonomiskās, sociālās un vides ilgtspējas kontekstā.

Lai sasniegtu Eiropas Zaļā kursa un nacionālos mērķus, pašvaldībām ir jāizmanto integrēta un sistemātiska pieeja. Ilgtspējīgas enerģētikas un klimata rīcības plāni ar energopārvaldības sistēmu spēj nodrošināt šādu integrētu un sistemātisku pieeju. Sasniedzot labus energoefektivitātes rādītājus savā infrastruktūrā, pašvaldības var rādīt labās prakses piemēru gan iedzīvotājiem, gan rūpniecības un pakalpojumu sektoram, šādi stimulējot virzību uz klimatneitralitāti arī sektoros, kas nav tiešā pašvaldības pakļautībā.

Sākot promocijas darba izstrādi, tika identificēts, ka ilgtspējīgas enerģētikas un klimata rīcības plāni ir izstrādāti daudzās Eiropas pašvaldībās. Tomēr šo plānu ieviešana bieži nenotiek, vai notiek haotiski un nepilnīgi [8], [9]. Galvenais iemesls tam ir būtisks kompetenču un izpratnes trūkums pašvaldību darbinieku vidū [11], [12]. Turklāt pašvaldībās risināmo problēmu un jautājumu apjoms ir liels, un ar klimatu un enerģētiku saistītie jautājumi bieži tiek uztverti kā mazāk akūti un ar zemāku prioritāti [16]. Pašvaldības pārsvarā ir arī salīdzinoši lielas organizācijas ar lielu darbinieku skaitu, kā arī to atbildībā ir nozīmīga infrastruktūras apsaimniekošana. Šādās organizācijās darbinieki bieži neizjūt personīgu interesi par potenciālajiem finanšu ietaupījumiem, kas var rasties dažādu īstenoto energoefektivitātes pasākumu rezultātā. Tas būtiski mazina motivāciju rīkoties [17]. Šie šķēršļi rada nepieciešamību identificēt un testēt dažādas pieejas un metodikas, kā pašvaldībām sākt sistemātisku rīcību plānošanu un ieviešanu klimata un enerģētikas jomā.

Promocijas darba mērķis un uzdevumi

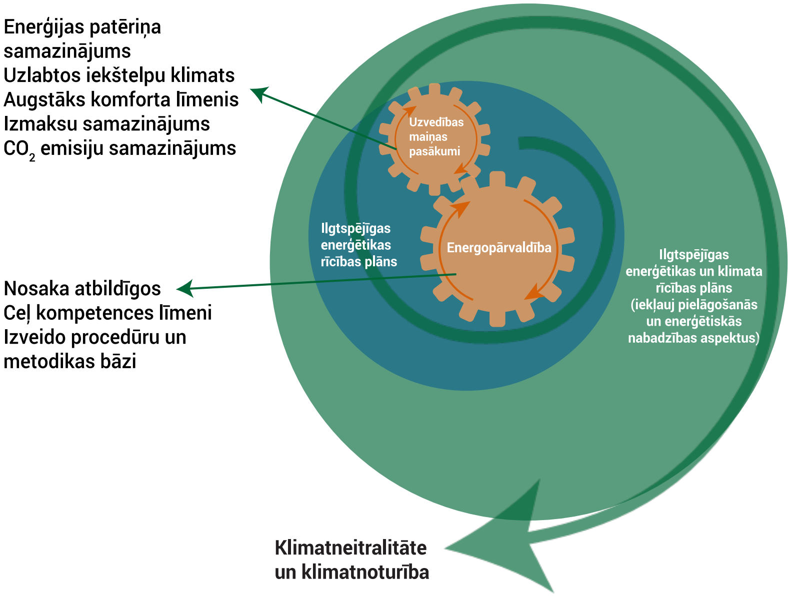
Promocijas darba mērķis ir izstrādāt metodiku un rekomendācijas sistemātiskas pieejas ieviešanai pašvaldību enerģētikas un klimata jomu pārvaldībai, lai nodrošinātu skaidru virzību uz klimatneitralitātes mērķu sasniegšanu, uzsverot energopārvaldības sistēmas lomu konkrētu rīcību sākšanā.

Lai sasniegtu mērķi, definēti vairāki uzdevumi.

1. Veikt esošo ilgtspējīgas enerģētikas rīcības plānu izstrādes un ieviešanas procesa un satura analīzi ar mērķi padziļināti izpētīt pašvaldību definētos klimata mērķus un noteikt galvenās barjeras šo mērķu sasniegšanai.
2. Izstrādāt pieeju, kā integrēt pielāgošanās aspektus pašvaldību ilgtspējīgas enerģētikas rīcības plānos klimatnoturības mērķu sasniegšanai un aprobēt to Eiropas pašvaldībās.
3. Veikt Daugavpils pilsētas pašvaldības energopārvaldības sistēmas izstrādes, ieviešanas, uzturēšanas un sasniegto rezultātu izpēti un analīzi ar mērķi noteikt sertificētas energopārvaldības sistēmas ieviešanas priekšrocības un lomu pašvaldības klimatneitralitātes mērķu sasniegšanā.
4. Izvērtēt sistemātisku uzvedības maiņas pasākumu ieviešanas ietekmi uz enerģijas patēriņa izmaiņām pašvaldības ēkās Eiropas Savienības valstīs un plašāku energoefektivitātes un klimatneitralitātes mērķu sasniegšanu pašvaldībās.
5. Veikt pašvaldības ēku enerģijas patēriņa datu analīzi *COVID-19* pandēmijas laikā Latvijas pašvaldībās, lai identificētu enerģijas patēriņa izmaiņu tendences un potenciālo ietekmi uz pašvaldību klimatneitralitāti.
6. Veikt energopārvaldības sistēmas aprobāciju Eiropas Savienības pašvaldībās atbilstoši *ISO 50001* standarta prasībām, lai identificētu galvenos ieguvumus un trūkumus pašvaldību enerģētikas mērķu sasniegšanai, kā arī izaicinājumus un šķēršļus standarta ieviešanas procesā.

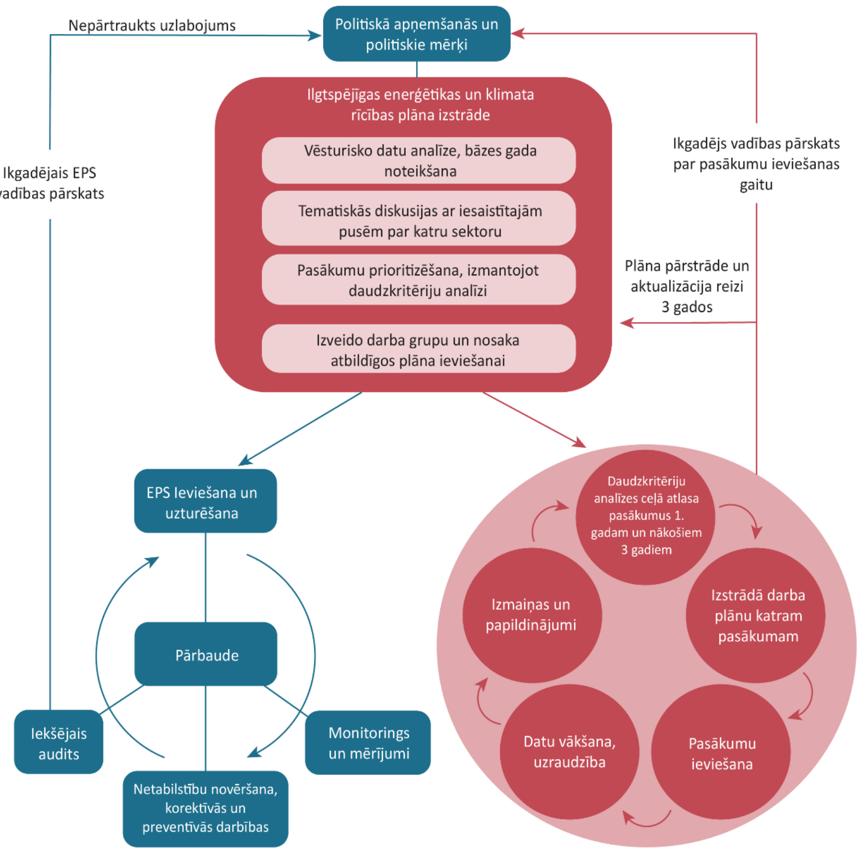
Promocijas darba zinātniskā novitāte

Promocijas darba izstrādes gaitā ir veidota cieša sadarbība ar daudzām pašvaldībām Latvijā un citās Eiropas Savienības valstīs, lai atrastu tos mehānismus, kas pašvaldībām var atvieglot un palīdzēt sasniegt klimatneitralitāti un citus vides un klimata mērķus. Vairāki autori savos pētījumos identificējuši problēmas Ilgtspējīgas enerģētikas rīcības plānu ieviešanas gaitā, jo paredzētās aktivitātes netika sistemātiski ieviestas un izstrādāto plānu ieviešanas uzraudzības mehānismi netika izveidoti [8], [9], [11]. Ņemot vērā to, ka līdz šim nav veikti padziļināti pētījumi par standartizētas energopārvaldības sistēmas ieviešanu pašvaldībās, promocijas darbā tika testētas dažādas pieejas un metodes šī standarta ieviešanai pašvaldībās. Promocijas darba konceptuālais ietvars redzams 1. attēlā.



1. att. Promocijas darba konceptuālais ietvars.

ISO 50001 standarta "Energopārvaldības sistēma" ieviešanas gaitā izveidotā darba grupa un pārvaldības struktūra ir būtisks atspēriena punkts arī Ilgtspējīgas enerģētikas un klimta rīcības plānu ieviešanai un pašvaldības klimata mērķu noteikšanai.



2. att. Promocijas darbā izstrādātā metodika.

Promocijas darbā ir izstrādāta integrētas energopārvaldības sistēmas [18] un Ilgtspējīgas enerģētikas un klimata rīcības plānu ieviešanas metodika (2. att.). Gan EPS, gan IEKRP izstrādes sākšanai ļoti būtisks ir pašvaldības vadības un deputātu politiskais atbalsts. Tāpēc lēmums par EPS un IEKRP izstrādi ir jāpieņem pašvaldības domes balsojumā. Sākot IEKRP izstrādi, esošās situācijas analīzi var veikt pašvaldība, izmantojot savus resursus vai piesaistot ārējos ekspertus. Abos gadījumos ir nepieciešams organizēt darba grupu sanāksmes, lai iesaistītu katra pašvaldības sektora atbildīgo speciālistus, skaidrotu datu analīzes rezultātus un diskutētu par potenciālajiem pasākumiem katrā sektorā. IEKRP izstrādes gaitā ir jāizveido darba grupa plāna ieviešanai un jānosaka atbildības, līdzīgi kā EPS izveidē. Kad pašvaldībai ir izstrādāts IEKRP un ieviesta energopārvaldības sistēma, jāsāk ciklisks darbs pasākumu ieviešanā un uzraudzībā. EPS gadījumā cikls ilgst vienu gadu. Katru gadu jādefinē mērķi un jāizplāno rīcības, kas tiks īstenotas pašvaldības infrastruktūras objektos, kas ir iekļauti EPS. Visa gada garumā jāveic datu monitorings, un gada beigās jāsagatavo gada pārskats, kas jāiesniedz pašvaldības vadībai. Ilgtspējīgas enerģētikas un klimata rīcības plāna gadījumā tiek ieviests ikgadējs cikls, kas iekļauj pasākumu plāna izveidi katram gadam, tā uzraudzību un ziņošanu, un trīs gadu cikls, lai aktualizētu un koriģētu rīcības plānu, ņemot vērā, ka IEKRP ir vidēja termiņa plānošanas dokuments.

Promocijas darbā izvirzītā hipotēze

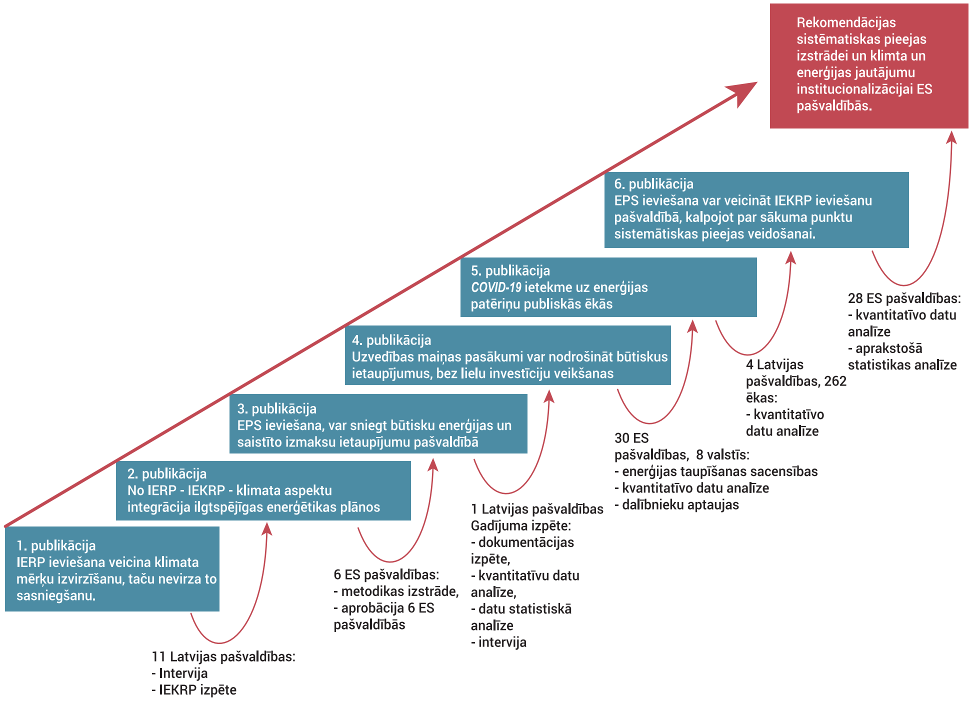
Lai pašvaldības Eiropā spētu virzīties uz klimatneitralitāti un klimatnoturību (saskaņā ar Eiropas Zaļo kursu), nepieciešams sistemātisks process enerģētikas un klimata pielāgošanās sektoru pārvaldībā, kas ietver ciklisku esošās situācijas un sasniegto rezultātu analīzi un rīcību plānošanu. Energopārvaldības sistēmas ieviešana veicina sistemātiskas rīcības klimata un enerģētikas jomā institucionalizāciju pašvaldības ikdienas procesos.

Promocijas darba praktiskā vērtība

Promocijas darbā gūtie secinājumi un izstrādātās pieejas ir praktiski ieviešamas Eiropas pašvaldībās, nodrošinot nepieciešamo zināšanu un kompetenču bāzi, lai iesāktu virzību uz klimatneitralitāti un klimatnoturību. Promocijas darbā izstrādātās pieejas un metodes ir pakāpeniski pilnveidotas un uzlabotas, ņemot vērā pētījumos identificētos šķēršļus, ar ko saskarās pašvaldības, sākotnēji izstrādājot un ieviešot Ilgtspējīgas enerģētikas rīcības plānus. Enerģētikas sektora pārvaldībā integrējot energopārvaldības sistēmas pieeju, kā arī līdz ar Eiropas Savienības politikas attīstību Ilgtspējīgas enerģētikas plānu, metodikā tiek iekļauti pielāgošanās klimata pārmaiņā aspekti. Pētījumā izstrādātā metodika un rekomendācijas ir aprobētas Eiropas pašvaldībās. Izstrādāto metodiku var integrēt arī politikas plānošanā ES, nacionālā un reģionālā līmenī, ņemot vērā to, ka ir pierādīts, ka energopārvaldības sistēma ir efektīvs instruments enerģijas patēriņa samazināšanai un virzībai uz klimatneitralitāti.

Promocijas darba struktūra

Promocijas darbs balstīts sešās zinātniskajās publikācijās, kurās pētīti dažādi enerģētikas pārvaldības aspekti pašvaldībās un aprobētas izstrādātās metodes un pieejas, lai pašvaldības spētu izveidot ilgtspējīgu un funkcionējošu enerģētikas un klimata sektoru pārvaldības sistēmu, nodrošinot klimata un enerģētikas mērķu sasniegšanu. Darbs ietver vairākus savstarpēji saistītus pētījumus, kuru rezultāti atspoguļoti sešās zinātniskajās publikācijās (3. att.).



3. att. Promocijas darba struktūra.

Darba gaitā veikta izpēte par ilgtspējīgas enerģētikas rīcības plānu izstrādes gaitu, to saturu, ietvertajiem mērķiem, kā arī plānu ieviešanas un uzraudzības gaitu. Nākošais solis bija izstrādāt un sešās Eiropas Savienības pašvaldībās (no trīs valstīm) izmēģināt pieeju klimata pielāgošanās aspektu integrēšanai pašvaldību ilgtspējīgas enerģētikas un klimata rīcības plānos. Trešajā publikācijā analizēta energopārvaldības sistēmas ieviešanas gaita, tās sistēmas robežas, procedūru izstrāde, kā arī galvenie šķēršļi un izaicinājumi, ar ko Daugavpils pašvaldība saskaras, ieviešot un uzturot energopārvaldības sistēmu Daugavpils pašvaldībā. EPS analīzes ietvaros arī veikta datu analīze, nosakot reālos enerģijas ietaupījumus, ko pašvaldībā ir izdevies sasniegt ieviešot EPS. Nākošā solī analizēta enerģijas taupīšanas sacensību norise 30 ES pašvaldībās (no astoņām valstīm), to gaitā sasniegtie rezultāti, ieiešot uzvedības maiņas pasākumus. Paralēli analizēta arī *COVID-19* pandēmijas ietekme uz pašvaldību ēku enerģijas patēriņu 4 pašvaldībās Latvijā. Pēc tam pētīta EPS ieviešana saskaņā ar *ISO 50001* standartu 28 ES pašvaldībās. Darba gaitā veiktā izpēte iezīmē galvenos šķēršļus un izaicinājumus, ar kuriem pašvaldības Eiropā saskaras klimata un enerģētikas pārvaldībā. Izpētes rezultātā izstrādātas rekomendācijas un metodika, kā pašvaldībām izveidot ilgtspējīgu enerģētikas un klimata jomu pārvaldību savās pašvaldībās, kas tiks turpināta izmēģināt 44 ES pašvaldībās.

Promocijas darba zinātniskā aprobācija

Zinātniskās publikācijas par promocijas darba tēmu

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2. Jēkabsone, A., Kamenders, A., Rošā, M. Implementation of Certified Energy Management System in Municipality. Case Study. *Environmental and Climate Technologies*, 2020, Vol. 24, No. 2, 41.–56. lpp. ISSN 1691-5208. e-ISSN 2255-8837. Pieejams: doi:10.2478/rtuect-2020-0053.
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Zinātniskās konferences

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3. Kaselofsky, J., Schule, R., Rošā, M., Prodaņuks, T., Jēkabsone, A., Vadovics, E., Vadovics, K., Heinel, T. Top Energy Saver of the Year: Results of an Energy Saving Competition in Public Buildings. Conference of Environmental and Climate technologies, CONECT 2020, 2020. gada 13.–15. maijs.

4. Jēkabsone, A., Delgado Marin, J., Martins, S., Rošā, M., Kamenders, A. Upgrade from SEAP to SECAP: Experience of 6 European Municipalities. Conference of Environmental and Climate technologies, CONECT 2021, 2021. gada 12.–14. maijs.
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1. LITERATŪRAS ANALĪZE

Pēdējās dekādes laikā klimata pārmaiņu problemātika ir ieviesusi nopietnas izmaiņas politikas plānošanā un ekonomiskās attīstības tendencēs. Kopš Apvienoto Nāciju Organizācijas konferences "Vide un attīstība" jeb Rio konferences 1992. gadā [19] klimata pārmaiņu mazināšana ir bijusi viena no Eiropas Savienības politikas prioritātēm [20]. ANO ģenerālā asambleja 2015. gadā pieņēma rezolūciju "Ilgtspējīgas attīstības programma 2030.gadam", nodefinējot 17 ilgtspējīgas attīstības mērķus, kur cita starpā 13. mērķis ir "Veikt steidzamus pasākumus, lai cīnītos pret klimata pārmaiņām un to ietekmi" [21]. Papildus tam 2015. gadā Parīzes klimata konferencē (*COP21*) tika apstiprināts "Parīzes nolīgums klimata pārmaiņu jomā" jeb Parīzes nolīgums, kura ietvaros 195 valstis apņemas nepieļaut globālās vidējās gaisa temperatūras palielināšanos vairāk nekā par 2 ^{o}C [1]. Lai samazinātu klimata pārmaiņas, sasniegtu ANO ilgtspējas un Parīzes nolīguma mērķus, 2019. gadā Eiropas Savienībā tika publicēta stratēģija "Eiropas Zaļais kurss" [22], kuras pamatmērķis ir sasniegt klimatneitralitāti Eiropas Savienībā līdz 2050. gadam [23]. Lai to sasniegtu 2020. gadā, tika izvirzīts priekšlikums paaugstināt SEG samazināšanas mērķi no 40 % SEG samazinājuma 2030. gadā [24] līdz 55 % SEG samazinājuma 2030. gadā, salīdzinot ar 1990. gadu [25]. 2011. gadā tika publicēts "Ceļvedis virzībai uz konkurētspējīgu ekonomiku ar zemu oglekļa dioksīda emisiju līmeni 2050. gadā" [26], kurā skaidroti veidi, kā sasniegt Eiropas Savienības ilgtermiņa mērķus un kādas pārmaiņas ir jāveic enerģijas ražošanas, rūpniecības, transporta, ēku un būvniecības, lauksaimniecības un citos sektoros. Papildus tam 2021. gadā Eiropas Komisija publicēja tiesību aktu pakotni "Gatavi mērķrādītājam 55 %" (Fit for 55), kuras mērķis ir salāgot un pilnveidot ES likumdošanas aktus, lai tie būtu saskaņā ar ES klimata mērķiem [27].

Tomēr, pat sasniedzot izvirzītos klimata pārmaiņu mazināšanas mērķus, ir skaidrs, ka klimats jau ir mainījies un turpinās mainīties, kas noved pie akūtākas nepieciešamības pielāgoties klimata pārmaiņām. Salīdzinot ar periodu no 1978. līdz 1997. gadam, uzskaitītie zaudējumi, kas radušies ekstrēmu klimata notikumu rezultātā, ir pieauguši par 151 % 1998.-2017. gadu periodā [28]. Pasaules ekonomikas foruma globālo risku pārskatā [29] ekstrēmas klimata parādības ir ierindotas starp TOP 5 globālajiem riskiem gan iestāšanās iespējamības, gan potenciālās ietekmes ziņā kopš 2017. gada, bet 2020. gadā pirmo reizi visi TOP 5 riski iestāšanās iespējamības ziņā ir ar vidi un klimatu saistīti riski. Tikmēr 2022. gadā nepietiekama rīcība klimata pārmaiņu mazināšanai ir ierindota kā augstākais risks ietekmes smaguma ziņā [30].

Saskaņā ar Klimata pārmaiņu starpvaldības padomes (Intergovernmental Panel on Climate Change) definīciju klimata pārmaiņu mazināšanas mērķis ir samazināt siltumnīcefekta gāzu rašanos un palielināt šo gāzu piesaisti. Tikmēr pielāgošanās klimata pārmaiņām ir definēta kā "*Process, lai pielāgotos faktiskajam vai gaidāmajam klimatam un tā radītajām izmaiņām. Cilvēka radītās sistēmās tas parasti izpaužas, kā centieni mazināt vai izvairīties no zaudējumiem vai gūt labumu, kamēr dabīgās sistēmās cilvēka iejaukšanās var veicināt spēju pielāgoties izmaiņām*" [31]. No šāda skatpunkta klimata pārmaiņu mazināšanu var uzskatīt par ilgtermiņa pasākumu kopu, lai novērstu klimata izmaiņas nākotnē, kamēr pielāgošanos, kā īstermiņa pasākumu kopumu, kā atbildi uz notiekošām izmaiņām [32]. Tomēr ANO mērķu un

Parīzes vienošanās kontekstā, arī pielāgošanās ir uzskatāma par ilgtspējīgu rīcību izturētspējas veicināšanai ilgtermiņā [33]. Eiropas Savienībā ir izstrādāta Pielāgošanās stratēģija, kuras pamatā ir 4 principi – gudrāka, ātrāka un sistemātiskāka pielāgošanās un sadarbības veicināšana, lai ieviestu pielāgošanās pasākumus starptautiskā līmenī.

1.1. Ilgtspējīgas enerģētikas un klimata rīcības plāni pašvaldībās

Ilgtspējīgas enerģētikas un klimata rīcības plāns ir dokuments, kurā pašvaldības nodefinē savus īstermiņa, vidēja termiņa un ilgtermiņa mērķus un vīziju, kā arī izstrādā pasākumu plānu, kas ļauj sasniegt izvirzītos mērķus [34]. IEKRP izstrādes gaitā tiek veikta esošās situācijas analīze gan enerģētikas, gan klimata pielāgošanās jomās [35].

Ilgtspējīgas enerģētikas plānošanai pašvaldību līmenī Eiropā plašāku uzmanību sāka pievērst 2008. gadā, kad tika izveidota Pilsētu Mēru pakta iniciatīva [36], kuras pamatmērķis bija veicināt SEG gāzu emisijas samazināšanu pašvaldībās. Pašvaldības, kuras paraksta Mēru paktu apņemas samazināt SEG emisijas, izstrādāt Ilgtspējīgas enerģētikas rīcības plānu (IERP) un regulāri veikt emisiju monitoringu [37], [38]. Mēru pakta iniciatīva ir bijusi īpaši veiksmīga, iesaistot tieši mazās un vidējās pašvaldības, tostarp no valstīm, kur nav stingru nacionālo prasību pašvaldībām attiecība uz klimata un enerģētikas jomām [34], [39]. 2015. gadā Mēru pakta iniciatīva tika apvienota ar "*Mayors Adapt*" iniciatīvu, izveidojot Mēru paktu enerģētikas un klimata jomā, šādi integrējot pielāgošanās klimata pārmaiņām un enerģētiskās nabadzības aspektus pašvaldību ilgtspējīgas enerģētikas un klimata rīcības plānos (IEKRP) [40].

Neskatoties uz lielo pašvaldību skaitu, kas ir izstrādājušas ilgtspējīgas enerģijas rīcības plānus, tikai neliela daļa spēj uzrādīt, kādi pasākumi ir ieviesti un kādi ir sasniegtie rezultāti [8], [9]. *Rivas et al*., pētot Mēru pakta iniciatīvas ietekmi, secināja, ka tikai 32,5% pašvaldību ir iesniegušas starpposma monitoringa ziņojumu, kā vienu no iemesliem minot prasmju un zināšanu trūkumu mazās un vidējās pašvaldībās [11]. Lai gan *Melica et.al* savā pētījumā secina, ka vidējām un mazām pašvaldībām konsultantu atbalsts ir būtisks, lai tās spētu piedalīties tādās iniciatīvās kā Mēru pakts [12], tomēr nepietiekama pašas pašvaldības pārstāvju iesaiste procesā vēlāk kļūs par šķērsli mērķu sasniegšanai. Galvenie faktori, kas veicina ilgtspējīgas enerģētikas plānu ieviešanu, ir: pašvaldību darbinieku tieša iesaiste, IEKRP izstrādes uzticēšana pašvaldības darbiniekiem nevis ārējiem konsultantiem, iesaistīto pušu iesaiste un līdzdalības procesa organizēšana, atbilstoša budžeta plānošana, kā arī IEKRP plāna izstrāde pēc iespējas agrāk [11].

Reckien et. al. pētījums parāda, ka klimata pārmaiņu mazināšanas jomā pašvaldības biežāk iekļauj konkrētus pasākumus emisiju samazināšanai, kamēr pielāgošanās jomā salīdzinoši biežāk tiek plānoti horizontālie pasākumi, nevis konkrēti pielāgošanās pasākumi, lai uzlabotu pašvaldības izturētspēju. Tas norāda, ka pielāgošanās vairāk tiek saprasta, kā multidimensionāls un holistisks process, kas jāintegrē pašvaldības uzdevumos [41]. *Coelho et.al.* norāda, ka pašvaldības biežāk izvēlas fokusēties uz sektoriem, pār kuriem tām ir tieša ietekme – ielu apgaismojums, pašvaldības ēkas u.tml. [42].

1.2. Pielāgošanās klimata pārmaiņām aspekti pašvaldību pārvaldībā

Ņemot vērā, ka neatkarīgi no tā, cik efektīvus klimata pārmaiņu mazināšanas pasākumus pasaules valstis ieviestu, klimata pārmaiņas turpinās notikt, tāpēc ir nepieciešams tām pielāgoties. Daudzviet pasaulē urbanizācija tikai pieaug (54 % pasaules populācijas 2015. gadā dzīvoja pilsētās [33]), tādēļ tieši pilsētas ir teritorijas ar ļoti augstu ievainojamību, jo jebkuri klimata ekstrēmi skar lielu skaitu cilvēku. Un kamēr lielām pilsētām bieži ir pieejami samērā plaši resursi, lai strādātu pie pielāgošanās klimata pārmaiņām [43], mazām pilsētām un pašvaldībām, kurās iedzīvotāju skaits sarūk, pielāgošanās klimata pārmaiņām bieži nenonāk prioritāšu sarakstā. Arī novērtēt pašvaldības izturētspēju, ja nav pieejami ilgtermiņa dati un kompetences, var būt sarežģīti [44]. Pētījumos arī atklājas, ka visvairāk potenciāli var ciest tieši enerģētiski nabadzīgās mājsaimniecības [45], ņemot vērā, ka daudz šādu mājsaimniecību dzīvo mājokļos, kas nav būvēti nākotnes, vai pat šī brīža klimatiskajiem apstākļiem [46].

Daudzas pašvaldības Eiropā ir iesaistījušās Mēru pakta iniciatīvā [37] un izstrādājušas ilgtspējīgas enerģētikas rīcības plānus, tā sniedzot savu pienesumu cīņai ar globālajām klimata izmaiņām. Vairāki pētnieki ir pētījuši, cik efektīvs instruments ir IERP izstrāde, kādi ir to potenciālie ieguvumi un šīs pieejas trūkumi [9], [34], [36], [42], [47], [48]. 2015. gadā Mēru pakts integrēja “*Mayors Adapt*” iniciatīvu un izveidoja Mēru paktu klimatam un enerģijai, un būtiskākā izmaiņa ir pielāgošanās un enerģētiskās nabadzības aspektu integrācija rīcības plānos, pārsaucot tos par Ilgtspējīgas enerģētikas un klimata rīcības plāniem. Šāda pieeja ļauj pašvaldībām gan pielāgošanās, gan enerģētikas jautājumus adresēt vienoti un ieviest kompleksus pasākumus, kas adresē gan pielāgošanos, gan enerģētiku vienlaikus.

Klimata mazināšanas joma pēdējos gados ir plaši pētīta no dažādiem aspektiem [18], [39], [49], kamēr metodikas un pieejas, kā pašvaldībām adresēt pielāgošanos klimata pārmaiņām, ir pētītas maz. Lai pielāgotu pilsētas klimata pārmaiņām, ir jāveic kompleksi pasākumi un detalizēta esošās situācijas un nākotnes klimata prognožu analīze, lai izprastu pilsētu riskus un ievainojamības. Lai to izdarītu, zinātniskajā literatūrā tiek piedāvātas dažādas metodes, piemēram, ģeogrāfiskās informācijas sistēmu piedāvātie risinājumi [50], sistēmdinamikas rīki [44] vai pat mašīnmācības rīki [51]. Tomēr pārsvarā šo metožu izmantošanai ir nepieciešami daudz un dažādi dati, un tās ir samērā sarežģītas, lai tās ikdienā varētu izmantot pašvaldības. Tādējādi, lai pašvaldības integrētu ikdienas procesos pielāgošanos klimata pārmaiņām aspektus, tām ir nepieciešami vienkārši, strukturēti un pašvaldību kompetencei atbilstoši rīki.

1.3. Standarta *ISO 50001* ieviešana pašvaldībās

Līdz ar nepieciešamību samazināt dažāda veida ietekmi uz vidi, tika izstrādāti dažādi rīki, lai veicinātu negatīvās ietekmes mazināšanu, piemēram, politikas instrumenti, likumi, vides nodokļu sistēmas, emisiju tirdzniecības sistēmas, sertifikācijas shēmas, marķējumi u.c. [52], [53]. Viens no plaši zināmiem instrumentiem ir vides pārvaldības sistēmas [54], [55]. Vides pārvaldības sistēmas var būt gan individuāli izstrādātas, gan saskaņā ar dažādiem standartiem, taču viena no plašāk zināmajām ir vides pārvaldības sistēma saskaņā ar *ISO 14001* un ES *EMAS* (vides pārvaldības un auditu sistēma) [56]. Vēlāk 2011. gadā tika izstrādāts arī *ISO 50001* standarts Energopārvaldības sistēma, kas ir balstīts uz *ISO 14001*, taču jau skaidri mērķēts uz enerģētikas un energoefektivitātes jautājumu risināšanu. Standarta mērķis ir izveidot organizācijās tādu sistēmu un procedūras, kas ļauj sistemātiski uzlabot enerģijas patēriņa un ražošanas rādītājus [57], kopumā panākot, ka energoefektivitātes pasākumu ieviešana tiek integrēta ikdienas darbībās un procesos [58]. *Backlund et al.* savā pētījumā secina, ka, uzlabojot energopārvaldības praksi, ir iespējams ietaupīt pat līdz 20 % enerģijas un energoefektivitātes pasākumi bez labas ikdienas energoārvaldības prakses nesniegs labākos iespējamos rezultātus [59], [60]. Tikmēr *Pelser et al.*, pētot energopārvaldības praksi cementa ražošanas uzņēmumos, secina, ka, ieviešot energopārvaldības sistēmu saskaņā ar *ISO 50001*, ir iespējams sasniegt 25 % enerģijas ietaupījumu, neveicot investīcijas jaunās iekārtās [61]. Līdzīgi secinājumi izdarīti arī pētot Vācijas auto industrijas uzņēmumus, kur *ISO 50001* ieviešana veicina CO_2 emisiju samazinājumu auto industrijā [62]. Taču, neskatoties uz lielo potenciālu, kā viens no negatīviem aspektiem tiek izcelts tas, ka standarts nenosaka, cik plašas robežas ir jānosaka, ieviešot energopārvaldības sistēmu, un neatkarīgi no tā, cik sistēma ir liela, tiek piešķirts sertifikāts, kuru var izmantot mārketinga nolūkos [63]. *ISO 50001* ir izmantojams jebkura veida organizācijās: no lieliem ražošanas uzņēmumiem līdz maziem uzņēmumiem un organizācijām, pie tam standarts ir savietojams ar *ISO 14001* un *ISO 90001* standartiem, pateicoties to līdzīgajai struktūrai [64].

Viena no plaši izmantotām pieejām publiskās un privātās ēkās ir "Ēku energopārvaldības sistēma" jeb *BMS* [65]–[69]. Lielākoties *BMS* ietver ēku gudrās sistēmas, nodrošinot enerģijas patēriņa datu analīzi ļoti augstā detalizācijas pakāpē, tāpēc lielākoties to izmanto lielās ēkās vai ēku kompleksos. Taču izmantot šādu pieeju organizācijās ar lielu ēku skaitu, kuras ir izkliedētas plašā teritorijā, kā tas bieži ir pašvaldību gadījumā, var būt sarežģīti un pārāk resursu ietilpīgi. Organizācijās kā pašvaldība, kurām var būt nepieciešams pārvaldīt vairāk nekā 100 ēkas, plašu ielu apgaismojuma sistēmu un pašvaldības transportu ir nepieciešama visaptveroša un centralizēti pārvaldāma sistēma.

Pēdējos gados arī pašvaldības ir sākušas ieviest un sertificēt *ISO 50001* standartu, uzrādot labus enerģijas ietaupījuma rezultātus [70], [71], un panākot standarta ieviešanas atmaksāšanos jau mazāk nekā gada laikā [18].

Dati par *ISO* standarta ieviešanu parāda, ka sertificētu energopārvaldības sistēmu skaits ES ir būtiski pieaudzis: no 5526 sertifikātiem 2014. gadā līdz 22575 sertifikātiem 2021. gadā, no kuriem 62 sertifikāti izsniegti pašvaldībām [14], [72]. Viens no iemesliem, kāpēc *ISO 50001* standarts strauji kļuva populārs, ir likumdošanas prasības par SEG emisiju gāzu samazināšanu lielākajā daļā ES dalībvalstu, kā arī tas, ka standarta ieviešana organizācijās, kurās jau ir ieviesti *ISO 140001* un *ISO 9001*, ir samērā vienkārša [73].

1.4. Uzvedības maiņas pasākumi

Ēku sektoram ir nozīmīga loma klimata pārmaiņu mazināšanā, kā rezultātā ES laika gaitā ir izstrādātas vairākas direktīvas, tostarp direktīva par ēku energoefektivitāti 2010/31/EU [74] un direktīva par energoefektivitāti 2012/27/EU [75] un tām pakārtotā likumdošana, lai veicinātu energoefektīvu ēku būvniecību. Tomēr saskaņā ar ES ēku fonda observatorijas (*EU building* *stock observatory*) datiem, lielā daļā ES valstu vairāk nekā puse dzīvojamo ēku ir būvētas pirms tika ieviesti augsti energoefektivitātes standarti. Vidējais īpatnējais enerģijas patēriņš dzīvojamā ēkā ES vidēji bija 178 kWh/m^2 gadā (2016. gada dati). Tikmēr nedzīvojamās ēkās vidējais īpatnējais enerģijas patēriņš vidēji ES bija 300 kWh/m^2 (2016. gada dati) [76], kas liecina, ka nedzīvojamo ēku sektorā ēku vecuma struktūra varētu būt līdzīga, kā arī enerģijas patēriņš ir būtiski augstāks nekā dzīvojamo ēku sektorā. Nedzīvojamo ēku sadalījums pēc izmantošanas veida dažādās valstīs ļoti atšķirīgs, bet vidēji 30 % no nedzīvojamo ēku platībām tiek izmantotas publiskiem un privātiem birojiem, tirdzniecībai 27 %, un 16% izglītībai. Latvijā lielākās platības aizņem izglītības iestādes 29,62%, tirdzniecība 25,17 %, privātās biroju telpas 14,8 % un publiskās biroju telpas 12,53 %, pārējās platības aizņem viesnīcu, restorānu un veselības aprūpes pakalpojumu iestādes [77]. Ņemot vērā, ka pašvaldību pārziņā visbiežāk ir publiskās nedzīvojamās ēkās, piemēram, kultūras nami, administrācijas ēkas, kā arī izglītības iestādes, pašvaldības ir būtiska iesaistītā puse enerģijas patēriņa samazināšanā ēkās. Ēku atjaunošanas un renovācija ir būtisks solis, lai samazinātu enerģijas patēriņu, bet bieži tik pat būtiski ir arī uzlabot ēkas lietotāju zināšanas, kā pareizi ēku lietot un samazināt enerģijas patēriņu caur paradumu maiņu.

Ēku lietotāju paradumiem ir liela nozīme ēkas enerģijas patēriņā. Mūsdienās arī ēku enerģijas patēriņa modelēšanā, lietotāju paradumus ir iespējams ņemt vērā, iegūstot realitātei tuvāku enerģijas patēriņa prognozi [78]. Pētījumi rāda, ka ir iespējams samazināt enerģijas patēriņu ar uzvedības maiņas pasākumiem [79], un potenciālais samazinājums var būt no 2 % līdz pat 20 % [80]. Tomēr lielākā daļa pētījumu ir vērsta uz uzvedības maiņas pasākumu ietekmi uz enerģijas patēriņu dzīvojamās ēkās, kamēr nedzīvojamo ēku sektors ir pētīts maz. *Staddon et al.* ir izpētījuši 22 dažādus pētījumus par uzvedības maiņas pasākumu ietekmi uz enerģijas patēriņu nedzīvojamās ēkās, un viens no secinājumiem ir, ka būtiska nozīme ir organizāciju iekšējai kultūrai un spējai pozitīvi mudināt un motivēt darbiniekus izmaiņām [17]. Bieži uz uzvedības maiņu motivē nolūks ietaupīt finanšu līdzekļus, taču darba vietā darbinieki individuāli nav atbildīgi par ēkas enerģijas patēriņu un tā izmaksām, tāpēc šis aspekts zaudē savu nozīmi. *Bull* un *Janda* savā pētījumā iezīmē vēl vienu faktoru – konkurējošas prioritātes [16], kad darbinieka pienākumu un uzdevumu saraksts ir pietiekami garš, enerģijas taupīšana tiek atstāta prioritāšu sarakstā zemāk. Tai pat laikā *Bull* un *Janda* norāda, ka organizāciju iekšējai kultūrai ir liela nozīme šī efekta mazināšanā.

Staddon et al. iepriekš minētajā pētījumā [17] izstrādāja pasākumu klasifikatoru, kurš tiek izmantots arī organizējot enerģijas taupīšanas sacensības, kuras aprakstītas promocijas darba 3.4. nodaļā. Būtiskākie pasākumu veidi ir [17]:

- izglītošana – uzlabot zināšanas un izpratni;
- pārliecināšana – izmantojot komunikāciju radīt pozitīvas vai negatīvas emocijas vai stimulēt rīcību;
- stimulēšana – radīt sajūtu, ka tiks apbalvots, novērtēts;
- izmaiņas vidē – izmainīt fizisko vai sociālo kontekstu;
- aktivizēšana – mazināt šķēršļus, vairot resursus, lai radītu spējas un izdevības uzvedības maiņai.

Jāņem arī vērā, ka ne vienmēr robežas starp šiem pasākumu veidiem ir stingri novelkamas [17]. *Gustafson* un *Longland* apraksta uzvedības maiņas programmu, kas iekļauj enerģijas taupīšanas komandu veidošanu, dažādu sacensību elementu izmantošanu, uzlīmju, plakātu u.c. pamudinošu materiālu izmantošanu, regulāru informācijas un padomu izsūtīšanu e-pastos u.tml. Programmas rezultātā tika ietaupīti 5 % enerģijas pirmajā gadā un papildus 4 % otrajā gadā [81]. Arī *Metzger et al.* savā pētījumā novēroja 6 % enerģijas patēriņa samazinājumu pēc enerģijas taupīšanas sacensībām administratīvā ēkā ASV. Sacensības tika organizētas 4 mēnešu garumā [82]. *Murtagh et al.* veica eksperimentu universitātes administrācijas biroja darbinieku vidū. Tika nodrošināti enerģijas patēriņa mērītāji un atgriezeniskā saite par enerģijas patēriņu, un regulāri sniegti padomi, kā samazināt enerģijas patēriņu. Četru nedēļu laikā tika samazināts enerģijas patēriņš par 16 % [83]. Savukārt *Petersen et al.* [84] apraksta enerģijas taupīšanas sacensības, kas tika organizētas universitātes kopmītnēs. Sacensībās piedalījās vairāk nekā 300 000 kopmītņu iedzīvotāji divu gadu laikā. Pētījumā secināts, ka zināšanas par sacensībām un motivācija piedalīties pozitīvi korelē ar elektroenerģijas ietaupījumu. Kā arī pozitīva korelācija tika novērota starp elektroenerģijas patēriņu un studentu uztveri par to, cik motivēti piedalīties ir citi studenti. Kopumā studentu kopmītnēs šo sacensību laikā 2 gadu garumā tika ietaupīti 4 % elektroenerģijas [84].

1.5. *COVID-19* pandēmijas ietekme uz enerģijas patēriņu

2020. gada pavasarī Pasaules Veselības organizācija izsludināja globālo pandēmiju [85]. Lielākajā daļā pasaules valstu tika ieviesti dažādi ierobežojumi, lai novērstu veselības sistēmas pārslodzi un iedzīvotāju masveida saslimšanu [86]. Ierobežojumi galvenokārt bija vērsti uz iedzīvotāju pulcēšanās samazināšanu, kā rezultātā dažādu pakalpojumu sniegšana tika ierobežota un lielākā daļa kultūras un citi sociāli pasākumi tika aizliegti, radot būtisku ietekmi uz ekonomiku, labklājību, nodarbinātību, vidi, veselības jomu, ražošanas industriju, un arī transporta un enerģētikas sektoriem. Vairāki pētījumu rāda, ka daudzās valstīs *COVID-19* ierobežojumu laikā elektrības patēriņš samazinājās, bet lielākā daļā gadījumu tas ir dēļ elektrības patēriņa samazinājuma pakalpojumu un ražošanas sektoros, bet enerģijas patēriņš mājsaimniecību sektorā pieauga [87]–[92].

Pētījums, kurā iekļautas 53 valstis un reģioni parāda, ka kopējais elektrības patēriņš 2020. gada aprīlī samazinājās par 7.6 %, tomēr rezultāti dažādās valstīs būtiski atšķiras. Pētījumā arī parādās, ka valstu ieviesto ierobežojumu apjoms stipri korelē ar enerģijas patēriņu tikai pirmā *COVID-19* uzliesmojuma laikā [93].

Pētījums par elektrības patēriņu Ontario, Kanādā parāda, ka pēc pandēmijas sākšanās kopējais elektrības patēriņš samazinājās, un pieprasījuma dinamika nedēļas griezumā izmainījās, salīdzinot ar pirmspandēmijas datiem. Stundu dati savukārt, uzrādīja rīta un vakara elektrības pieprasījuma pīķu mazināšanos [94], [95]. Līdzīgi rezultāti iegūti analizējot elektroenerģijas patēriņus 4 Eiropas valstīs – Spānijā, Itālijā, Beļģijā un Lielbritānijā, kur darba dienu enerģijas patēriņš samazinājās, un patēriņa dinamika bija līdzīgāka pirmspandēmijas patēriņa tendencēm nedēļu nogalēs [96]. Arī pētījumā par elektroenerģijas patēriņu Saudu Arābijas mājsaimniecību sektorā uzrādās elektroenerģijas patēriņa pieaugumus, ko rada gaisa kondicionēšanas sistēmu un apgaismojuma lietošanas pieaugums [97], [98]. Citos pētījumos parādās, ka Ņujorkā elektrības patēriņš samazinājās par 17 % [99], kamēr Itālijā elektroenerģijas patēriņš sasniedza pat 37 % [100], Portugālē un Spānijā 2020. gada maijā elektroenerģijas patēriņš bija samazinājies par 12 % [101], bet Ķīnā vidēji elektroenerģijas patēriņš samazinājās par 29 %, salīdzinot ar elektroenerģijas patēriņa prognozi, ja pandēmijas nebūtu [102].

Latvijā gada bruto enerģijas patēriņš samazinājās par 6.1 % 2020. gadā, salīdzinot ar 2019. gadu (Centrālās statistikas pārvaldes dati [103]). Transporta sektorā pasažieru un pārvadājumu transporta galapatēriņš samazinājās par 12.8 %, bet ražošanas sektorā enerģijas patēriņš palielinājās par 3.3 % [103]. Latvijā tika ieviesti vairāki plāni [104] un politikas instrumenti, lai samazinātu enerģijas patēriņu un pārietu uz atjaunojamiem energoresursiem un sasniegtu izvirzītos klimata mērķus [105], [106], bet, neskatoties uz to, samazinājums, kas novērojams 2020. gadā, daļēji ir saistāms ar *COVID-19* ietekmi.

2. METODIKAS

2.1. Padziļināta aptauja

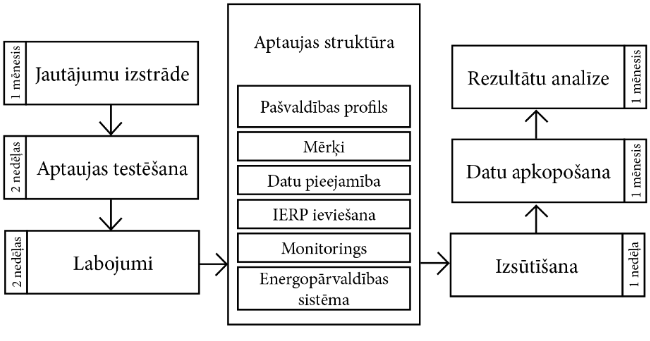
Pētījuma gaitā veikta dokumentu (IERP, EPS dokumentācijas) analīze un izstrādāta padziļināta aptauja Ilgtspējīgas enerģētikas rīcības plānu izpētei. Pētījums veikts Eiropas Savienības programmas “Apvārsnis 2020” finansētā projektā *Compete4SECAP*. Kopumā Latvijā pētījuma brīdī IERP bija izstrādāti 42 pašvaldībās, no kurām 11 piekrita piedalīties aptaujā. Aptaujā iekļauto pašvaldību raksturlielumi doti 2.1. tabulā.

2.1. tabula

Pašvaldību raksturlielumi, kuras piedalījās intervijā

Pašvaldība	Pašvaldības izmērs	Pievienojusies Pilsētu mēru paktam	IERP periods
A	Liela	Ir pievienojusies	2014–2020
B	Liela	Ir pievienojusies	2016–2020
C	Vidēja	Ir pievienojusies	2013–2020
D	Vidēja	Ir pievienojusies	2011–2020
E	Maza	Nav	2016–2020
F	Maza	Nav	2014–2020
G	Maza	Nav	2015–2020
H	Maza	Ir pievienojusies	2016–2020
J	Maza	Ir pievienojusies	2013–2020
K	Maza	Nav	2018–2025
L	Ļoti maza	Ir pievienojusies	2013–2020

Aptauja sastāvēja no sešām daļām – pamatinformācija par pašvaldību (pašvaldības profils), mērķi, datu pieejamība, IERP ieviešanas process, monitorings un uzraudzība, un energopārvaldības sistēma. Kopumā aptaujā tika iekļauti 43 jautājumi, un aptaujas gaitā iegūta informācija tika papildināta un precizēta, balstoties publiski pieejamos pašvaldību ilgtspējīgas enerģētikas rīcības plānos. Tika veikta kvalitatīva datu analīze un definēti secinājumi. Intervijas struktūra un process ir parādīti 2.1. attēlā.



2.1. att. Aptaujas struktūra un procesa shēma.

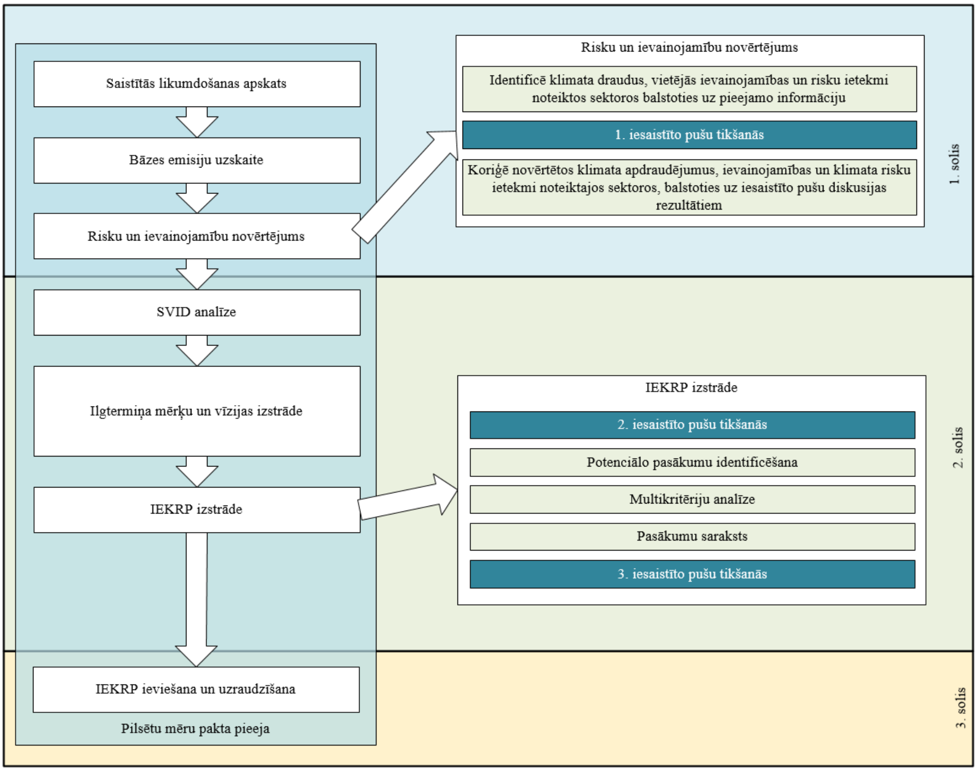
Rezultātu analīzei 11 pašvaldības tika sadalītas 4 grupās, balstoties uz iedzīvotāju skaitu pašvaldībās – lielas pašvaldības (>50 000 iedzīvotāju), vidējas (30 000 – 50 000 iedzīvotāju), mazas (10 000 – 30 000 iedzīvotāju), ļoti mazas pašvaldības (<10 000 iedzīvotāju). Abas lielās pašvaldības bija pilsētas, un pārējās pašvaldības nelielas pilsētas ar pagastu teritorijām.

2.2. Daudzkritēriju analīzes metode pasākumu atlasei

Pieeja, kā plānot un īstenot pielāgošanās klimata pārmaiņām pasākumus, tika izstrādāta projektā *Life Adaptate*. Pieeja tika balstīta trīs pamatsoļos – IEKRP izstrāde, vietējā līmeņa politikas pielāgošana un klimata pārmaiņu pielāgošanās pasākumu ieviešana. Projekta laikā izstrādātā pieeja tika testēta sešās Eiropas pašvaldībās – Lorka, Aguilas, Kartahena Spānijā, Alfandega da Fe un Mertola Portugālē un Smiltene Latvijā. Katra pašvaldība izstrādāja Ilgtspējīgas enerģētikas un klimata rīcības plānu saskaņā ar projekta partneru piedāvāto metodiku un ieviesa vienu pasākumu, lai demonstrētu sabiedrībai pielāgošanās pasākumu nozīmīgumu.

Tāpat daudzos gadījumos, klimata pārmaiņu seku mazināšanas un pielāgošanās pasākumi var būt viens otru papildinoši, un tāpēc IEKRP izstrādei ir nepieciešama holistiska pieeja, tostarp SEG emisiju, pielāgošanās un enerģētiskās nabadzības novērtējums.

Kopumā process lielā mērā bija atkarīgs no ieinteresēto pušu līdzdalības un atgriezeniskās saites, lai kompensētu kvantitatīvo datu trūkumu par klimata riskiem un apdraudējumiem, kā arī lai motivētu iesaistītās puses piedalīties IEKRP pasākumu īstenošanā. Līdzdalības procesam tika izveidotas trīs dažādu iesaistes līmeņu darba grupas: mazāko grupu veido galvenā tiešā komanda, kas ir atbildīga par IEKRP izstrādi un redakciju, tie parasti ir vietējās pašvaldības dažādu departamentu pārstāvji. Plašāka darba grupa tiek izveidota ar visām ieinteresētajām un iesaistītajām pusēm ar mērķi saņemt atgriezenisko saiti gan par esošo situāciju, gan potenciālo pasākumu ieviešanu. Un, visbeidzot, visi vietējie iedzīvotāji un ieinteresētās personas tiek iesaistītas publiskās sapulcēs un aptaujās, nodrošinot gan iespēju sniegt savu viedokli un ieguldījumu, gan saņemt informāciju par pašvaldības mērķiem un plāniem.



2.2. att. Mēru pakta pieeja un izstrādātie soļi IEKRP izstrādē [35], [107].

Ilgtspējīgas enerģētikas un klimata rīcības plāni pašvaldībās tika izstrādāti 3 galvenajos soļos (skatīt 2.2. attēlu). 1. solis – klimata izraisīto risku un ievainojamību noteikšana vietējā līmenī. Izstrādājot risku un ievainojamību izvērtējumu, Mēru pakta ietvaros, jau tika konstatēts, ka mazām pašvaldībām ir nepieciešama vienkārša, kvalitatīva pieeja, lai risku un ievainojamības novērtējumu spētu veikt pašvaldības darbinieki bez ekspertīzes klimata pārmaiņu jautājumos [107]. Projekta ietvaros galvenokārt tika izmantota Mēru pakta pieeja, papildus iesaistot ieinteresētās personas. Sākotnējā klimata apdraudējumu analīze tika veikta, izmantojot datus no klimata pārmaiņu valstu rīkiem (visi apkopoti *EU Climate Adapt* platformā) [108] (Latvijas gadījumā tika izmantots klimata rīks https://www4.meteo.lv/klimatariks/), taču iesaistīto personu sniegtā informācija bija vienlīdz būtiska klimata risku un ievainojamību novērtējumā. Vietējās ievainojamības tika klasificētas pēc sociālās, ekonomiskās, fiziskās un vides ievainojamības. Katras ievainojamības saikne ar klimata apdraudējumu līmeni tika piemērota noteiktām nozarēm, nosakot potenciālus riskus un klimata ietekmi uz pašvaldību. Kā arī, ievērojot Mēru pakta metodiku, lai novērtētu katru risku, tika izmantoti trīs kritēriji: rašanās iespējamība, paredzamās ietekmes līmenis un laika grafiks.

Ieinteresēto pušu viedoklis tika iegūts, organizējot publisku ieinteresēto pušu sanāksmes un aicinot uz tām pārstāvjus no visām saistītajām pašvaldību un privātajām struktūrām, kā arī vietējos iedzīvotājus. Bija svarīgi izskaidrot klimata pielāgošanās nepieciešamību un pieejamos datus par vietējām, reģionālajām vai valsts klimata tendencēm (atkarībā no tā, kādi dati ir pieejami), lai vairotu izpratni un dalībnieku iesaistīšanos. Pēc tam dalībnieki tika iesaistīti "prāta vētras" sesijā, lai uzskaitītu visus iespējamos klimata apdraudējumus un ievainojamības, ko viņi uzskatīja par būtiskiem. Pamatojoties uz sanāksmes rezultātiem, tika koriģēts sākotnējais risku un ievainojamības novērtējums.

2. solis – pielāgošanās darbību noteikšana. Kad tika apzināti galvenie riski un ievainojamības, tika organizēta vēl viena ieinteresēto personu sanāksme, lai noteiktu iespējamo pielāgošanās pasākumu klāstu. Vispirms tika rīkota "prāta vētras" sesija, lai uzskaitītu visus potenciālos pasākumus. Otrkārt, katra pasākuma novērtēšanai tika izmantots daudzkritēriju analīzes princips, un visaugstāk novērtētie pasākumi tika iekļauti IEKRP. Šajā posmā pašvaldība var noteikt ierobežojošus kritērijus, lai plānā iekļautie pasākumi būtu reālistiski un īstenojami.

Daudzkritēriju analīzei vadlīnijās kā ieteikums pašvaldībām tika iekļauti deviņi kritēriji, taču tās varēja izvēlēties, cik kritērijus izmantot. Deviņi kritēriji bija šādi:

− efektivitāte – līmenis, kādā piedāvātais risinājums spēj atrisināt problēmu;
− efektivitāte – apmērs, kādā ieguvumi pārsniedz izmaksas/zaudējumus;
− taisnīgums – apmērs, kādā darbība nelabvēlīgi ietekmē citas jomas vai iedzīvotāju grupas;
− elastīgums – darbība ļauj veikt pielāgojumus vai pakāpenisku ieviešanu;
− leģitimitāte – darbība ir politiski, likumīgi un sociāli pieņemama;
− steidzamība – problēmas risināšanas termiņš;
− sinerģija – saskaņotības pakāpe ar citiem mērķiem vai pasākumiem;
− izmaksas – Investīciju summa;
− finansējums – iekšējā vai ārējā finansējuma pieejamība pasākuma īstenošanai.

Pašvaldības arī varēja izvēlēties, vai katram kritērijam jāpiešķir svari, vai arī visi kritēriji tiks uzskatīti par vienādiem [35]. Daudzkritēriju analīzi veica visi darba grupas dalībnieki un sanāksmē iesaistītās puses.

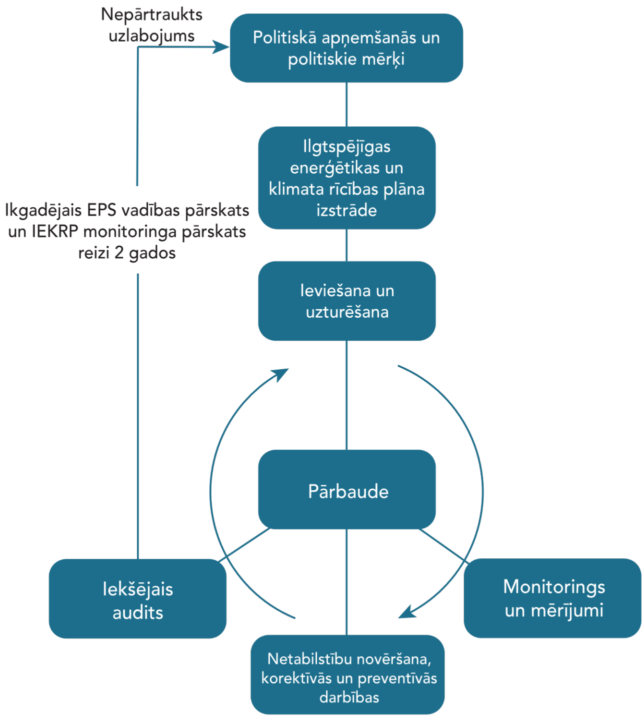
3. solis – IEKRP pabeigšana. Kad svarīgāko pielāgošanās darbību saraksts bija izstrādāts, nepieciešamie resursi, laiks un pienākumi noteikti, tika organizēta 3. ieinteresēto pušu sanāksme, lai prezentētu galīgo IEKRP, un plāna īstenošana varētu sākties. Projekta laikā visas sešas pašvaldības īstenoja vismaz vienu demonstratīvu pielāgošanās pasākumu.

Šī pieeja ļauj mazajām pašvaldībām ar ierobežotām zināšanām un resursiem risināt pielāgošanās problēmas atbilstoši savai konkrētajai situācijai un modificēt metodi atbilstoši savām ambīcijām.

2.3. Energopārvaldības sistēmas ieviešanas izpēte

Energopārvaldības sistēmas ieviešanas izpēte Daugavpils pilsētā

Teorētiskais ietvars energopārvaldības sistēmas ieviešanas un darbības analīzei balstīts Kamenders u. c. izstrādātajā metodiskajā shēmā (2.3. att.) [18]. Teorētiskajam ietvaram ir četri galvenie posmi. Pirmais posms ir nodrošināt pašvaldības vadības politisko atbalstu un apņemšanos sasniegt vidēja termiņa un ilga termiņa klimata un enerģētikas mērķus. Tas nozīmē, ka pašvaldība arī apzinās nacionālos un starptautiskos mērķus un ir gatava rīkoties šo mērķu sasniegšanai. Otrais posms ir plānošanas fāze, kad tiek analizēta esošā situācija, noteiktas bāzes vērtības un, balstoties esošās situācijas analīzē, tiek noteikti kvantitatīvie un kvalitatīvie mērķi un pasākumi šo mērķu sasniegšanai. Esošās situācijas analīzi var veikt pašvaldība ar saviem resursiem vai uzticēt ārējiem pakalpojumu sniedzējiem.



2.3. att. EPS un IEKRP integrēta pieeja [18].

Trešais posms ir energopārvaldības sistēmas ieviešana un uzturēšana, kas ietver pasākumu ieviešanu un procedūru ieviešanu, tostarp ikmēneša datu vākšanas un apstrādes procedūru un noviržu noteikšanas procedūru. Pēdējais posms ir uzraudzība, kas iekļauj iekšējo auditu, kvantitatīvo rezultātu analīzi, stipro un vājo pušu identificēšanu sistēmas procesā. Šajā posmā tiek identificētas, kādas korektīvās un preventīvās aktivitātes būtu jāveic, lai sistēma efektīvi darbotos.

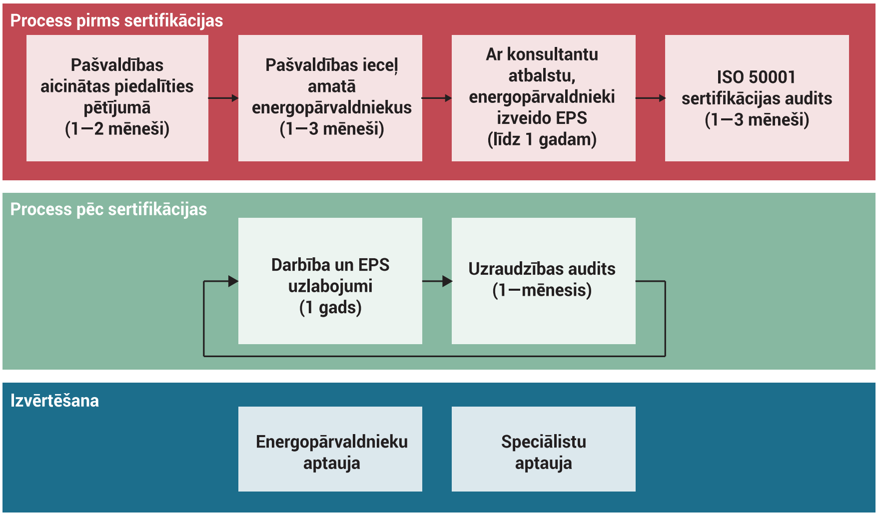
Četru posmu cikls ir viens gads, un, balstoties uz uzraudzības posma rezultātiem, pašvaldība katru gadu pārskata savus mērķus un sasniegumus un nosaka mērķus nākošam gadam. Šāds process nodrošina, ka energopārvaldības sistēma atbilst pašvaldības realitātei un pašvaldība spēj pielāgoties jauniem apstākļiem un vajadzībām.

Šie teorētiskā ietvara principi ir pamatā promocijas darba ietvaros veiktā tālākā pētījuma struktūrai, kura rezultāti aprakstīti 3.2. nodaļā. Kopumā pētījuma ietvaros tika veikta gan kvantitatīvā un kvalitatīvā datu analīze, gan veikta kvalitatīva intervija ar pašvaldības energopārvaldnieku. Divi galvenie dokumenti, kas tika padziļināti analizēti, bija “Daugavpils pilsētas Ilgtspējīgas enerģētikas rīcības plāns” un “Daugavpils energopārvaldības sistēmas rokasgrāmata”, kā arī ikgadējie *ISO 50001* sertifikācijas ietvaros veikto iekšējo auditu rezultāti. Energopārvaldnieka aptauja galvenokārt skāra jautājumus par EPS ieviešanas procesu un šķēršļiem, ar kuriem pašvaldība saskaras un tās struktūra un saturs aprakstīta 3.1. nodaļā. Visi kvantitatīvie dati, kas iekļauti šajā pētījumā (3.2. nodaļa), tika apkopoti pašvaldības energopārvaldības sistēmas ietvaros, kur konkrēto objektu vai ēku atbildīgie ik mēnesi iesniedz enerģijas patēriņa datus tiešsaistes datu monitoringa platformā, saskaņā ar izdotajiem rīkojumiem un procedūrām.

Pašvaldības tehniskais personāls ik mēnesi iesniedz datus par patērēto siltumu, elektrību un karsto ūdeni. Energopārvaldnieks iesniedz datus par enerģijas tarifiem un vidējo āra gaisa temperatūru katrā mēnesī. Siltumenerģijas datiem platformā tiek veikta klimata korekcija saskaņā ar nacionālo metodiku, kas ir balstīta uz *ISO 13790:2008*, kas nosaka aprēķinu metodes, dzīvojamo un nedzīvojamo ēku sildīšanas un dzesēšanas enerģijas aprēķiniem [109], [110]. Datu vizualizācijas un aprēķini platformā tiek veidoti atbilstoši *ISO 50001* un likumdošanas prasībām. Katrai ēkai individuāli tiek aprēķināta arī novirze patēriņa rādītājos. Pētot Daugavpils EPS ieviešanas rezultātus un efektivitāti, tika analizēti tikai publisko ēku dati. Kopumā tika analizēti dati piecu gadu periodā no 2015.–2019. gadam, lai noteiktu ieviesto pasākumu atdevi. IERP un EPS izstrādes gaitā tika apkopoti arī vēsturiskie dati kopš 2012. gada, taču šo datu kopa ir nepilnīga, pastāvīga datu uzkrāšana un apkopošana tika uzsākta 2016. gadā.

EPS ieviešanas procesa analīze 28 pašvaldībās Eiropā

Projekta *Compete4SECAP* ietvaros tika ieviesta energopārvaldības sistēma 28 pašvaldībās Eiropā. Lai noteiktu galvenos ieguvumus un izaicinājumus EPS ieviešanas procesā tika veiktas pašvaldību energopārvaldnieku un iesaistīto ekspertu aptaujas, kā arī enerģijas patēriņa datu analīze. EPS izstrāde pašvaldībai ir vienreizējs process, taču tā darbība un uzlabošana ir pastāvīgs un ilgstošs process. Tas var būt laikietilpīgs un bieži prasa ārēju palīdzību. Ārējās palīdzības (ekspertu atbalsta) nozīme jau ir tikusi identificēta literatūrā [111], [112] pētot sistēmas ieviešanu uzņēmumos.



2.4. att. Pētījuma laikā īstenotās aktivitātes.

2.4. attēlā redzami veiktā pētījuma galvenie posmi – pirmssertifikācijas, pēcsertifikācijas un novērtēšanas posms. Pašvaldības tika aicinātas iecelt energopārvaldniekus un darba grupas sistēmas izveidei. Visā EPS ieviešanas procesā tika nodrošināts ekspertu atbalsts (*Compete4SECAP* projekta ietvaros). Pirms sertifikācijas posms beidzās ar sertifikācijas auditu, pēc kura pašvaldība saņēma *ISO 50001* sertifikātu. Pēc tam EPS tika nepārtraukti uzturēta un regulāri uzlabota, veicot regulārus uzraudzības auditus. Šajā posmā speciālisti sniedza atbalstu tikai, kad tas bija nepieciešams. Nepārtraukti uzlabojumi ir viens no *ISO 50001* standarta stūrakmeņiem [13], [57], šis aspekts jau ir akcentēts arī iepriekšējos pētījumos [113], [114].

Lai novērtētu EPS izveides procesu, tika veiktas divas aptaujas: vienā tika aptaujāti pašvaldību energopārvaldnieki, bet otrā speciālisti, kas sniedza atbalstu iesaistītajām personām pašvaldībā. Sākotnēji tika plānots aptaujas veikt tikai izvērtēšanas posmā, taču dažu pašvaldību kavēšanās dēļ, to energopārvaldnieki un speciālisti tika aptaujāti jau pirms *ISO 50001* sertifikāta iegūšanas.

Pašvaldību darbinieku pieredzes trūkums darbā ar EPS rada nepieciešamību pēc ārējā atbalsta no speciālistu puses, kā arī neatkarīgas puses viedoklis var rosināt izmantot pieejas, kas ir efektīvākas par jau pašvaldībā ierastajām. Projekta ietvaros tika nodrošināti arī šādi atbalsta elementi:

— EPS ieviešanas vadlīnijas, kurās sniegta, detalizēta informācija par to, kā ieviest un uzturēt EPS sistēmu saskaņā ar *ISO 50001* standartu;
— pašvaldību energopārvaldniekiem un darba grupām tika sniegts atbalsts enerģētikas politikas un plānu izstrādē, kas ietvēra nozīmīgāko enerģijas patērētāju (piemēram ēkas, ielu apgaismojuma posmi, kuri patērē visvairāk enerģijas) noteikšanu, mērķu noteikšanu un energoefektivitātes uzlabošanas pasākumu noteikšanu. Ielu apgaismojums ir sektors, kur energoefektivitātes pasākumus ir salīdzinoši viegli

veikt [42], savukārt energoefektivitātes celšanai pašvaldību ēkās viens no priekšnoteikumiem ir informētība un izpratne, taču ne vienmēr ar to pietiek [115];
- atbalsts EPS rokasgrāmatas izstrādē – EPS rokasgrāmata ietver detalizētu procedūru aprakstu par sistēmu un sistēmas uzturēšanu;
- ar speciālistu atbalstu tika veikts iekšējais audits saskaņā ar projekta ietvaros izstrādātu veidni, lai noteiktu vai pašvaldība ir veikusi visus nepieciešamos priekšdarbus sertifikācijas procesa uzsākšanai;
- projekta ietvaros tika pielāgota un pašvaldībām nodrošināta tiešsaistes datu analīzes platforma, kurā tika vadīti ikmēneša patēriņa dati un veikta datu analīze, šādi būtiski samazinot laika un resursu patēriņu datu vākšanai un apstrādei. Literatūrā identificēts, ka šādu rīku pieejamība būtiski atvieglo sistēmas uzturēšanu [116];
- pēc nepieciešamības palīdzība tika nodrošināta arī sertifikācijas auditora iepirkuma procedūras laikā, kā arī sertifikācijas procesa laikā.

Laikposmā no 2020. gada maija līdz oktobrim tika veiktas tiešsaistes intervijas ar energopārvaldniekiem, kas atbildīgi par EPS viņu pašvaldībās. Lai veicinātu godīgu atbilžu sniegšanu, intervijas tika veiktas anonīmi, nenorādot, kura pašvaldība tiek pārstāvēta.

Intervijas mērķis bija noskaidrot:
- kas motivēja pašvaldības ieviest energopārvaldības sistēmas. Respondentiem vispirms tika lūgts pašiem nosaukt galvenos motivējošos faktorus. Pēc tam tika doti piemēri un lūgts novērtēt to nozīmi piecu punktu skalā no “nav svarīgi” līdz “ļoti svarīgi”. Piemēri tika formulēti, pamatojoties uz *Marimon* un *Casadesús* pētījuma rezultātiem [117];
- kādi bija būtiskākie izaicinājumi, ieviešot EPS. Pēc līdzīga principa kā pirmais jautājums, arī šeit tika sākotnēji uzdots atvērts jautājums, un pēc tam doti izaicinājumu piemēri, kurus respondenti novērtēja skalā no 1 līdz 5, kur 1 “nesagādāja grūtības”, un 5 “ļoti izaicinoši”. Piemēri tika balstīti uz literatūrā identificētajiem [117]–[119];
- kādi bija, galvenie ieguvumi no EPS ieviešanas. Jautājumi, kuru mērķis bija novērtēt EPS ieguvumus, ietvēra enerģijas datu monitoringu, motivāciju noteikt ambiciozākus enerģētikas mērķus un energoefektivitātes iekļaušanu iepirkumu procedūrās. Dotos apgalvojumus respondenti novērtēja 5 punktu skalā. Intervijā minētie ieguvumi atspoguļoja vajadzību pēc administratīvas un ar personālu saistītas prakses ieviešanu, piemēram, regulāras apmācības par enerģijas taupīšanu. Tika ietverti arī jautājumi par prioritāšu noteikšanu investīcijām energoefektivitātes jomā un lielāku energoefektivitātes budžetu. Adekvātu investīciju nepieciešamība ēku atjaunošanas sektorā ir jau tikusi uzsvērta zinātniskajā literatūrā [115];
- Papildus tika uzdoti jautājumi, par cilvēku skaitu, kuri norīkoti darbam ar EPS, sertifikācijas statusu un energoefektivitātes uzlabošanas pirmo periodu;

Respondentu vērtējumi tika kvantificēti atbilstoši 2.2. tabulā dotajām vērtībām. Kvantificētajiem rezultātiem tika aprēķināts aritmētiskais vidējais $\bar{x}$ un standartnovirze s, katram jautājumam. Secinājumi doti rezultātu sadaļā. Ņemot vērā mazo datu kopu, padziļināta statistiskā faktoru analīze līdzīgi kā to darīja *Marimon* un *Casadesús* [117] netika veikta.

2.2. tabula

Rezultātu aprēķina metodika

Kvantitatīvās vērtības	Motivācija	Izaicinājumi	Apgalvojumi	Izmaiņas
1	Nav svarīgi	Nesagādāja grūtības	Pilnībā nepiekrītu	Ļoti zemas
2	Nedaudz svarīgi	Nedaudz apgrūtināja	Nepiekrītu	Zemas
3	Vidēji svarīgi	Vidējs apgrūtinājums	Nezinu	Aptuveni tāpat
4	Svarīgi	Izaicinājums	Piekrītu	Augstas
5	Ļoti svarīgi	Būtisks izaicinājums	Pilnībā piekrītu	Ļoti augstas

Speciālistu, kuri sniedza atbalstu pašvaldībām projekta *Compete4SECAP* ietvaros, aptaujas mērķis bija novērtēt pašvaldību EPS ieviešanu no iesaistīto speciālistu perspektīvas, ņemot vērā, ka viņi netika nodarbināti pašvaldībās, ļaujot domāt, ka viņu viedoklis varētu būt objektīvāks.

Speciālistiem tika lūgts sniegt viedokli par situāciju energopārvaldības jomā katrā pašvaldībās pirms un pēc EPS ieviešanas un sertificēšanas, šķēršļu pārvarēšanas grūtībām, pašvaldību ambīcijām enerģētikas jomā, kā arī pašvaldību interesi EPS uzturēt ilgtermiņā.

Visos jautājumos, kur tika izmantota 5 punktu skala, kvantitatīvās vērtības atbildēm tika piešķirtas saskaņā ar 2.2. tabulu.

2.4. Uzvedības maiņas pasākumu datu statistiskā analīze

Viens no veidiem, kā uzlabot ēku energoefektivitāti un ietaupīt enerģiju, ir veicināt ēkas lietotāju uzvedības maiņu saistībā ar enerģijas tērēšanas paradumiem. Lai gūtu priekšstatu par uzvedības maiņas pasākumu potenciālo ietekmi uz enerģijas patēriņu, *Compete4SECAP* projekta gaitā tika organizētas enerģijas taupīšanas sacensības astoņās Eiropas valstīs, iesaistot 30 dažādas pašvaldības un kopumā 91 publisko ēku. Dati, lai novērtētu enerģijas taupīšanas sacensību (turpmāk tekstā – sacensības) panākumus, galvenokārt iegūti no diviem avotiem. Sacensību laikā nepārtraukti tika apkopoti dati par enerģijas patēriņu visās sacensībās iesaistītajās publiskajās ēkās un veiktas eneregokomandu dalībnieku aptaujas pirms un pēc sacensību norises.

Enerģijas taupīšanas sacensību aktivitātes var sagrupēt trīs grupās:

1. Sagatavošanās: Iesaistīto ēku atlase, atsauces (bāzes) datu vākšana, energokomandas izveide ēkas līmenī, atbalsta materiālu izstrāde un energokomandu dalībnieku apmācība.

2. Īstenošanas posms: Ēkās tiek reizi mēnesī nolasīti enerģijas skaitītāji un energokomandas organizē aktivitātes, lai aktīvi iesaistītu savus kolēģus, kuri strādā konkrētajā ēkā. Energokomandām tiek nodrošināts nepārtraukts projekta partneru profesionāls atbalsts, nodrošinot dažādus materiālus, izglītojošu informāciju un organizējot motivācijas seminārus.

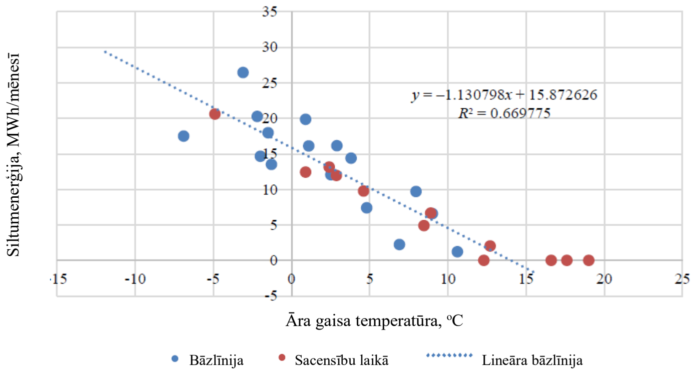
3. Izvērtēšana un apbalvošanas ceremonija. Visas energokomandas izveidoja gada rīcības plānu (sacensību periodam), iekļaujot plānotās aktivitātes, kā piemēram, nodrošināto atbalsta materiālu izmantošana, enerģijas patēriņa datu iesniegšana un informēšana par sacensību

rezultātiem. Projekta partneri organizēja arī dažādus izaicinājumus energokomandām un ēku darbiniekiem, kā arī motivācijas seminārus energokomandu dalībniekiem. Sacensību gaitā tika izmantoti instrumenti, kas klasificēti atbilstoši *Staddon et al.* [17] aktivitāšu veidiem un paredzēti vai nu energokomandu dalībniekiem, vai pārējiem ēku lietotājiem, vai abiem. Šie pasākumi iekļāva – enerģijas taupīšanas padomus, motivējošos seminārus, izaicinājumus energokomandām un ēku darbiniekiem, ikmēneša jaunumu lapas (ieskaitot informāciju par aktuālo enerģijas ietaupījumu), kontrolsarakstus enerģijas taupīšanas potenciāla identificēšanai, kā arī citus informatīvos materiālus (uzlīmes, plakāti u.tml.), tehniskos materiālus, piemēram, termometrus un gaisa kvalitātes mērītājus, elektroenerģijas skaitītājus u.tml.

Pēc viena gada ilgām enerģijas taupīšanas sacensībām tika apkopoti enerģijas galapatēriņa dati, un apbalvošanas ceremonijās valstu līmenī, tika apbalvotas labākās ēkas. Pasākumu laikā dalībnieki dalījās pieredzē, padomos un veiksmes stāstos ne tikai ar iesaistīto vietējo pašvaldību darbiniekiem, bet arī citiem interesentiem (citas pašvaldības, preses pārstāvji, NVO, ekspertu institūcijas u.c.).

Pirms sacensību sākuma tika izstrādāta metodika, kā noteikt mēneša un gada enerģijas ietaupījumus publiskajās ēkās enerģijas taupīšanas sacensību laikā visās astoņās valstīs. Vēsturiskie enerģijas patēriņa dati no katras ēkas tika apkopoti, izmantojot pašvaldības iesniegtās mēneša veidnes par pēdējiem trim gadiem. Ja bija datu iztrūkums, tika izmantots iepriekšējā gada vai divu gadu periods. Ēkas ar mazāk nekā 12 mēnešu datiem no sacensībām tika izslēgtas. Sacensībās varēja piedalīties arī tādas ēkas, kurās bija pieejami dati tikai par elektroenerģijas vai siltuma patēriņu, bet ietaupījums tika aprēķināts tikai par pieejamajiem datiem. Sākotnējais (bāzes) enerģijas patēriņš katrai ēkai tika iegūts, pamatojoties uz elektroenerģijas patēriņu un siltuma patēriņu attiecībā pret āra gaisa temperatūru. Kopējais enerģijas patēriņš ir elektroenerģijas un siltuma bāzes līniju summa.

Sacensību periodā (2019. gada janvāris–decembris) pašvaldību pārstāvji siltuma un elektroenerģijas patēriņu ($Q_{sacensību}$) un āra gaisa temperatūras datus reģistrēja atsevišķi par katru mēnesi un ievadīja tos enerģijas monitoringa sistēmā. Pēc mēneša datu ievietošanas, bāzes līnijas patēriņu ($Q_{bāzlīnija}$) aprēķināja, izmantojot aprēķinu metodiku, kas izveidotas vēsturisko (atsauces) datu analīzes laikā.



2.5. att. Piemērs siltumenerģijas bāzlīnijas vērtības noteikšanai

$Q_{\text{bāzlīnija}}$ aprēķināja saskaņā ar 2.5. attēlā redzamo vienādojumu, kur x ir āra gaisa temperatūra. Nosakot $Q_{\text{sacensību}}$ sacensību laikā, absolūtos mēneša un gada enerģijas ietaupījumus ($Q_{\text{ietaupījums}}$) aprēķināja, izmantojot formulu (1):

$$Q_{\text{ietaupījums}} = Q_{\text{bāzlīnija}} - Q_{\text{sacensību}}, \text{ MWh/mēnesī} \qquad (1)$$

Uzkrāto enerģijas ietaupījumu aprēķināja, lai aplēstu kopējo enerģijas ietaupījumu attiecīgajā sacensību periodā. Tas ļāva arī sacensību dalībniekiem sekot enerģijas taupīšanas rezultātiem un pielāgot tālākās darbības. $Q_{\text{ietaupījums}}$ aprēķins tika atkārtots katru mēnesi. Lai aprēķinātu kumulatīvo vai kopējo ietaupījumu ($Q_{\text{kopējais ietaupījums}}$) sacensību periodā, tika apkopoti visi atsevišķie mēneša enerģijas ietaupījuma rezultāti.

Lai noteiktu enerģijas taupīšanas sacensību uzvarētāju, $Q_{\text{ietaupījums}}$ tika izteikts procentos ($q_{\text{ietaupījums}}$), izmantojot formulu (2):

$$q_{\text{ietaupījums}} = \frac{Q_{\text{ietaupījums}}}{Q_{\text{bāzlīniju}}} \cdot 100, \% \qquad (2)$$

Enerģijas ietaupījumus, kas izteikti procentos, izmantoja, lai salīdzinātu ēkas neatkarīgi no to lieluma un veida. Tas ļāva noteikt enerģijas taupīšanas sacensību uzvarētāju.

Katras ēkas komandu pārstāvji tika aicināti piedalīties divās aptaujās: vienā pirms sacensību norises un otrā pēc sacensībām. Viens no aptaujas mērķiem bija novērtēt, cik lielā mērā kvalitatīvo mainīgo lielumu atšķirības var izskaidrot panākumu atšķirības enerģijas taupīšanas sacensību laikā. Lai to izdarītu, tika izmantoti šādi aptaujas elementi:

- augstākā līmeņa atbalsts – rādītājs balstīts uz 3 jautājumiem, par vadības interesi, motivāciju un resursu nodrošinājumu. Atbildēm kvantitatīva vērtība tika piešķirta, balstoties uz 2.3. tabulā dotajām vērtībām. Lai aprēķinātu atsevišķu rādītāju, katram respondentam (1–5 diapazons), tika aprēķinātas vidējās vērtības. Ēkas punktu skaits ir vidējais no visiem energokomandas dalībnieku punktiem, kuri atbildēja;
- interese – rādītājs aprēķināts, balstoties uz respondentu doto vērtējumu (saskaņā ar 2.3. tabulā doto) un proporciju (piemēram, 100% kolēģu ir ļoti ieinteresēti). Ēkas punktu skaits ir vidējais no visiem energokomandas dalībnieku punktiem, kuri atbildēja;
- motivācija – aprēķināts pēc tāda paša principa kā intereses rādītājs;
- uzvedības maiņa – aprēķināts pēc tāda paša principa kā intereses rādītājs;
- palīgmateriāli – šis rādītājs raksturo energokomandu vērtējumu par *Compete4SECAP* izstrādāto materiālu noderīgumu;

Kopumā aptaujā bija iekļauti 8 dažādi materiāli, un rezultātu apkopojumā tika iekļautas tās respondentu atbildes, kur tika sniegts vērtējums par vismaz 5 materiāliem. Ēkas punktu skaits ir vidējais no visiem energokomandas dalībnieku punktiem, kuri atbildēja.

2.3.tabula

Rezultātu aprēķina metodika

Kvantitatīvā vērtība	Augstākā līmeņa atbalsts	Interese	Motivācija	Uzvedības maiņa	Palīgmateriāli
5	Pilnībā piekrīt	Ļoti ieinteresēti	Ļoti motivēti	Būtiski mainīja uzvedību	Ļoti noderīgi
4	Piekrīt	Ieinteresēti	Motivēti	Mainīja uzvedību	Noderīgi
3	Nezina	Diezgan ieinteresēti	Diezgan motivēti	Nedaudz mainīja	Diezgan noderīgi
2	Nepiekrīt	Nedaudz ieinteresēti	Nedaudz motivēti	Ļoti nedaudz mainīja	Noderēja maz
1	Pilnībā nepiekrīt	Nav interese	Nav motivēti	Nemainīja	Nebija noderīgi

Pamatojoties uz secinājumiem literatūrā, tika sagaidīta:

- pozitīva korelācija starp vadības atbalstu un enerģijas ietaupījumu. Vadība, kas publiski atbalsta enerģijas taupīšanas sacensības, palīdz atrast laika un cilvēkresursus visu konkurējošo pašvaldības prioritāšu vidū [5];
- pozitīva korelācija starp kolēģu interesi un enerģijas ietaupījumu. Interesi par enerģijas taupīšanas sacensībām var uzskatīt par apliecinājumu vēlmei mainīt enerģijas lietošanas paradumus;
- pozitīva korelācija starp kolēģu motivāciju un enerģijas ietaupījumu. Motivācija liecina par vēlmi mainīt enerģijas lietošanas paradumus;
- pozitīva korelācija starp novērotajām uzvedības izmaiņām un enerģijas ietaupījumiem. Tomēr jāatzīmē, ka šajā gadījumā korelācija būs pozitīva tikai tad, ja a) darbinieki mainīs savus enerģijas patēriņa paradumus un b) energokomandu dalībnieki spēs to pareizi novērot un novērtēt;
- pozitīva korelācija starp to, kā respondenti novērtē *Compete4SECAP* projekta nodrošinātos palīgmateriālus un enerģijas ietaupījumu. To var interpretēt kā rādītāju *Compete4SECAP* partneru izplatīto materiālu sekmīgai darbībai enerģijas taupīšanas sacensību laikā.

Korelācijas novērtēšanai izmantots Spīrmana ranga korelācijas koeficients ρs, t.i., Pīrsona korelācijas koeficients ranga vērtībām. Tika izmantota programmas "R" [120] iebūvētā funkcija, lai aprēķinātu ρs un testētu, vai korelācija būtiski atšķiras no nulles.

2.5. Kvantitatīvā datu analīze un klimata korekcija

Lai analizētu *COVID-19* pandēmijas ietekmi uz pašvaldību publisko ēku enerģija patēriņu, tika analizēta ikmēneša siltumenerģija un elektroenerģijas patēriņa dati 4 Latvijas pašvaldībās (skatīt 2.4. tabulu). Visas šīs 4 pašvaldības ir veiksmīgi ieviesušas energopārvaldības sistēmu saskaņā ar *ISO 50001:2018*, kuras ietvaros tiek sistemātiski vākti un apkopoti enerģijas patēriņa dati ēkās, nodrošinot šādu datu pieejamību. Enerģijas patēriņa datus enerģijas monitoringa platformā ievada pašvaldības darbinieki, tāpēc cilvēcisko kļūdu dēļ atsevišķas ēkas netika iekļautas datu kopā, kurai tika veikta analīze (netika iekļautas ēkas, kurām bija datu iztrūkumi, vai nereālistiskas datu vērtības). Pēc datu kvalitātes pārbaudes datu kopā tika iekļauti 262 ēku siltumenerģijas patēriņa dati un 240 ēku elektroenerģijas dati (skatīt 2.5. tabulu).

2.4. tabula

Pašvaldību raksturlielumi

	Ēku skaits	**Ēku skaits, kas iekļautas izpētes datu kopā siltumenerģijas analīzei (elektroenerģijas datu analīzei)**	**Kopējā apkurinātā platība, m2**	**ISO 50001**
Pašvaldība Nr. 1	62	60 (60)	92276	Sertificēts
Pašvaldība Nr. 2	128	95 (73)	262095	Sertificēts
Pašvaldība Nr. 3	28	27 (27)	20308	Ieviests, nav sertificēts
Pašvaldība Nr. 4	92	79 (80)	134885	Sertificēts
Kopā	311	262 (240)	509564	

2.5. tabula

Datu kopas kopsavilkums

Ēku grupas	**Ēku skaits siltumenerģijas datu analīzei**	**Ēku skaits elektroenerģijas datu analīzei**
Skolas un izglītības iestādes	46	45
Pirmsskolas izglītības iestādes	53	49
Administrācijas un biroju ēkas	47	46
Kultūras nami un citas kultūras iestādes	25	26
Kopā	262	240

Lai salīdzinātu siltumenerģijas patēriņa datus, nepieciešams veikt klimata korekciju, normalizējot datus pret standarta apkures sezonu (skatīt 3. un 4. formulu klimata korekcijas aprēķinam, izmantojot apkures grādu dienu rādītāju). Elektroenerģijas patēriņš netiek normalizēts, pieņemot, ka elektroenerģijas patēriņš nav atkarīgs no āra gaisa temperatūras. Kopumā tika analizēti 4 gadu dati: 2018. un 2019. gada dati tika izmantoti par bāzes vērtību (gadi, kuros patēriņu *COVID – 19* pandēmija neietekmēja) un 2020.–2021. gada dati.

$$K = \frac{L_{\mathrm{st}} \cdot (t_{\mathrm{ind}} \cdot t_{\mathrm{out.reg}})}{L_{\mathrm{act}} \cdot (t_{\mathrm{ind}} \cdot t_{\mathrm{out.act}})} \qquad (3)$$

kur

K – klimata korekcijas koeficients;

L_{st} – standarta ikmēneša apkures dienu skaits, dienas;

L_{act} – reālais ikmēneša apkures dienu skaits, dienas;

t_{ind} – vidējā iekštelpu gaisa temperatūra apkures sezonā, °C;

$t_{out.\,reg}$ – standarta ikmēneša vidējā āra gaisa temperatūra, °C;

$t_{out.act}$ – reālā ikmēneša vidējā āra gaisa temperatūra, °C.

$$H_K = K \cdot H_a, \quad (4)$$

kur

H_k – ikmēneša siltumenerģijas patēriņš ar klimata korekciju, MWh;

K – klimata korekcijas koeficients;

H_a – reālais ikmēneša siltumenerģijas patēriņš, MWh;

Enerģijas patēriņa novirzes *COVID-19* pandēmijas laikā tika analizētas, salīdzinot bāzes vērtību ar 2020. un 2021. gada vērtībām, kuru laikā tika ieviesti dažādi ierobežojumi *COVID-19* pandēmijas rezultātā. Bāzes vērtība tika aprēķināta kā 2018. un 2019. gadu patēriņa vidējā vērtība. Novirzes no bāzes patēriņa tika aprēķinātas saskaņā ar 5. formulu, kur starpība starp analizēto gadu un bāzes vērtību tiek dalīta ar bāzes vērtību [121]. Novirze parāda vai enerģijas patēriņš *COVID-19* pandēmijas laikā bija zemāks (negatīva vērtība) vai augstāks (pozitīva vērtība) kā vidējais enerģijas patēriņš 2018. un 2019. gadā.

$$D = \sum_{i=1}^{n} \left(\frac{\left[E_y - \left(\frac{E_{2018} + E_{2019}}{2} \right) \right]}{\frac{E_{2018} + E_{2019}}{2}} \right), \quad (5)$$

kur

D – enerģijas patēriņa novirze 2020. un 2021. gadā, %;

E_y – enerģijas patēriņš 2020. vai 2021. gadā, MWh;

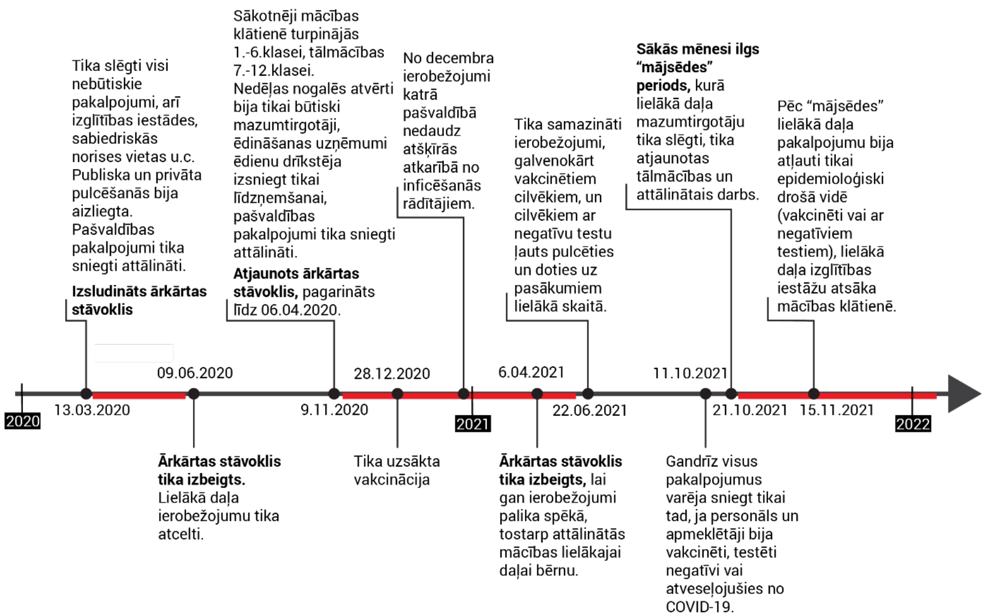
E_{2019} – enerģijas patēriņš 2019. gadā, MWh;

E_{2018} – enerģijas patēriņš 2018. gadā, MWh;

n – ēku skaits.

COVID-19 pandēmijas laikā 2020. un 2021. gadā dažādu ēku lietošana un noslogojums būtiski mainījās ieviesto ierobežojumu rezultātā. No 2020. gada 13. marta līdz 9. jūnijam visas skolas, izglītības iestādes, un kultūras pasākumu ēkas tika slēgtas, lai novērstu jebkādu iedzīvotāju pulcēšanos [122]. Tikmēr 2020. gada vasarā lielākā daļa ierobežojumu tika atcelti, ņemot vērā saslimšanas izplatība būtiski kritās (skatīt 2.6. attēlu). Otrais pandēmijas vilnis sākās 2020. gada rudenī, un no 9. novembra lielākā daļa ierobežojumu tika atjaunoti [123]. Piemēram, rudens brīvlaiks skolēniem tika pagarināts, un attālinātās mācības tika atsāktas skolēniem no 7. – 12. klasei (atsevišķās skolās arī jaunākām klasēm). Lielākā daļa ar kultūras pasākumiem saistītās ēkas bija slēgtas. Plaša vīrusa testēšana tika ieviesta skolās un darba vietās, lai samazinātu ierobežojumus personām ar negatīvu *COVID-19* testu. No 2020. gada decembra, ierobežojumu dažādās pašvaldībās varēja būt atšķirīgi, atkarībā no infekcijas izplatības rādītājiem pašvaldībā. Tomēr lielākā daļa skolu, biroju un kultūras iestāžu turpināja darbu attālināti, vai ar būtiski samazinātu cilvēku plūsmu. Ierobežojumi saglabājās spēkā līdz pat 2021. gada pavasara semestra beigām. Līdz ar vakcinācijas sākšanos 2020. gada pašās beigās [124], no 2021. gada vasaras vakcinētajām personām ierobežojumi tika būtiski samazināti [125], [126], tomēr arī 2021. gada rudenī kad sākās trešais *COVID-19* vilnis, vienu mēnesi no

21. oktobra līdz 15. novembrim, tika ieviesta mājsēde, būtiski ierobežojot jebkādu iedzīvotāju pulcēšanos un pārvietošanos [127]. Pēc tam ierobežojumi tika atviegloti vakcinētām un testētām personām, ļaujot atsākt darbu skolām, birojiem, kā arī atsākt organizēt kultūras pasākumus [128]. Bērnudārzi un pirmsskolas izglītības iestādes darbojās gan 2020. gan 2021. gadā, taču vecākiem tika rekomendēts bērnus turēt mājās, ja iespējams.



2.6. att. Būtiskāko *COVID-19* ierobežojumu kopsavilkums laika periodam no 2020. līdz 2021. gadam Latvijā [122]–[128].

3. REZULTĀTI

3.1. Ilgtspējīgas enerģētikas rīcības plāni pašvaldībās

Kopumā 2019. gadā Latvijā bija 119 pašvaldības, no kurām 40 bija izstrādājušas Ilgtspējīgas enerģētikas rīcības plānus. Jāatzīmē, ka lielākā daļa šo plānu tika izstrādāti ar nozīmīgu ārējo speciālistu atbalstu galvenokārt ES finansētajos projektos (piemēram, *Conurbant*, *SEAP+*, *Meshartility*, *50000&1 SEAP* u. c.). Šī pētījuma gaitā tika veikta padziļināta to pašvaldību aptauja, kurām bija izstrādāti IERP. Aptaujai piekrita 11 pašvaldību energopārvaldnieki vai atbildīgie speciālisti (šo pašvaldību raksturojums iekļauts 2. nodaļas 2.1. tabulā).

Pašvaldību izvirzītie mērķi

Kā redzams 3.1. tabulā, visas pašvaldības ir izvirzījušas CO_2 mērķi, un lielākā daļa ir izvirzījušas mērķus atsevišķiem sektoriem. Redzams, ka pašvaldības izmērs neietekmē to, cik ambiciozi mērķi tiek izvirzīti. Lielākais CO_2 mērķis ir izvirzīts mazajā pašvaldībā, bet tajā pašā laikā arī mazāko mērķi ir izvirzījusi maza pašvaldība. Vidēja izmēra pašvaldībās neviena no tām nav izvirzījusi papildus mērķus.

Visas pašvaldības, kas ir izvirzījušas papildu mērķus, lielākoties plāno samazināt enerģijas patēriņu nozarēs, kuras tiešā veidā pārvalda pašvaldības iestādes; citām nozarēm tiek plānotas informatīvas aktivitātes, lai motivētu samazināt enerģijas patēriņu, neuzņemoties atbildību par kvantitatīvu mērķu sasniegšanu. No tām pašvaldībām, kas izvirzījušas specifiskus mērķus konkrētiem sektoriem, visas ir apņēmušās samazināt energopatēriņu pašvaldībai piederošajās ēkās, piecas apņēmušās samazināt enerģijas patēriņu enerģijas ražošanas sektorā, bet tikai viena apņēmusies samazināt enerģijas patēriņu transportā un sabiedriskā apgaismojuma sektoros.

Visās, izņemot vienu pašvaldību, mērķi ir noteikti līdz 2020. gadam un kā bāzes gadi ir noteikti dažādi gadi, sākot ar 2000. līdz 2006. gadam. Tas galvenokārt ir saistīts ar to, ka pēc vairākām teritoriālajām reformām vēsturisko datu apkopošana praktiski nav iespējama, jo liela daļa datu nav saglabājusies.

3.1. tabula

Ilgtspējīgas enerģijas rīcības plānos noteiktie mērķi pašvaldībās

Pašvaldība		CO_2 ietaupījums, %	Mērķa gads	Bāzes gads	Citi mērķi
Liela	A	35	2020	2006	1. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 10 % 2. Veicināt enerģijas patēriņa samazināšanu dzīvojamo māju sektorā par 5 % 3. Samazināt enerģijas patēriņu enerģijas ražošanas sektorā par 5 % (bāzes gads 2012)
Liela	B	10	2020	2010	1. Līdz 2030. gadam samazināt CO_2 emisijas par 40 %; 2. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 10 % (bāzes gads 2014) 3. Veicināt enerģijas patēriņa samazināšanu dzīvojamo māju sektorā par 5% 4. Samazināt elektroenerģijas patēriņu par 5 % publiskajam apgaismojumam (bāzes gads 2015) 5. Samazināt elektroenerģijas patēriņu sabiedriskajā transportā par 5% (bāzes gads 2015)
Vidēja	C	20	2020	2008	–
Vidēja	D	20	2020	2000	–
Maza	E	40	2020	2010	1. Samaziniet CO_2 emisijas par 45% līdz 2030. gadam 2. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 10% 3. Veicināt enerģijas patēriņa samazināšanu dzīvojamo māju sektorā par 5% 4. Samazināt enerģijas patēriņu enerģijas ražošanas sektorā (bāzes gads 2014)
Maza	F	10	2020	2012	1. Samazināt CO_2 emisijas par 30% līdz 2030. gadam 2. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 10% 3. Veicināt enerģijas patēriņa samazināšanu dzīvojamo māju sektorā par 5% 4. Samazināt enerģijas patēriņu enerģijas ražošanas sektorā par 5% (bāzes gads 2015)
Maza	G	20	2020	2010	1. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 5% (bāzes gads 2014) 2. Veicināt enerģijas patēriņa samazināšanu dzīvojamo māju sektorā par 5% 3. Samazināt enerģijas patēriņu enerģijas ražošanas sektorā par 5 % (bāzes gads 2012)
Maza	H	40	2020	2008	1. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 20% 2. Veicināt enerģijas patēriņa samazināšanu dzīvojamajā sektorā par 10% (bāzes gads 2014.g.)
Maza	J	20	2020	2010	–
Maza	K	20	2025	2016	1. Samazināt enerģijas patēriņu pašvaldībai piederošajās ēkās par 10% (bāzes gads 2016.) 2. Veicināt enerģijas patēriņa samazināšanu dzīvojamo māju sektorā par 5% 3. Samazināt enerģijas patēriņu enerģijas ražošanas sektorā par 5% (bāzes gads 2016)
Ļoti maza	L	20	2020	2007	–

Datu pieejamība pašvaldībās

Intervijās tika iekļauti jautājumi par datu pieejamību CO_2 uzskaites veikšanai, enerģijas patēriņa datu analīzei un enerģijas izmaksu analīzei. Sešas (2 lielās, 4 mazās) pašvaldības no 11 ir veikušas CO_2 vai SEG emisiju novērtējumu savai pašvaldībai, un 5 pašvaldības norādīja, ka šo novērtējumu atjauno regulāri. Aptaujātie arī tika aicināti novērtēt (subjektīvi – 1 ļoti svarīgi, 3 – vidēji, 5 – nav svarīgi) cik svarīgs ir CO_2 vai SEG emisiju novērtējums IERP pasākumu izstrādei un ieviešanai. Atbildes ievērojami atšķīrās, tikai divas pašvaldības novērtēja CO_2 vai SEG novērtējumu kā ļoti svarīgu, lielākā daļa to novērtēja kā vidēji svarīgu. Pašvaldības kuras nav veikušas enerģijas patēriņa un emisiju novērtējumu šo aspektu novērtēja no 1–3 (1 ļoti svarīgi, 3 – vidēji, 5 – nav svarīgi), bet pašvaldības, kuras ir veikušas CO_2 novērtējumu, novērtēja gan ar zemāko, gan augstāko novērtējumu.

Lai saprastu enerģijas patēriņa datu pieejamību, pašvaldībām tika lūgts norādīt, kādus datus tās apkopo un cik bieži. Vairākās pašvaldībās datu pieejamība var tikt uzskatīta par izaicinājumu, ņemot vērā, ka 2 pašvaldības (vidēja un ļoti maza) datus par enerģijas patēriņiem ēkās regulāri neapkopo, četras pašvaldības apkopo datus par katru pašvaldības ēku atsevišķi, trīs pašvaldībās ir pieejami tikai kopīgi dati par vairākām ēkām, bet divās pašvaldībās ir ēkas, kurām tiek apkopoti dati individuāli un daļa ēku, kurām pieejami kopīgi dati. Puse no aptaujātajām pašvaldībām apkopo informāciju gan par enerģijas patēriņu, gan enerģijas izmaksām, tikmēr otra puse tikai par enerģijas patēriņu ēkās. Četrās pašvaldībās enerģijas patēriņa dati ēkās tiek iegūti, manuāli nolasot skaitītāju rādītājus, četrās pašvaldībās ir uzstādīti viedie skaitītāji, kas nodrošina datus elektroniski, viena pašvaldība norādīja citu datu ieguves veidu. Visas aptaujātās pašvaldības, izņemot vienu, apkopo ikmēneša datus, kamēr viena pašvaldība apkopo datus reizi gadā.

Jautājot par to, kādi ir galvenie izaicinājumi saistībā ar enerģijas patēriņa datu apkopošanu, galvenokārt atbildes saistījās ar cilvēkfaktora kļūdām un procedūru trūkumu. Piemēram, ka dati tiek nolasīti vai iesniegti kļūdaini, skaitītāju nolasīšana netiek veikta konkrētā datumā, vai par to aizmirst, vai nav izstrādāta procedūra par atbildību pārņemšanu, darbinieku slimības gadījumos u.tml.

IERP ieviešana

Lai novērtētu, ko pašvaldības ir gatavas apņemties, lai IERP tiktu ieviesti un izvirzītie mērķi sasniegti, tika jautāts par ieplānotajiem cilvēkresursiem un finanšu resursiem IERP ieviešanai. Novērtējums apkopots 3.2. tabulā.

Visas pašvaldības, izņemot D pašvaldību, ir oficiāli iecēlušas atbildīgo departamentu vai personu par IERP ieviešanu, taču atbildīgā ieņemamā amata līmenis būtiski atšķiras katrā pašvaldībā. Kamēr lielākā daļa pašvaldību atbildību par IERP ieviešanu ir uzticējušas departamentam vai iestādei kopumā, vai tās vadītājam, divās pašvaldībās pašvaldības vadītājs ir norādīts kā atbildīgais, vienā energopārvaldnieks un vienā IERP darba grupa. Pašvaldībās, kur par plāna ieviešanu atbild pašvaldības vadītājs, iespējams, norāda uz atbildīgo trūkumu ikdienas rīcību veikšanai un plāna uzraudzībai.

No piecām pašvaldībām, kuras atbildēja par atbildīgo personu skaitu, kas nozīmētas IERP ieviešanai, viena pašvaldība (G) ir piešķīrusi pienākumus desmit personām, pārējās četrās (A; C; J; K) pašvaldībās ir norīkota viena persona, kā arī tiek izmantotas dažas ārējo speciālistu atbalstītas aktivitātes. Pašvaldības norādīja, ka ekspertu atbalsts izmantots IERP un energoauditu izstrādei, risinājumu meklēšanai ēku energoefektivitātes paaugstināšanai u.c.

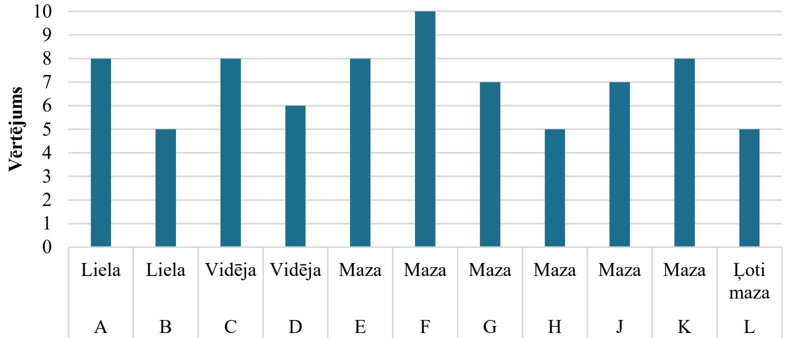
3.2. tabula

Atbildību sadale un finansējums IERP ieviešanai

Pašvaldība		Kura struktūrvienība vai iestāde ir atbildīga par IERP ieviešanu jūsu pašvaldībā?	Vai jūs, lūdzu, varētu novērtēt darbinieku skaitu, kas ir atbildīgi par IERP ieviešanu?	Vai jūs, lūdzu, varētu novērtēt to darbinieku darbaspēka izmaksu daļu, kuri ir atbildīgi par IERP ieviešanu, ko finansē no trešo personu līdzekļiem?	Kuru uzdevumu veikšanai galvenokārt ir iesaistīti ārējie speciālisti un pētniecības iestādes (ja vispār)?
A	Liela	Izpilddirektora vietnieks (īpašumu jomā)	1	0 %	Pārsvarā attīstības departaments strādā ar IERP jautājumiem. Dažu konkrētu uzdevumu veikšanai tiek nolīgti ārējie konsultanti, piemēram, universitāte.
B	Liela	Dome, attīstības departaments		0 %	Eksperti ir iesaistīti energoauditu veikšanā, energopārvaldības sistēmas sertifikācijā un plānošanas dokumentu izstrādē.
C	Vidēja	Infrastruktūras attīstības nodaļa	1	0 %	–
D	Vidēja				–
E	Maza	Energopārvaldnieks		–	–
F	Maza	Izpilddirektora vietnieks (par īpašumiem un vidi)		0 %	Valsts finanšu iestādes “Altum” konsultācijas par daudzdzīvokļu māju siltināšanas projektiem.
G	Maza	Izpilddirektors	10	1–10 %	
H	Maza	Saimnieciskās darbības departamenta tehnisko projektu vadītājs		11–25 %	Pašvaldība ir partneris projektā “Life Adaptate”, kura laikā plānota SECAP (ilgtspējīgas enerģētikas un klimata rīcības plāna) izstrāde.
J	Maza	Izpilddirektors	1	0 %	–
K	Maza	Attīstības plānošanas nodaļa	1	76–100 %	
L	Ļoti maza	IERP darba grupa		0 %	Ārējie konsultanti ir iesaistīti risinājumu meklēšanā pašvaldības ēku energoefektivitātes uzlabošanai, energoaudita veikšanai un sākotnējās situācijas izpētei.

No visām aptaujātajām pašvaldībām, tikai viena bija spējīga norādīt IERP ieviešanai paredzētā budžeta apjomu, citas sniedza tikai aptuvenu prognozi, kā arī, B pašvaldībā plānots, ka vismaz 67 % no visa IERP paredzētā budžeta paredzēts piesaistīt, kā ārējo finansējumu no ES fondiem, un tikai 9 % nodrošināt no pašvaldības līdzekļiem. Citas pašvaldības norādīja, ka ikgadējais pašvaldības budžets netiek veidots balstoties uz IERP plānu, bet kā daļa no pašvaldības attīstības plāna. Tā kā daļa aktivitāšu IERP un attīstības plānā pārklājas, tad no budžeta plānošanas skatupunkta, IERP ieviešana daļēji notiek bez mērķtiecīgas rīcības plāna ieviešanas virzienā. Kopumā visās pašvaldībās tiek plānots, ka būtiska daļa no nepieciešamā finansējuma lielāku energoefektivitātes projektu realizēšanai tiks piesaistīta kā ārējais finansējums.

Desmit no 11 pašvaldībām ir izveidojušas darba grupu veltītu IERP uzraudzībai un ieviešanai, tomēr darba grupas tikšanās biežums ir vērtējams kā zems. Divās pašvaldībās (B un G) darba grupa tiekas vienu reizi gadā, pašvaldībā H tikšanās tiek organizētas reizi ceturksnī. Citas pašvaldības norādīja, ka tikšanās nenotiek regulāri, bet tiek organizētas pēc nepieciešamības. Pašvaldība C nav izveidojusi IERP darba grupu, taču ir izveidotas divas citas darba grupas: viena, kas fokusējas uz energoefektivitātes pasākumu ieviešana daudzdzīvokļu ēkās, un otra, kas strādā klimata un enerģētikas jomā.



3.1. att. Pašvaldību vērtējums par politisko atbalstu pasākumu ieviešanai vides un enerģētikas jomās vērtējot no 1 (zems) līdz 10 (augsts).

Pašvaldībām tika lūgts novērtēt arī politiskā atbalsta līmeni skalā no 1 līdz 10. Kā redzams 3.1. attēlā, politiskais atbalsts pašvaldībās tiek vērtēts no 5 (viduvējs), līdz 10 (augsts). Šāds rezultāts varētu būt saistītas ar IERP īstenošanai piešķirto budžetu, taču ne tikai. Pašvaldība F norādīja, ka klimata un energoefektivitātes aktivitātes ir integrētas ikdienas darbībās un netiek izceltas vai analizētas atsevišķi, kas traucē izvērtēt, vai augsts politiskais atbalsts tiek pamatots ar atbilstošām praktiskām darbībām. Piemēram, pašvaldība B politisko atbalstu novērtēja ar 5, taču bija vienīgā, kas spēja sniegt informāciju par IERP aktivitātēm paredzēto budžetu. Šī pašvaldība arī norādīja, ka pašvaldībai vajadzētu novirzīt vairāk atbildīgo darbinieku energoparvaldības sistēmas ieviešanai, kā arī vairāk investēt risinājumos datu ieguvei, apkopošanai un analīzei, kā arī veltīt vairāk uzmanības izglītojošām kampaņām. Arī pašvaldība A norādīja, ka viens atbildīgais cilvēks nav pietiekošs resurss enerģētikas sektora pārvaldīšanai pašvaldībā. Pašvaldība G, H, J norādīja, ka investīciju apjoms, kas tiek ieguldīts enerģētikas sektorā, nav pietiekošs, kā arī pašvaldību iespējas aizņemties ilgtermiņā ir ierobežotas, kas apgrūtina pašvaldībām veikt lielākus investīciju projektus. Savukārt pašvaldības D un L norādīja uz komunikācijas problēmām starp dažādiem pašvaldības departamentiem un iestādēm, un izpratnes trūkumu pašvaldības darbinieku vidū par enerģētikas un klimata mērķiem.

3.3. tabula

Galvenās aktivitātes, kas iekļautas 11 pašvaldību IERP

Pašvaldība		**Pasākums A**	**Pasākums B**	**Pasākums C**
A	Liela	Izveidot datu tiešsaistes pārvaldības un uzraudzības sistēmu	Renovācijas projekti visām skolām. Dažās skolās tas ietver energoefektivitātes pasākumus – automātisko vadību vai radiatorus, jaunus ventilācijas risinājumus	Konkrētu ēku renovācijas projekti
B	Liela	Energoefektivitātes pasākumi ēkām, ko finansē ERAF	Tramvaju infrastruktūras modernizācija	Paplašināt publisko apgaismojumu un atjaunot esošo, ko finansē no pašvaldības budžeta
C	Vidēja	Paaugstināt sabiedrisko ēku energoefektivitāti	Būvēt katlumāju, kas darbināma ar šķeldu.	Energoefektivitātes pasākumi daudzdzīvokļu mājās. (SIA "Labs nams" izveidota procesa atbalstam)
D	Vidēja	Notiek pirmsskolas izglītības iestādes "Pasaciņa" renovācija, pabeigta "Pepija"	Transporta nozare – 2016. gadā nopirkti 2 elektromobiļi	Apkures un ūdensvada izbūve divām ielām, jaunu siltumvadu izbūve trīs jaunu ielu pieslēgšanai esošajam centralizētās siltumapgādes tīklam
E	Maza	–	–	–
F	Maza	Novadu energoefektivitātes projekts Jaunpils (kultūras mantojums) un kultūras centra energoefektivitātes projekts, ko finansē no trešo personu finansējuma	Energoefektīvu prasību izstrāde jaunu transportlīdzekļu iepirkumam	Pamatskolas energoefektivitātes projekts (projekts pabeigts 2017. gadā)
G	Maza	Ieviest energoefektivitātes līgumu principus (EPC), renovācijas projektiem		
H	Maza	Apkopot un analizēt enerģijas datus	Aizstāt esošo pašvaldības autoparku ar jauniem, energoefektīvākiem transportlīdzekļiem	Nomainiet ielu apgaismojumu pret efektīvāku
J	Maza	Pašvaldības ēku renovācija un siltināšana	Daļēji, nomainīt gaismekļus uz LED	2 elektromobiļu sagāde
K	Maza	Izstrādāts enerģētikas rīcības plāns 2018. –2025. gadam.	Izveidota energopārvaldības sistēmas darba grupa	
L	Ļoti maza	–	–	–

Galvenās aktivitātes, kas iekļautas pašvaldību IERP, ir galvenokārt pašvaldības ēku atjaunošanas projekti un publiskā apgaismojumā modernizēšana, kas norāda, ka pašvaldības pamatā fokusējas uz pašvaldības infrastruktūru, pār kuru tām ir tieša kontrole. Vairākas pašvaldības (A, H, K) arī norāda, ka tikai sāk vākt datus un analizēt tos, lai spētu pieņemt kvalitatīvākus lēmumus nākotnē. Savukārt pašvaldības J, B, un D ir vienīgās, kas norāda, ka plāno veikt pasākumus transporta sektorā. Lai gan pašvaldības pārsvarā norāda pasākumus, kas saistīti ar pašvaldības infrastruktūru, tiek arī norādīts uz būtisku finanšu resursu trūkumu pašvaldībās. Papildus pašvaldība D identificēja risku – zemas kvalitātes energoauditi un zemas kvalitātes ēku siltināšanas projekti, kas noved pie zemākiem enerģijas un finanšu ietaupījumiem, kā sākotnēji iecerēts. Arī citi pētnieki jau ir identificējuši, ka zemas kvalitātes būvdarbi noved pie zemākas uzticības ēku atjaunošanas projektiem un energoefektivitātes pasākumiem kopumā [129].

Uzraudzība un energopārvaldības sistēma

Uzraudzība ir ļoti būtiska daļa no jebkura procesa. Tomēr divas pašvaldības C un L, atbildēja, ka neveic IERP pasākumu ieviešanas uzraudzību vai efektivitātes novērtējumu. Pašvaldības B, E, H, K un D tikai uzrauga IERP ieviešanu, bet gan ieviešanu, gan ieviešanas efektivitāti uzrauga pašvaldībās A, F, G un J.

No 11 pašvaldībām tikai 3 nav nekādas pieredzes saistībā ar energopārvaldības sistēmas principiem un ieviešanu. Gan lielās, gan mazās pašvaldības bija ar domes lēmumu apstiprinājušas plānu ieviest EPS un pieņēmušas darbā energopārvaldnieku, no kurām sešās pašvaldībās tika izstrādāta energopārvaldības rokasgrāmata un piecās (A, B, F, G, H) ir ieviesta energopārvaldības sistēma. A un B pašvaldībās EPS ieviešanu pieprasa normatīvo aktu prasības. Daļai pašvaldību 2019. gadā bija prasība ieviest energopārvaldības sistēmu, bez prasības sistēmu sertificēt, šīs prasības attiecās uz pašvaldībām ar iedzīvotāju skaitu virs 10000 un teritorijas attīstības indeksu virs 0,5. Pārējām pašvaldībām EPS ieviešana bija brīvprātīga.

Energopārvaldības sistēmas robežas, piecās pašvaldībās, kurās ir ieviests EPS, ir atšķirīgas, bet visas pašvaldības, kur ir EPS, ir organizējušas informatīvās kampaņas par energopārvaldības aktivitāšu ieviešanu un visas veic CO_2 emisiju monitoringu.

3.2. Klimata komponentes integrēšana pašvaldību enerģētikas plānos sešās pašvaldībās Eiropā

Sešās pašvaldībās tika izstrādāti Ilgtspējīgas enerģētikas un klimata rīcības plāni (IEKRP) un īstenotas demonstrējošas pielāgošanās aktivitātes ar mērķi demonstrēt pielāgošanās klimata pārmaiņām pasākumus un iespējas virzīties klimatnoturības virzienā. Demonstrācijas projekti ietvēra arī monitoringa veikšanu, taču, tā kā līdz šīs publikācijas brīdim visi mērījumi nebija pabeigti, pielāgošanās pasākumu rezultāti ir izskaidroti tikai indikatīvi.

Lai efektīvi strādātu ar IEKRP izstrādi, visas pašvaldības izveidoja IEKRP izstrādes darba grupu, kurā tika iekļauti pašvaldības darbinieki, kuru atbildības sfērā ietilpst kāda no plāna jomām. IEKRP paplašinātajā darba grupā tika iekļautas arī ieinteresētās puses no publiskā un privātā sektora, un visās pašvaldībās tika organizētas 2 – 3 ieinteresēto pušu sanāksmes, lai iesaistītu procesā ieinteresētās puses.

Kopumā IEKRP izstrādes gaitā 6 pašvaldībās tika iesaistītas 385 organizācijas un personas (Aguilas 61, Alfandega da Fe 44, Kartahena 69, Lorka 45, Mertola 70, Smiltene 96). Iesaistīto pušu sanāksmēs piedalījās pārstāvji no šādām sabiedrības grupām un organizācijām:

- uzņēmēju un nozaru asociācijas;
- organizācijas, kas iesaistītas seku mazināšanas un/vai pielāgošanās risinājumu izpētē un izstrādē;

- izglītības iestādes;
- finanšu un apdrošināšanas nozares;
- zemes īpašnieki un apsaimniekotāji;
- nevalstiskās organizācijas, kas iesaistītas vides un sociālo mērķu veicināšanā;
- institūcijas, kas sniedz tehnisko atbalstu gan valdībai, gan nozarei (piemēram, universitātes, pētniecības iestādes, ideju laboratorijas un konsultanti);
- atkritumu un ūdens apgādes uzņēmumi;
- civilā aizsardzība, policija, ugunsdzēsēji un citi dienesti;
- lauksaimniecības un mežsaimniecības nozares;
- veselības nozares pārstāvji;
- tūrisma nozares pārstāvji;
- iedzīvotāji.

Tā kā process tika organizēts 3 daļās, ne visos semināros piedalījās vienas un tās pašas personas, kas deva iespēju iesaistīt plašāku cilvēku loku, bet arī radīja izaicinājumu iesaistīt jaunpienācējus procesā, kas jau bija sācies. Tika novērots zināms klimata pārmaiņu noliegums, taču kopumā dalībnieku attieksme bija pozitīvāka, un tika atzīta ilgtspējīgas pielāgošanās nepieciešamība. Tā kā sanāksmēs piedalījās dažādas ieinteresētās puses, piemēram, sabiedriskās organizācijas, kas nav tieši saistītas ar pašvaldībām, nepieciešamība pēc pielāgošanās tika izcelta arī no viņu puses. Sanāksmju laikā dažas ieinteresētās personas arī sniedza prezentāciju par klimata pārmaiņu ietekmi viņu pārstāvētajās nozarēs. Piemēram, Latvijā akciju sabiedrības “Latvijas Valsts meži” pārstāvis iepazīstināja ar meža ugunsgrēku statistiku pēdējā desmitgadē, bet vietējās pašvaldības policijas pārstāvji – ar civilās aizsardzības principiem. Šī informācija sniedza pašvaldībai vērtīgu informāciju lēmumu pieņemšanai turpmākajā IEKRP procesā. Tādā veidā sabiedrībai tika parādīts, ka pašvaldība atzīst klimatu pārmaiņas par būtisku, kā arī šādas sanāksmes dod iespēju arī aktīviem iedzīvotājiem izteikt savas vajadzības un gaidas.

Katra pašvaldība IEKRP izstrādes procesā īstenoja arī demonstrācijas projektu, lai akcentētu pielāgošanās nepieciešamību un parādītu piemēru, kā to var darīt. Pašvaldības Spānijā vairāk adresēja karstuma un ūdens trūkuma ietekmi, veidojot noēnojumu, apzaļumojot jaunas teritorijas, veidojot dabīgu noēnojumu un atkārtoti izmantojot attīrītus notekūdeņus apūdeņošanā. Arī Portugāles pašvaldības adresēja karstuma risku, veidojot noēnojumu, kā arī ugunsgrēku risku, ierīkojot ūdens rezervuāru. Pašvaldība Latvijā veica ezera tīrīšanu, padziļināšanu un slūžu rekonstrukciju, lai mazinātu eitrofikāciju ezerā un plūdu risku pilsētas centrā.

Pašvaldībās veikto aptauju rezultāti par pilotprojektiem (Lorka 51, Águilas 62, Kartahena 29, Smiltene 36 respondenti) liecina, ka kopumā sešās pašvaldībās iedzīvotāji ir informēti par klimata pārmaiņu problēmām, vairāk nekā 80 % respondentu uzskata, ka klimata pārmaiņas ir nozīmīgs jautājums, un vairāk nekā 90 % aptaujāto uzskata, ka pašvaldībām būtu jāiesaistās klimata pārmaiņu mazināšanā.

Aptaujas rezultāti par katru izmēģinājuma projektu atšķiras. Smiltenes un Lorkas pašvaldībās lielākā daļa aptaujāto, ap 90 %, uzskata, ka projekts ir uzlabojis vietējo pilsētvidi, bet Aguilas – 65 % un Lorkā tikai 35 %. Apmēram 65 % Lorkā, 70 % Aguilas un 55 % Smiltenē domā, ka šīs darbības samazina vietējos klimata riskus, savukārt Kartahenā aptuveni 33 % domā, ka riski ir samazināti.

Daudzkritēriju analīzes pielietošana

Viens no procesā identificētajiem izaicinājumiem bija IEKRP izstrādes procesa organizācija pašvaldības iekšienē. Pašvaldībai bija nepieciešams savākt dažādus izejas datus un veikt klimata risku, un ievainojamību novērtējumu, taču šī aktivitāte gandrīz visās pašvaldībās prasīja vairāk laika kā plānots. Tā rezultātā projekta ietvaros tika nodrošināts plašākas atbalsts pašvaldībām, lai nodrošinātu plānu izstrādi. Kad pašvaldības strādā ar IEKRP izstrādi pirmo reizi, pieredzes un zināšanu trūkums ir būtiska barjera, tostarp mazinot personāla un vadības motivāciju pie plāna strādāt.

Galvenie klimata riski, kas ietekmē un apdraud novadu iedzīvotājus un attīstības potenciālu ir apkopoti 3.4. tabulā. Katras pašvaldības atlasītie riski ir saistīti ar pašvaldības ģeogrāfisko novietojumu, vietējo klimatu, kā arī sociālajiem, ekonomiskajiem un politiskajiem aspektiem.

3.4. tabula

Galvenie klimata riski, ietekmētie sektori un klimata ietekme 6 pašvaldībās

Pašvaldība	Galvenie klimata riski	Ietekmētie sektori	Gaidāmās ietekmes
Smiltene	Ekstrēms karstums Ekstrēmi nokrišņi Sausums	Ēkas Vide un bioloģiskā daudzveidība Enerģētika	Pieprasījums pēc ēku dzesēšanas vasarā. Energoapgādes tīklu un infrastruktūras bojājumi. Kaitēkļu līmeņa paaugstināšanās, kukaiņu invāzija, bioloģiskās daudzveidības samazināšanās, eitrofikācija.
Mertola	Ekstrēms karstums Sausums Mežu ugunsgrēki	Tūrisms Sabiedrības veselība Bioloģiskā daudzveidība	Negatīvā ietekme uz tūrismu, jo gaisa temperatūra kļūst nepanesami augsta. Meža ugunsgrēki palielina risku veselībai un palielina spiedienu uz civilās aizsardzības dienestiem.
Alfandega da Fe	Ekstrēms karstums Sausums Mežu ugunsgrēku risks	Tūrisms Sabiedrības veselība Bioloģiskā daudzveidība	Sagaidāmā sausuma indeksa pasliktināšanās apgabalos, kas ir pakļauti pārtuksnešošanai, noved pie bioloģiskās daudzveidības samazināšanās un ekosistēmu izmaiņām. Meža ugunsgrēku risks palielina risku veselībai. Temperatūras izmaiņas ietekmēs ziemas un vasaras tūrisma īpašības.
Kartahena	Ekstrēms karstums Sausums Vētras	Teritorijas plānošana Sabiedrības veselība Enerģētika	Slikta teritorijas izmantošanas plānošana veicina siltuma salas efektu. Ārkārtējais karstums negatīvi ietekmē ne tikai iedzīvotāju veselību, bet arī palielina pieprasījumu pēc dzesēšanas enerģijas.
Aguilas	Ekstrēms karstums Sausums Jūras līmeņa celšanās	Tūrisms Ūdensapgāde Enerģētika	Ilgi sausuma un karstuma viļņi izraisīs tīra ūdens trūkumu. Pieprasījums pēc enerģijas palielināsies, ņemot vērā nepieciešamību pēc lielākas dzesēšanas jaudas, un ārkārtējs karstums vasaras sezonā samazina tūrisma aktivitātes.
Lorka	Ekstrēms karstums Sausums Zemes nogruvumi	Ūdensapgāde Sabiedrības veselība Enerģētika	Ārkārtējais karstums un sausums veicina pārtuksnešošanos un bioloģiskās daudzveidības samazināšanos. Karstuma viļņi rada spiedienu uz veselības nozari un palielina pieprasījumu pēc dzesēšanas enerģijas.

Lai adresētu identificētos klimata riskus, IEKRP tika iekļauti pasākumu, lai pielāgotos klimata pārmaiņām. Iesaistīto pušu sanāksmju laikā tika identificēti daudz dažādi pasākumi un tika pielietota daudzkritēriju analīzes metode, lai izvēlētos lietderīgākos un reālistiskākos pasākumus. Spānijas un Portugāles pašvaldības izmantoja 9 kritērijus, kamēr pašvaldība no Latvijas izmantoja vienkāršotu 5 kritēriju analīzi, kuras ietvaros katrs pasākums tika vērtēts pēc tā – efektivitātes, steidzamības, sinerģijas, finansiāliem aspektiem, un leģitimitātes. Šie pieci kritēriji tika noformulēti pašvaldības darbiniekiem saprotamā formātā, liekot darba grupas dalībniekiem atbildēt uz šādiem jautājumiem par katru pasākumu:

- efektivitāte – Vai vides un sociālie ieguvumi atsvērs finanšu un vides zaudējumus;
- steidzamība – Cik steidzama ir pasākuma ieviešana? Steidzami pasākumi, ir tādi, kurus neieviešot jau tuvākajos gados ir paredzami vides un/vai finanšu zaudējumi;
- praktiskums (sinerģija) – vai pasākuma ieviešanu ir iespējams integrēt pašvaldības ikdienas darbā, esošajā budžetā un plānotajās aktivitātēs. Grūti integrējami pasākumi ir tādi, kuru ieviešana prasītu veikt izmaiņas esošajās pašvaldības struktūrās, piemēram, jaunas nodaļas vai jaunu amatu izveide u.c.;
- finansiālie aspekti – vai pasākuma ieviešana ir finansiāli ietilpīga, vai būtu nepieciešams meklēt papildu finansējumu;
- ilgtspēja (leģitimitāte) – vai pasākums ir ilgtspējīgs, un saskaņā ar novada vides, sociālo un attīstības politiku.

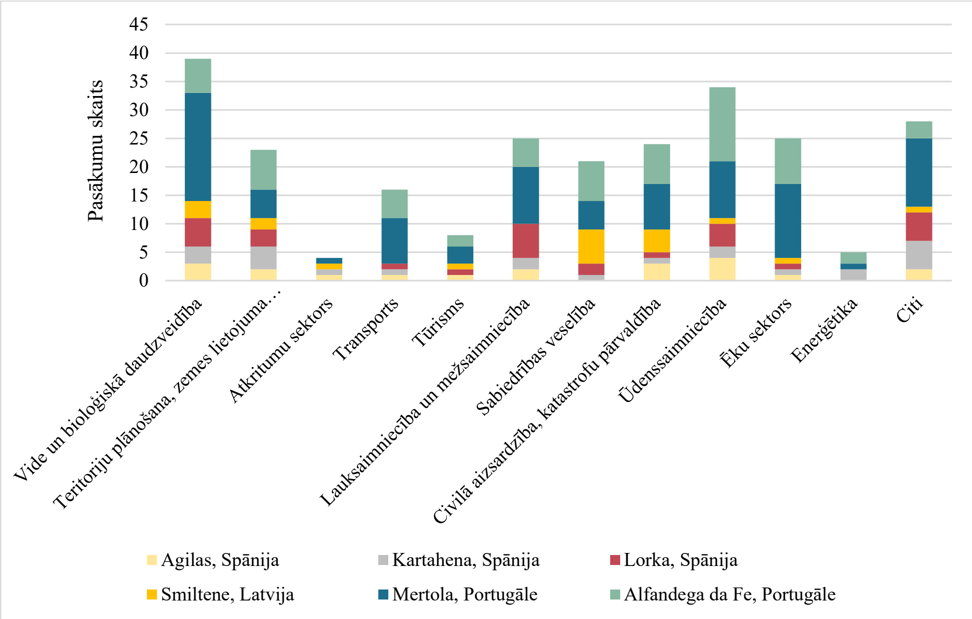
Smiltenes pašvaldības gadījumā tika izvēlēts kritērijiem atšķirīgus svarus nepiešķir, lai vienkāršotu metodes pielietošanu. Tomēr, izvērtēt faktoru nozīmīgumu un piešķirt atšķirīgu svaru katram kritērijam ir vēlams, lai iegūtu objektīvāku rezultātu. Tā pat ir rekomendējams daudzkritēriju analīzes anketu veidot pēc iespējas vienkārši aizpildāmu un lūgt aizpildīt dažādu pašvaldības institūciju pārstāvjiem, lai mazinātu viedokļu neobjektivitāti. Piemērs daudzkritēriju analīzes pielietošanai Smiltenes pašvaldībās dots 3.5. tabulā.

3.5. tabula

Piemērs daudzkritēriju analīzes pielietošanai Smiltenes pašvaldībā

	Pasākums	**Efektivitāte**	**Steidzamība**	**Sinerģija**	**Finansiālie aspekti**	**Ilgtspēja**	**Summa**
1.	Daudzdzīvokļu ēku iekšpagalmu sakārtošana, atbilstoši operatīvā transporta vajadzībām.	23	21	19	14	19	96
2.	Abula ezeru kaskādes aizaugšanas mazināšana.	23	19	18	12	19	91
3.	Nodrošināt, ka, izstrādājot pilsētu teritoriālos plānus tiek ņemti vērā klimatnoturīgas attīstības aspekti.	22	14	19	17	19	91
4.	Informatīvas kampaņas par ugunsdrošību, kūlas dedzināšanu u.c.	24	20	16	11	19	90
5.	Invazīvo augu sugu apkarošana (latvāņi).	22	19	16	13	19	89
6.	Sabiedrības izglītošana veselības jomā.	23	16	19	11	19	88
7.	Publisko peldvietu un to piekļuves sakārtošana.	22	18	19	10	19	88
8.	Attīstot vai reģenerējot urbānās teritorijas, paredzēt un īstenot zaļās infrastruktūras risinājumus, kas sekmē pielāgošanos klimata pārmaiņām.	22	14	18	14	19	87
9.	Identificēt jutīgākās valsts un pašvaldību ēkas, kam būtu nepieciešama pielāgošana klimata pārmaiņām un to saistītajiem riskiem.	22	16	18	12	19	87
10.	Meliorācijas būvju sakārtošana.	22	17	16	12	19	86
11.	Infrastruktūras, kas atrodas applūstošās teritorijās, identificēšana.	20	16	17	15	17	85
12.	Dažādu ar klimata parādībām saistītu risku apzināšana, informācijas uzkrāšana, kartēšana.	21	15	17	14	18	85
13.	Bezmaksas dzeramā ūdens pieejamības nodrošināšana sabiedriskās vietās, kur pulcējas daudz iedzīvotāju un tūristu.	19	16	17	14	18	84
14.	Vietējo uzņēmumu izglītošana par klimata riskiem un kā tiem pielāgoties.	21	15	18	13	17	84
15.	Noēnojuma uzlabošana Smiltenes pilsētā.	20	14	17	14	18	83
16.	Infrastruktūras uzlabošana pašvaldības mežu īpašumos (ceļu infrastruktūra, stigas, ugunsdzēsības dīķi u.t.t.).	21	16	16	11	17	81
17.	Kanalizācijas sistēmas uzlabošana.	19	15	17	13	16	80
18.	Apzināt lietus ūdens sistēmas vājās vietas.	19	12	17	18	14	80
19.	Veicināt valsts nozīmes kultūras pieminekļu un dabas pieminekļu pielāgošanu klimata pārmaiņu ietekmēm.	17	10	12	14	13	66
20.	Agrīnās brīdināšanas sistēmas izstrāde.	17	13	13	5	15	63

Rezultātā savos plānos Lorka iekļāva 29 pasākumus, Aguilas 20, Kartahena 23, Mertola 95, Alfandega da Fe 65 un Smiltene 20 pasākumus.



3.2. att. Pašvaldību IEKRP iekļauto pasākumu sadalījums pa jomām.

Kā redzams 3.2. attēlā, katras pašvaldības fokuss atšķiras. Lielākā daļa pasākumu ir mērķēti uz vides un bioloģiskās daudzveidības uzlabošanu, ūdensapgādi un ēku sektoru. Visas pašvaldības ir iekļāvušas pasākumus zili zaļās infrastruktūras attīstīšanai, kas norāda uz vēlmi attīstīt ilgtspējīgu pilsētvidi savās pašvaldībās. Lai gan pasākumi ir pakārtoti katras pašvaldības individuālajām vajadzībām, tomēr to mērķi un saturs bieži ir līdzīgi. Piemēram, vides un bioloģiskās daudzveidības veicināšanai pašvaldības plāno īstenot dabīgo teritoriju un dzīvotņu saglabāšanu un atjaunošanu teritorijās ar augstu dabas vērtību (Alfandega da Fe, Mertola, Kartahena), zaļo teritoriju īpatsvara palielināšana pilsētvidē (visas pašvaldības) un citi pasākumi. Pasākumi ūdensapgādes sektorā iekļauj attīrīto notekūdeņu vai lietusūdeņu atkārtotu lietošanu, dzeramā ūdens patēriņa mazināšana, ūdensapgādes un kanalizācijas sistēmas uzlabošana kopumā u.c. Kategorijā "citi" tika iekļauti dažādi izglītojošie un informatīvie pasākumi, politikas uzlabojumi, sistēmiskas pieejas ieviešana u.c.

3.3. Energopārvaldības sistēmas ieviešana Daugavpils pilsētā

Daugavpils ir otrā lielākā pilsēta Latvijā, kurā dzīvo 80627 iedzīvotāju (saskaņā ar Centrālās statistikas pārvaldes datiem [130]). Pašvaldības struktūrās ir nodarbināti ap 5910 cilvēkiem. Kopumā 2015. gadā pašvaldības publisko ēku kopējais siltumenerģijas patēriņš bija aptuveni 48 GWh, vidējais īpatnējais siltumenerģijas patēriņš bija 185 kWh/m^2 gadā. Kopējais elektroenerģijas patēriņš publiskajās ēkās bija ap 17 GWh, elektrības patēriņš ielu apgaismojumā ~5.6 GWh, un enerģijas patēriņš sabiedriskajā transportā bija ap 13GWh (autobusi, miniautobusi, tramvaji). 2016. gadā pašvaldība parakstīja Mēru paktu.

Daugavpils pašvaldība izstrādāja Ilgtspējīgas enerģētikas rīcības plānu (IERP) 2015. un 2016. gada laikā, un paralēli tam ieviesa energopārvaldības sistēmu (EPS). Pašvaldība izstrādāja energopārvaldības sistēmas rokasgrāmatu, kurā tika nodefinētas energopārvaldības sistēmas robežas, sistēmas ieviešanas, uzturēšanas un uzraudzīšanas procedūras. Savukārt IERP nosaka klimata pārmaiņu mazināšanas mērķus un pasākumus pašvaldības teritorijā. Abi dokumenti tik apstiprināti pilsētas domes sēdē un 2016. gada beigās pašvaldība saņēma arī *ISO 50001:2012* sertifikātu.

Energopārvaldības sistēmas ieviešanas process tika analizēts to sadalot 4 fāzēs:

1. posms: pašvaldības motivācija attīstīt EPS (un IERP);

2. posms: EPS (un IERP) robežu un mērķu noteikšana;

3. posms: EPS ieviešanas procesa uzsākšana un organizēšana;

4. posms: uzraudzības un ieviešanas procesa novērtējums, tostarp komunikācija starp departamentiem un citām ieinteresētajām personām īstenošanas laikā.

1. posms: pašvaldības motivācija izveidot EPS (un IERP)

No 2010. līdz 2014. gadam Daugavpils pilsētā tika atjaunotas vairākas publiskās ēkās, galvenokārt izglītības iestādes. Lielā daļā šo ēku pēc atjaunošanas pabeigšanas, netika sasniegti gaidīties enerģijas ietaupījumi, kas arī radīja apziņu, ka energoefektivitātes jautājumi ir jāadresē plašāk. Kā galvenie izaicinājumi, kas motivēja rīkoties tika identificēti šādi:

- dati par enerģijas patēriņu nav, vai netiek apkopoti un analizēti;
- neviens pašvaldības darbinieks nav nozīmēts, kā atbildīgais enerģijas patēriņa uzraudzībā, nav energopārvaldnieka;
- energoefektivitātes pasākumi tika izvēlēti, balstoties uz pieejamo ārējo finansējumu, un bija projekta tipa pasākumi, kur pasākums tiek īstenots, bet pēc tam neseko tālākas un sistemātiskas rīcības, kā arī nebija skaidras metodikas, kā izvēlēties ēkas atjaunošanas projektiem;
- datu apkopošana bija haotiska, necaurspīdīga, kas apgrūtina enerģijas patēriņa datu un izmaksu apkopošanu un analīzi.

Šie novērojumi ļāva saprast, ka energopārvaldības sistēma ļautu sistemātiski pieņemt datos balstītus lēmumus, kas ļautu gan ietaupīt enerģiju, gan pašvaldības resursus.

Kopumā IERP izstrādes un EPS izstrādes un ieviešanas process aizņēma aptuveni vienu gadu un galvenie ieviešanas procesa posmi ir atspoguļoti 3.3. attēlā. Daugavpils pašvaldība saņēma nozīmīgu atbalstu no speciālistiem visa procesa laikā, kā arī uzsākot EPS ieviešanu spēkā stājās Energoefektivitātes likums, kurā tika noteikta prasība 9 lielākajām pilsētām ieviest un sertificēt energopārvaldības sistēmu, tostarp, prasība attiecās uz Daugavpils pilsētu, kas ļāva procesu virzīt ātrāk.

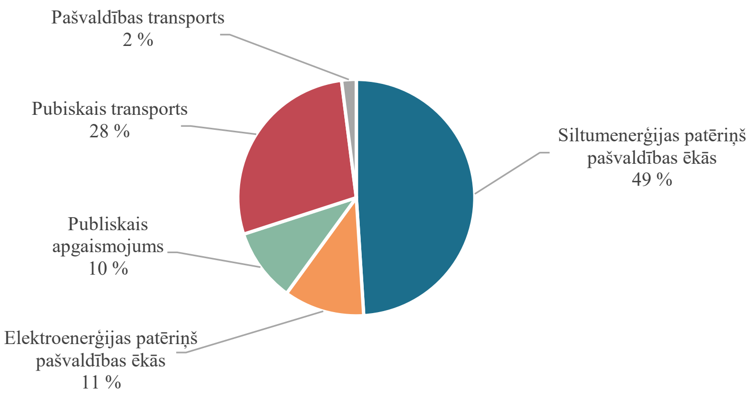
3.3. att. Galvenie EPS ieviešanas soļi [131].

2. posms: EPS (un IERP) robežu un mērķu noteikšana

Daugavpils pilsētas IERP galvenokārt tika fokusēts uz centralizēto siltumapgādi, energoefektivitāti ēkās, ielu apgaismojumā un publiskajā transportā. Energoefektivitāte privātajā sektorā tika skarta virspusēji un plānoti tikai informatīvi pasākumi, bez ambicioziem mērķiem sasniegt lielus ietaupījumus.

Savukārt EPS sākotnēji tika veidots visaptverošs, iekļaujot tajā 100 pašvaldības ēkas, publisko ielu apgaismojumu, kas kopumā iekļāva 9183 gaismekļus un 351km ielu apgaismojuma posmu, kā arī publisko transportu ar 90 transporta vienībām, kas nodrošina 32 autobusu un 3 tramvaja maršrutus.

Enerģijas patēriņa sadalījums pa sektoriem ir dots 3.4. attēlā. Lielākais enerģijas patēriņš ir pašvaldības ēku sektoram (49 % no kopējā pašvaldības enerģijas patēriņš), 11 % sastāda elektroenerģijas patēriņš pašvaldības ēkās, bet publiskais transports 28 % un 10 % tiek patērēti publiskajam apgaismojumam [132].



3.4. att. Enerģijas patēriņa sadalījums pa sektoriem Daugavpils pilsētā 2015. gadā [132].

IERP tiek noteikti vidēja un ilgtermiņa mērķi, bet EPS mērķi tiek izvirzīti viena gada periodam, katru gadu. Daugavpils pašvaldība IERP izvirzīja mērķi samazināt CO_2 emisijas par 40 % līdz 2030. gadam, un EPS tika izvēlēts, kā viens no instrumentiem kā šo mērķi sasniegt.

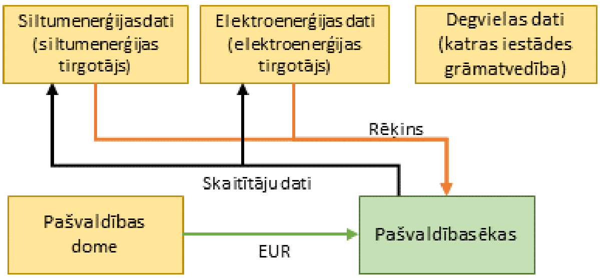
Pirmajā EPS gadā (2016. gads) pašvaldība izvēlējās salīdzinoši viegli sasniedzamus mērķus, t.i. ieviest un sertificēt EPS sistēmu, identificēt 10 ēkas ar lielāko īpatnējo enerģijas patēriņu un analizēt patēriņa dinamiku un ēkas lietotāju paradumus, kas var enerģijas patēriņu ietekmēt. Papildus tika izvirzīti mērķi ielu apgaismojuma un publiskā transporta sektoriem. Ņemot vērā, ka šiem sektoriem bija pieejami tikai daļēji vēsturiskie dati, kā viens no pirmajiem pasākumiem tika noteikts ikmēneša enerģijas patēriņa datu apkopošana un analīze. Kvantitatīvi mērķi enerģijas ietaupījumam un emisiju samazināšanai tika izvirzīti, sākot no 2017. gada. Tā pat neskatoties uz to, ka EPS ieviešana jau bija kļuvusi par obligātu prasību 9 pilsētām, EPS robežu noteikšana tika saglabāta, kā katras pašvaldības brīvprātīga izvēle. Daugavpils gadījumā pašvaldība uzņēmās risku, un jau sākotnēji EPS iekļāva lielāko daļu pašvaldības infrastruktūras, un sekojošos gados paplašināja EPS robežas iekļaujot pārējās pašvaldības ēkas.

3. posms: EPS ieviešanas procesa uzsākšana un organizēšana

EPS plānošanas un ieviešanas process pamatā sastāv no trīs soļiem – rokasgrāmatas un procedūru izstrāde, atbildīgo norīkošana un apmācību organizēšana iesaistītajiem darbiniekiem. *ISO 50001* standarta prasības nenosaka rokagrāmatas izstrādi, kā obligātu prasību, taču pašvaldībās bieži ir augsta darbinieku rotācija, vai darbinieku rotācijai netiek organizēta tā, lai nezaudētu būtiskas zināšanas un informāciju. Rokasgrāmatas izstrāde šādās situācijās palīdz nodrošināt sistēmas uzturēšanas pēctecību un nodrošina pareizu sistēmas darbību ilgtermiņā. Pēc rokasgrāmatas izstrādes pašvaldības vadība izdeva rīkojumus par konkrētu pienākumu piešķiršanu atbildīgajiem darbiniekiem, nosakot kurš, kad un kā nolasīs skaitītāju rādījumus un iesniegs informāciju centralizētā sistēmā datu analīzei. Noslēgumā tika noorganizēti vairāki apmācību semināri iesaistītajiem darbiniekiem par sistēmu kopumā, tās mērķiem un darbību, lai veidotu izpratni un motivāciju darboties.

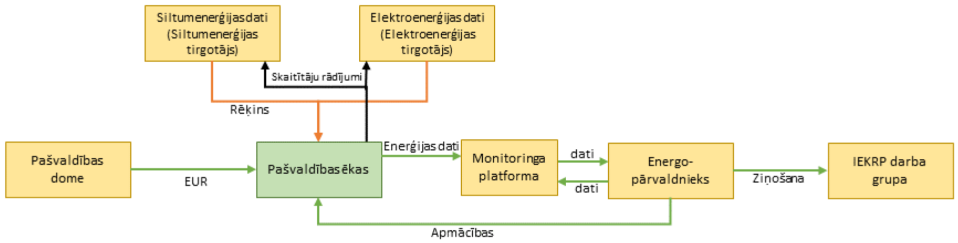
4. posms: uzraudzības un ieviešanas procesa novērtējums, tostarp komunikācija starp departamentiem un citām ieinteresētajām personām īstenošanas laikā

Pirms EPS ieviešanas, enerģijas patēriņa dati Daugavpils pašvaldības ēkās tika apkopoti tikai ēkas līmenī, galvenokārt, norēķinu un grāmatvedības nolūkiem. Atbildīgā persona iesniedza enerģijas patēriņa rādījumus enerģijas tirgotājam katru mēnesi. Uz tā pamata tika piestādīts rēķins par patērēto enerģiju un veikta apmaksa. Gada izmaksu budžetu katrai ēkai apstiprināja pilsētas dome, balstoties uz iepriekšējā gada vidējām izmaksām, bet enerģijas izmaksas atsevišķi no kopējām ēkas izmaksām vērtētas netika. Faktiski pašvaldības ēkās vai pašvaldībā kopumā nebija atbildīgās personas, kas vērtētu enerģija patēriņa tendences pašvaldības objektos un visbiežāk enerģijas patēriņa dati gada griezuma netika apkopoti vispār. Enerģijas patēriņa datu un izmaksu plūsma pirms EPS ieviešanas attēlota 3.5. attēlā.



3.5. att. Enerģijas patēriņa datu pārvaldības sistēma Daugavpils pašvaldībā pirms EPS ieviešanas.

Pēc EPS ieviešanas informācijas aprite tika uzlabota un papildināta tā, lai dati tiktu savākti centralizēti un regulāri analizēti (skatīt 3.6. attēlu). Balsoties uz apkopoto datu analīzes rezultātiem, tiek nodrošināta atgriezeniskā saite ēku atbildīgajiem (ja datos parādās novirzes) tiek izstrādāti ikgadējie ziņojumi par EPS un IERP ieviešanu, prezentēti darba grupai un lēmum pieņēmējiem.



3.6. att. Enerģijas patēriņa datu pārvaldības sistēma Daugavpils pašvaldībā pēc EPS ieviešanas.

Par IERP un EPS ieviešanu atbildīgais departaments ir Daugavpils domes attīstības departaments, ieviešanas procesā ir iesaistīti aptuveni 218 cilvēki, visas personāla izmaksas sedz pašvaldība. Ārējie eksperti tiek piesaistīti tikai specifisku uzdevumu veikšanai, kur pašvaldības darbiniekiem nav atbilstošās kvalifikācijas, piemēram, energoaudits, *ISO* sertifikācijas audits u.c. Daugavpils arī pieņēma darbā energoauditoru – personu, kas ir atbildīga par EPS uzturēšanu, uzraudzību, datu analīzi, un ikgadējo pārskatu sagatavošanu.

Vēsturiskie dati tika apkopoti IERP izstrādes laikā, bet EPS ietvaros tika uzsākta pastāvīga un sistemātiska datu vākšana. Datu vākšanai un apkopošanai Daugavpils izmantoja tiešsaistes enerģijas monitoringa platformu, rīku, kas paredzēts vienkāršai datu vākšanai un analīzei. Atbildīgajiem pašvaldības darbiniekiem ir jāievada tiešsaistē savas ēkas dati katru mēnesi, un rīks automātiski aprēķina datu novirzes un tendences. Energopārvaldnieks veic datu uzraudzību un atbilstoši rīkojas, kad tiek konstatētas būtiskas izmaiņas datos. Ņemot vērā pašvaldību infrastruktūras apjomu, tieši datu monitorings ir viens no sarežģītākajiem procesiem EPS ietvaros [133], [134], tāpēc rīks, kas atvieglo daļu darba ar datiem ir būtisks veiksmīga EPS ieviešanai.

Dati par katru ēku tiek apkopoti atsevišķi, cik iespējams, ja ēkai nav atsevišķa skaitītāja, dati tiek vākti par vairākām ēkām kopā. Apkopoti tiek elektroenerģijas un siltumenerģijas dati ēkās, kuri pārsvarā tiek ievadīti pēc manuālas skaitītāja nolasīšanas. Ikmēneša āra gaisa temperatūra, un enerģijas tarifu datus ievada energopārvladnieks. Kā galvenās problēmas datu vākšanas gaitā identificētas, galvenokārt, cilvēciskās kļūdas – tiek ievadīti kļūdaini dati, dati netiek ievadīti, jo atbildīgais darbinieks aizmirsa nolasīt skaitītāju vai nebija darbā, un cita atbildīgā persona nebija nozīmēta u.tml. Identificējot šādas problēmas, tika uzlabota datu vākšanas procedūra, katra atbildīgā persona saņēma instrukciju, kurā datumā, kā jānolasa skaitītās, kā arī kurš ir atbildīgas, kas aizstāj konkrēto personu. Papildus tam tika identificēti arī citi izaicinājumi EPS uzturēšanas gaitā, piemēram, zema darbinieku motivācija, kuri iesaistīti EPS, zināšanu un izpratnes trūkums par energoefektivitātes jautājumiem ēkās, publiskajā apgaismojumā un transporta jomā, izpratnes trūkums par datu vākšanas jēgu un procesu. Lai adresētu šos izaicinājumus, tika organizēti vairāki apmācību semināri, kur tik skaidroti šie jautājumi.

Vēlāk, veicot *ISO 50001* sertifikācijas auditu, 2019. gadā tika identificētas vairākas problēmas. Galvenokārt cilvēkresursu trūkuma dēļ tika kavēta datu ievade sistēmā, datu analīze un ziņojumu sagatavošana. Auditori rekomendēja arī pilnveidot procedūras, kā tiek apkopoti darbinieku – sistēmas lietotāju, ieteikumi EPS uzlabošanai, kā arī regulāri atjaunot pašvaldības politiku un mērķus energoefektivitātes jomā. Audita rezultāti arī parādīja, ka EPS ieviešanas rezultātā, darbinieki, kas ikdienā strādā pašvaldībās ēkās ir informēti par ēkas enerģijas patēriņa rādītājiem.

Pašvaldības ēku enerģijas patēriņu analīze

Galvenais *ISO 50001:2018* standarta mērķis ir sistemātiskas pieejas ieviešana organizācijās, lai nodrošinātu efektīvu un racionālu enerģijas patēriņu un resursu izlietojumu. Lai izvērtētu EPS rezultātus, tiek rekomendēts noteikt jau sākotnēji, kādi būs galvenie darbības rādītāji jeb indikatori, piemēram, īpatnējais siltumenerģijas patēriņš un īpatnējais elektroenerģijas patēriņš, kā arī kur, iespējams, jāizmanto pret klimatu koriģēti siltumenerģijas dati.

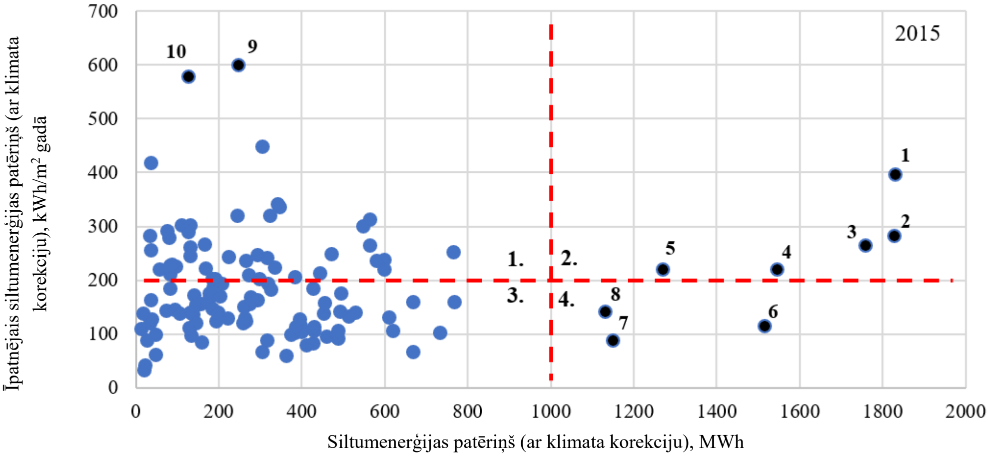
Ņemot vērā, ka Daugavpils pilsētas pašvaldībā vairāk nekā 120 pašvaldības ēkas ir iekļautas EPS, īpatnējie darbības radītāji var nebūt pietiekami lēmumu pieņemšanai. Lai noteiktu, kuras ēkas ir būtiskākie enerģijas patērētāji ar lielāko ietaupījuma potenciālu, nepieciešams veikt rādītāju salīdzināšanu.

Metode, kā pašvaldība var noteikt prioritārās ēkas, kurās sasniedzami vislielākie ietaupījumi, attēlota 3.7. un 3.8. attēlā. Metodes pamatā ir visu ēku iedalīšana 4 grupās pēc kopējā enerģijas patēriņa ēkā un īpatnējā enerģijas patēriņa (šajā analīzē veikta siltumenerģijas datu analīze). Grupu robežas tiek noteiktas, balstoties uz pašvaldības izvirzītajiem mērķiem un esošo situāciju ēkās, respektīvi, rebežlīnijas (sarkanās raustītās līnijas 6. attēlā) tiek novilktas tik tuvu kreisajam apakšējam stūrim, lai atlasītu tik ēku, cik nepieciešams. Tā pat atlasi iespējams veikt vairākās kārtās, ja atsevišķu ēku rādītāji ir būtiski atšķirīgi no pārējām ēkām, ierobežojot pietiekoša skaita ēku datu vizuālu analīzi.

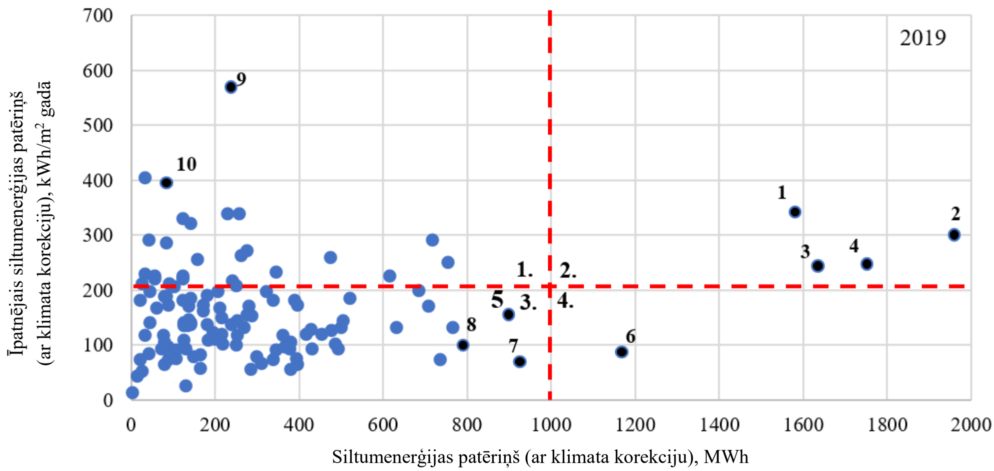
Ēkās, kas iekļautas 3. grupā prasa vismazāk uzmanības, jo gan kopējais siltumenerģijas patēriņš, gan īpatnējais siltumenerģijas patēriņš ir zemi, attiecīgi potenciāls iegūt lielu ietaupījumu šajās ēkās ir viszemākais. Arī 4. grupas ēkas var uzskatīt par efektīvām, jo īpatnējais siltumenerģijas patēriņš ir zems, bet absolūtais enerģijas patēriņš ir augsts, tāpēc arī mazs ietaupījums var dot nozīmīgu finansiālu ietaupījumu. Šajā grupā visbiežāk iekļausies ēkas ar lielu platību. Tikmēr 1. grupā ir ēkas, kam ir neliels kopējais enerģijas patēriņš, bet ļoti augsti īpatnējie enerģijas patēriņi, kas nozīmē, ka ēkas nav lielas taču tās ir neefektīvas, vai ar specifisku energoietilpīgu funkciju. Šajās ēkās ir liels potenciāls sasniegt labākus energoefektivitātes rādītājus, taču finansiālais ietaupījums pašvaldībā kopumā var nebūt ļoti liels. Vislielākais energoefektivitātes un potenciālais finansiālais ietaupījums ir sagaidāms 2. grupas ēkās, kur ir gan augsts īpatnējais enerģijas patēriņš, gan augsts kopējais enerģijas patēriņš. Šajās ēkās, pat nelieli enerģijas patēriņa ietaupījumu var sniegt lielu finanšu ietaupījumu. Tāpēc tieši 3. grupas ēkas būtu uzskatāmas, kā pirmās prioritātes ēkas, kurās investēt energoefektivitātes pasākumos. Atkarībā no atlases mērķa un laika gaitā no enerģijas patēriņa izmaiņām, šādu datu apkopojumu var veikt atkārtoti, noteikt jaunas grupu robežas un atlasīt jaunas prioritārās ēkas.

Daugavpils gadījumā, 2015. gadā 2. grupā bija 5 ēkas. Veiksmīgākais piemērs ir ēka nr. 5, skolas ēka ar 5844 m^2 platību, kura tika renovēta 2013. gadā, bet sākotnēji nesasniedza gaidītos energoefektivitātes rādītājus. Pēc apkures sistēmas ieregulēšanas un automātiskās regulācijas ieviešanas, šajā ēkā tika sasniegti būtiski augstāki energoefektivitātes rādītāji, pārvietojot ēku uz 3. grupu. Enerģijas patēriņš šajā ēkā samazinājās no 1273 MWh 2015. gadā līdz 899 MWh 2019. gadā attiecīgi īpatnējais enerģijas patēriņš samazinājās no 218 kwh/m^2 gadā līdz 154 kwh/m^2 gadā. Ēkā nr. 1 ēkas atjaunošana uzsākta 2019. gadā un ir sagaidāms enerģijas patēriņa samazinājums nākotnē. Ēkās nr. 2., 3., 4., energoefektivitātes pasākumi nav uzsākti.

Trīs ēkās, kas klasificējās 3. grupā 2015. gadā, ir redzami uzlabojumi. Ēkās nr. 6., un 7., tika veikta ēku atjaunošana 2013.–2014. gadā, bet nesasniedza plānotos energoefektivitātes rādītājus, taču pēc EPS ieviešanas situācija ir būtiski uzlabojusies. Arī 1. grupas ēkas tika atlasītas, kā prioritāras, ņemot vērā izteikti augstos īpatnējos enerģijas patēriņus. Ēkas nr. 9. ir publiskā pirts, kurā energoefektivitātes pasākumi nav veikti, un ēka nr. 10 arī tika atjaunota 2013.–2014. gadā nesasniedzot gaidītos energoefektivitāte rādītājus. Kopumā 10 atlasītajās ēkās enerģijas ietaupījums 2019. gadā bija 11 %, salīdzinājumā ar 2015. gada rādītājiem.



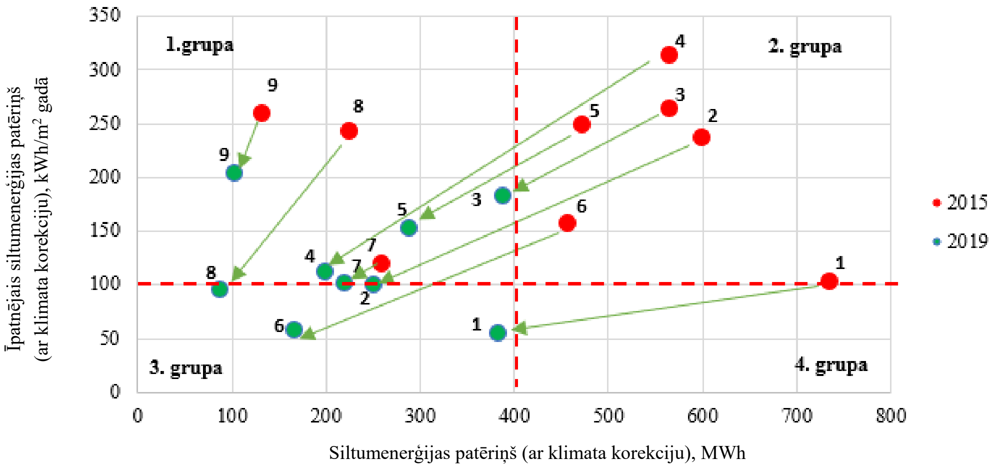
3.7. att. Siltumenerģijas patēriņš 123 Daugavpils pilsētas pašvaldības ēkās 2015. gadā.



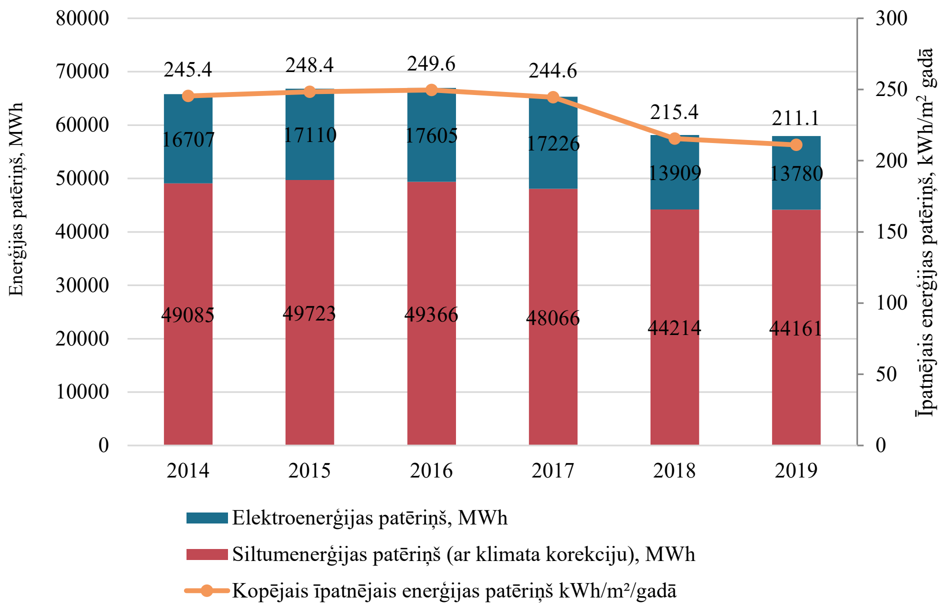
3.8. att. Siltumenerģijas patēriņš 123 Daugavpils pilsētas pašvaldības ēkās 2019. gadā.

Šajā analīzē netika iekļauta viena ēka, kas ir iekļauta EPS, pilsētas slimnīca. Ēkas siltuma patēriņš bija 5240 MWh 2015. gadā un 4288 MWh 2019. gadā (klimata koriģēti dati), īpatnējais siltumenerģijas patēriņš 137,8 un 112,8 kwh/m^2 gadā, tāpēc šo ēku sākotnēji identificē kā prioritāru, bet, lai atlasītu citas ēkas, šo ēku no grafika izslēdz, ņemot vērā, ka metodes mērķis ir spēt veikt vizuālu datu analīzi un ēku atlasi.

Pēc EPS ieviešanas līdz 2019. gadam 9 ēkas tika atjaunotas Daugavpils pilsētā, galvenokārt, skolas un bērnudārzi. Siltumenerģijas patēriņa dati ēkās pirms un pēc atjaunošanas attēloti 3.9. attēlā. Siltumenerģijas patēriņš lielākajā daļā ēku ir būtiski samazinājies, sasniedzot kopumā 47,7 % ietaupījumu 2019. gadā šajās 9 ēkās kopumā. Tomēr, trīs ēkās arī pēc atjaunošanas īpatnējais siltumenerģijas patēriņš saglabājās virs 150 kwh/m^2 gadā, kas nozīmē, ka enerģijas ietaupījuma potenciāls ir vēl lielāks.



3.9. att. Siltumenerģijas patēriņš 9 pašvaldības ēkās, kuras atjaunotas laikā no 2016. līdz 2018. gadam.

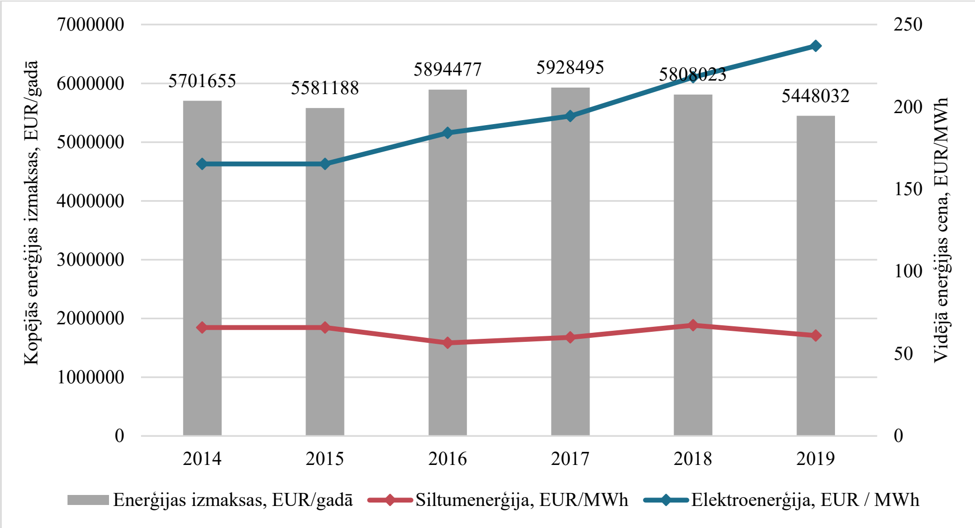


3.10. att. Kopējais enerģijas patēriņš 123 Daugavpils pašvaldības ēkās (2014 un 2015. gadā tikai daļēji vēsturiskie dati bija pieejami, tāpēc faktiskais enerģijas patēriņš bija augstāks).

Kopš EPS ieviešanas 2016. gadā, siltumenerģijas patēriņš visās 123 ēkās kopumā 2019. gadā bija samazinājies par 12 % jeb 5,2 GWh (dati ar klimata korekciju) (skatīt 3.10. attēlu). Elektroenerģijas patēriņš 2019. gadā bija par 8 % mazāks, kā 2016. gadā. Jāņem vērā, ka pilnīgi enerģijas patēriņa dati ir pieejami tikai no 2016. gada, kas izskaidro enerģijas patēriņa pieaugumu no 2014. gada līdz 2016. gadam, kad vēsturiskajos datos par 2014. un 2015. gadu bija iztrūkumi.

Enerģijas izmaksu ietaupījums un EPS ieviešanas izmaksas

Katru gadu Daugavpils pilsētas pašvaldība tērē aptuveni 5,5 līdz 6 miljonus EUR siltumenerģijas un elektroenerģijas nodrošināšanai pašvaldības ēkās. Pēc EPS ieviešanas un energoefektivitātes pasākumu veikšanas 2019. gadā kopējās izmaksas par enerģiju samazinājās par 8 %, salīdzinot ar 2016. gadu. Ietaupījums tika sasniegts, neskatoties uz to, ka elektroenerģijas cena pieauga šo gadu laikā.



3.11. att. Kopējās siltumenerģijas un elektroenerģijas izmaksas 123 Daugavpils pilsētas pašvaldības ēkās.

Saskaņā ar energopārvaldnieka sniegto informāciju, EPS ieviešana Daugavpils pilsētas pašvaldībai izmaksāja aptuveni 12 tūkst. EUR, un atmaksājās viena gada laikā (skatīt 3.11. attēlu).

3.4. Uzvedības maiņas pasākumu ietekme uz pašvaldību klimatneitralitātes mērķu sasniegšanu

Enerģijas patēriņa izmaiņas, enerģijas taupīšanas sacensību laikā

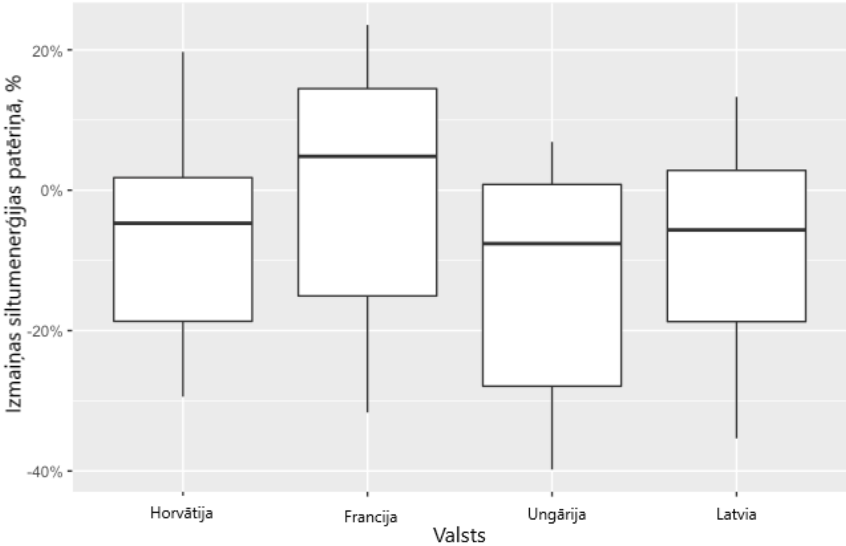
Enerģijas taupīšanas sacensību rezultāti tika noteikti trīs līmeņos - ēkas, pašvaldības un valstis. Rezultātu interpretācija galvenokārt tika koncentrēta uz procentuālajām izmaiņām salīdzinājumā ar bāzes līmeni. Trijās valstīs, kas piedalījās *Compete4SECAP* enerģijas taupīšanas sacensībās, iepriekšējā sadaļā aprakstītie metodoloģijas punkti nevarēja tikt pilnībā ievēroti, un ticamu datu ieguve izrādījās sarežģītāka, kā gaidīts, tāpēc analīzei tiek izmantoti dati no 61 ēkas Horvātijā, Francijā, Ungārijā, Latvijā un Spānijā, kurās tika apkopoti ticami dati un bija iespējams izmantot plānoto metodoloģiju datu analīzei. Siltumenerģijas datu analīzē tiek izmantoti dati no 43 ēkām, ņemot vērā, ka 18 ēkās siltumenerģija netiek patērēta.

3.6. tabula

Siltumenerģijas patēriņa izmaiņas salīdzinājumā ar bāzes siltumenerģijas patēriņu

n	Vidējais	Mediāna	Standartnovirze	Max	Min
43	-6,7%	-4,5%	16,8%	23,6%	-39,8%

Datu apstrādē tika konstatēts, ka vidējais siltuma patēriņa samazinājums par 6,7 % atbilst iepriekšējo pētījumu rezultātiem, taču novērojama arī augsta standartnovirze 16,8 % apmērā (skatīt 3.6. tabulu). Datu kopas maksimālā vērtība norāda uz siltuma patēriņa pieaugumu par 23,6 %. Minimālā vērtība norāda uz siltuma patēriņa samazināšanos par 39,8 %. Šie rādītāji ir divreiz lielāki par maksimālo vērtību, kas tika identificēta literatūrā par iespējamiem ietaupījumiem, veicot uzvedības maiņas un citus nelielus pasākumus [80], attiecīgi tā ir ievērojami augstāka par vērtībām, kas parasti atrodamas literatūrā. Taču šo sacensību ietvaros tika identificēts gadījums, kad energotaupības sacensības deva impulsu pazemināt apkures sistēmas uzstādīto temperatūru par vairākiem grādiem pēc Celsija skalas. Tas radīja ievērojamus ietaupījumus. Tāpēc neviena no atlikušajām vērtībām netiek atmesta kā netipiska vērtība, kas dod 43 novērojumus 3.6. tabulā. Siltuma patēriņa izmaiņas, kas grupētas pa valstīm, parādītas 3.12. attēlā.



3.12. att. Siltumenerģijas patēriņa izmaiņas pa valstīm.

3.12. attēls parāda, ka enerģijas taupīšanas sacensību panākumi atšķiras starp valstīm, kas piedalās sacensībās. Redzams, ka pat vienā valstī ir bijušas ievērojamas atšķirības siltumenerģijas patēriņa izmaiņu apjomā un virzienā. Katrā valstī ir ēkas, kurās enerģijas taupīšanas sacensību gadā ir novērots lielāks siltuma patēriņš, salīdzinot ar bāzes scenāriju. Francijā vidējā vērtība norāda uz siltumenerģijas patēriņa pieaugumu. *Compete4SECAP* projekta partneri varētu identificēt iespējamos iemeslus šim siltumenerģijas patēriņa pieaugumam. Šie iemesli svārstās no resursu trūkuma, ko energokomandas izmantoja, lai paaugstinātu informētības līmeni, līdz energokomandas locekļu aizstāšanai sacensību laikā. Tomēr ar pieejamajiem datiem nevarēja konkrēti noteikt iemeslu katrā individuālajā gadījumā.

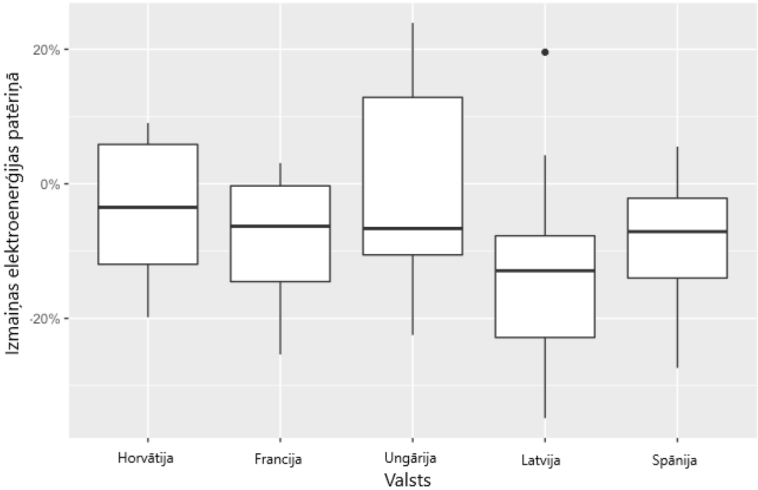
Elektroenerģijas patēriņa dati analizēti par 61 ēku, un rezultāti apkopoti 3.7. tabulā.

3.7. tabula

Elektroenerģijas patēriņa izmaiņas salīdzinājumā ar bāzes elektroenerģijas patēriņu

n	Vidējais	Mediāna	Standartnovirze	Max	Min
61	-7,6%	-7,5%	12,6%	23,9%	-34,8%

Vidēji ēku elektroenerģijas patēriņš energotaupības sacensībās tika samazināts par 7,6 %. Standartnovirze ir zemāka nekā siltuma patēriņa gadījumā, bet joprojām liela –12,6 %. Arī šajā gadījumā izlases minimālā vērtība (t. i., lielākais samazinājums) ir ievērojami lielāka nekā literatūrā [80] minētā vērtība. Tomēr, tāpat kā siltumenerģijas patēriņa izmaiņu gadījumā, neviens datu punkts netiek izslēgts no izlases. 3.13. attēls parāda elektroenerģijas patēriņa izmaiņas, kas grupētas pa valstīm.



3.13. att. Elektroenerģijas patēriņa izmaiņas pa valstīm.

Tāpat kā siltuma patēriņa gadījumā, 3.13. attēls ilustrē, ka elektroenerģijas patēriņa izmaiņas enerģijas taupīšanas sacensību gadā ievērojami atšķiras pat valstīs. Četrās valstīs (Francijā, Ungārijā, Latvijā un Spānijā) vismaz vienā ēkā enerģijas taupīšanas sacensību gadā panākts elektroenerģijas patēriņa samazinājums par 20 % vai vairāk. Tāpat kā siltuma patēriņa gadījumā, katrā valstī bija ēkas, kurās elektroenerģijas patēriņš bija lielāks, salīdzinot ar bāzes scenāriju. Iespējamie iemesli tam ir līdzīgi tiem, kas nosaukti siltuma patēriņa gadījumā. Kopumā sasniegtie enerģijas ietaupījumi norāda uz to, ka uzvedības maiņas pasākumiem ir nozīmīga loma virzībā uz klimatneitralitāti.

3.8. tabulā norādīti enerģijas taupīšanas sacensību rezultāti absolūtā izteiksmē, kā arī enerģijas patēriņa izmaiņas (t. i., siltumenerģija un elektroenerģija kopā) katrā no piecām valstīm. Jāņem vērā, ka rezultāti tabulās 3.5., 3.6., un 3.12. un 3.13. attēlā tiek vērtēti ēku līmenī, bet enerģijas patēriņa izmaiņas 3.7. tabulā tiek novērtētas valsts līmenī.

3.8. tabula

Enerģijas taupīšanas sacensību rezultāti pa valstīm

Valsts	$n_{elekrība}$	**Neto elektroenerģijas ietaupījums**	$n_{siltums}$	**Neto siltumenerģijas ietaupījums**	**Izmaiņas kopējā enerģijas patēriņā**
Horvātija	12	32,8 MWh	8	122,0 MWh	-5,5 %
Francija	12	220,3 MWh	11	122,0 MWh	-7,4 %
Ungārija	10	131,5 MWh	10	260,2 MWh	-9,9 %
Latvija	15	55,9 MWh	14	163,6 MWh	-8,1 %
Spānija	12	194,2 MWh	-	-	-6,8 %
Kopā	61	631,9 MWh	43	761,2 MWh	-8,4 %

Enerģijas taupīšanas sacensību dalībnieku aptaujas rezultāti

Aptauju pēc sacensību beigām aizpildīja 135 energokomandu dalībnieki, no kuriem viens netika norādījis pārstāvēto ēku, tāpēc analīzē iekļautas 134 atbildes no 52 ēkām (57 % no visām ēkām, kas piedalījās sacensībās). Rezultātu analīzes ietvaros tika aprēķināti 5 rādītāji:

- augstākas vadības atbalsts – lielākā daļa aptaujāto bija vienisprātis, ka viņu vadība ir ieinteresēti enerģijas taupīšanas sacensībās, motivēti to atbalstīt un nodrošina energokomandām nepieciešamos resursus. Vērtējuma vidējais aritmētiskais ir 3,7, tā standartnovirze 0,8. Maksimālā vērtība ir 5, minimālā vērtība 1,7;
- interese – Lielākā daļa aptaujāto minēja, ka ievērojama daļa kolēģu bija ieinteresēti enerģijas taupīšanas sacensību norisē. Intereses vērtējuma vidējais aritmētiskais ir 3,3, tā standartnovirze 0,9. Maksimālā vērtība ir 5 (t. i., viens energokomandas dalībnieks lēsa, ka 100 % viņa kolēģu bija ļoti ieinteresēti), minimālā vērtība ir 1,3;
- motivācija – arī šajā rādītājā lielākā daļa aptaujāto domāja, ka liela daļa viņu kolēģu ir diezgan motivēti atbalstīt sacensības. Motivācijas punktu vidējais aritmētiskais ir 3,3 ($s = 0,9$, $max = 5$, $min = 1,3$). Nelielās atšķirības starp interešu un motivācijas punktu skaitu var liecināt par to, ka respondentiem bija grūti nošķirt interesi un motivāciju;
- uzvedības maiņa – aptaujas respondentu atbildes liecina, ka viņu kolēģi mainīja savus enerģijas lietošanas paradumus. Uzvedības maiņas vērtējuma vidējais aritmētiskais ir 3,6 ($s = 0,8$, $max = 5$, $min = 1,55$);
- sniegto materiālu noderīgums – šajā jautājumā tika vērtēts, cik noderīgi bija materiāli, kurus nodrošināja projekts, šo punktu skaitu varētu aprēķināt tikai 51 ēkai. Kopumā respondenti uzskatīja par noderīgu *Compete4SECAP* komandas izplatīto materiālu. Materiālu noderīguma rezultāta vidējais aritmētiskais ir 3,7 ($s = 0,7$, $max = 5$, $min = 2,1$).

Spīrmana ranga korelācijas koeficients tika aprēķināts korelācijai starp elektroenerģijas un siltuma patēriņa izmaiņām un aptaujas rādītājiem atsevišķi, un tad katra korelācija tika pārbaudīta, lai noskaidrotu, vai tā būtiski atšķiras no nulles. Aprēķinot korelācijas, iepriekš izskaidroto iemeslu dēļ tika izmantoti dati tikai no piecām valstīm (Horvātijas, Francijas, Ungārijas, Latvijas un Spānijas). Tika konstatēts, ka visiem, izņemot vienu ranga korelācijas koeficientu, ir paredzamā zīme. Korelācija starp elektroenerģijas patēriņa izmaiņām un materiālu noderīguma rādītāju ir negatīva, bet ļoti vāja un būtiski neatšķiras no nulles.

Korelācijas starp pārējiem rādītājiem un elektroenerģijas patēriņa izmaiņām ir vājas vai mērenas, taču būtiski atšķiras no nulles. Korelācijām starp siltuma patēriņa izmaiņām un punktu skaitu ir gaidītā zīme, taču tās ir ļoti vājas vai vājas un būtiski neatšķiras no nulles. 3.9. tabulā ir parādīti analīzes rezultāti. Šos konstatējumus var skaidrot ar tēzi, ka elektroenerģijas patēriņa izmaiņas spēcīgāk izraisīja lietotāju uzvedības izmaiņas nekā siltuma patēriņa izmaiņas. Tas nozīmē, ka rezultāti ir atbilstoši rādītāji lietotāju uzvedības izmaiņām.

3.9. tabula

Korelācijas analīzes rezultāti

	$n_{elekrība}$	**Ps, elektrība**	$n_{siltums}$	**Ps, siltums**
Augstākas vadības atbalsts	37	0,38	25	0,09
Interese	37	0,42	25	0,35
Motivācija	37	0,56	25	0,22
Uzvedības maiņa	37	0,38	25	0,27
Sniegto materiālu noderīgums	37	0,01	25	0,22

3.5. *COVID-19* ietekme uz enerģijas patēriņu pašvaldību ēkās

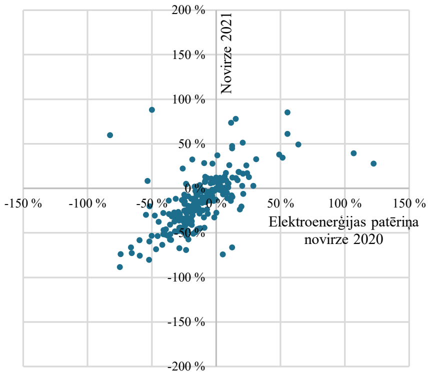
Enerģijas patēriņa tendences pašvaldību ēkās ir ļoti atšķirīgas, gan pašvaldību starpā, gan atkarībā no dažādiem ēku veidiem. Rezultāti 3.14. attēlā parāda, ka elektrības un siltumenerģijas patēriņi ir samazinājušies lielākajā daļā ēku, tomēr ir arī nozīmīgs skaits ēku, kurās enerģijas patēriņi nav samazinājušies, vai pat ir pieauguši 2020. gada un 2021. gada laikā. Vidēji elektroenerģijas patēriņš samazinājās par 12.1 %, bet siltumenerģijas patēriņš par 3.6 % 2020. gadā.

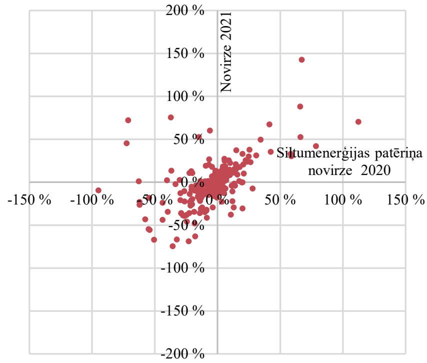
3.10. tabula

Statistikas kopsavilkums par novirzēm 2020. un 2021. gadā, salīdzinot ar bāzes scenāriju (vidējās patēriņa vērtības 2018. un 2019. gadam), %

	Elektroenerģijas patēriņa novirze 2020. gadā	**Elektroenerģijas patēriņa novirze 2021. gadā**	**Siltumenerģijas patēriņa novirze 2020. gadā**	**Siltumenerģijas patēriņa novirze 2021. gadā**
Vidējais	-12,1	-13,4	-3,6	1,04
Mediāna	-14,2	-13,9	-2,9	-2,6
Minimums	-82,4	-88,1	-95,1	-74,5
Maksimums	122,4	268,3	112,2	142,8
Apakšējā kvartile	-24,4	-33,3	-13,8	-13,5
Augšējā kvartile	-0,07	1,54	5,5	9,1
Standartnovirze	25,0	34,8	24,6	27,7

Vidējā enerģijas patēriņa novirze elektrībai ir zemāka, kā siltumenerģijas patēriņa novirze, kas nozīmē, ka *COVID-19* ierobežojumi vairāk ietekmēja tieši elektroenerģijas patēriņu (skatīt 3.10. tabulu). Tā pat ir nozīmīgs daudzums pašvaldības ēku, kur enerģijas patēriņš ir pieaudzis vairāk nekā par 20 %, kuras būtu jāanalizē detalizētā, lai noteiktu izmaiņu iemeslus.

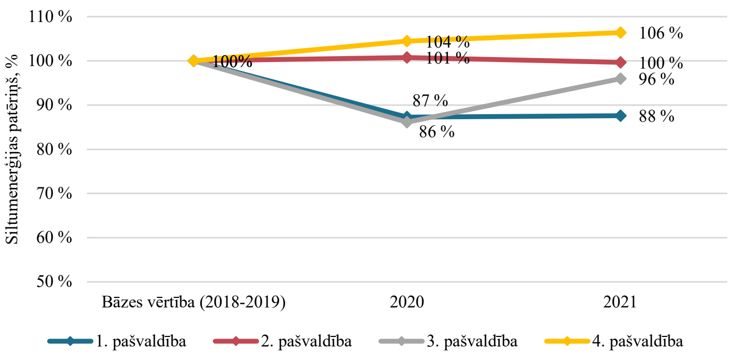




3.14. att. Siltuma (labās) un elektroenerģijas (kreisās) patēriņa datu novirzes pašvaldības ēkās 2020. un 2021. gadā, salīdzinot ar bāzes līniju (2018. un 2019. gada vidējais patēriņš), %.

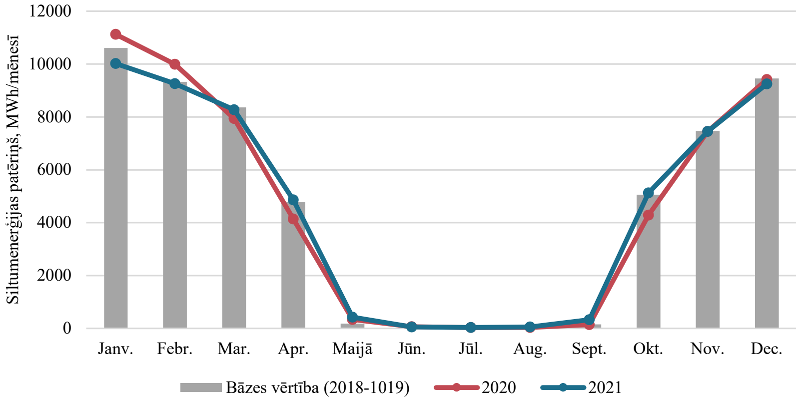
Siltumenerģijas patēriņā trendi

Kopējais siltumenerģijas patēriņš (ar klimata korekciju) 2020. gadā un 2021. gadā samazinājās divās no analizētajām pašvaldībām, pašvaldībā Nr. 1 par 13 % 2020. gadā un 12 % 2021. gadā, un pašvaldībā Nr. 3 par 14 % 2020. gadā un 4 % 2021. gadā. Tikmēr pašvaldībā Nr. 2 kopējais siltumenerģijas patēriņš 2020. gadā palielinājās par 1 % salīdzinot ar bāzes līmeni (skatīt 3.15. attēlu). Augstākais siltumenerģijas patēriņa pieaugums tika konstatēts 4. pašvaldībā, kur tas pieauga par 4 % un 6 % attiecīgi 2020. un 2021. gadā salīdzinot ar bāzes vērtību.



3.15. att. Apkures enerģijas patēriņa novirzes četrās pašvaldībās, salīdzinot ar bāzes scenāriju (2018-2019), %.

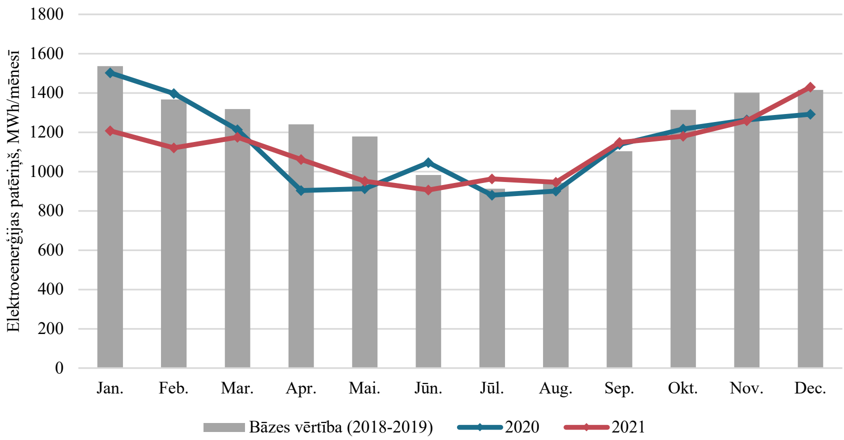
Kopējais siltumenerģijas patēriņš visās pašvaldībās palielinājās 2020. gada janvārī un februārī, bet martā un aprīlī samazinājās par 5 % un 13 %, salīdzinājumā ar bāzes līmeni (skatīt 3.16. attēlu). Tāpat 2020. gada oktobrī siltumenerģijas patēriņš samazinājās par 15 %, bet novembrī un decembrī samazinājās mazāk nekā par 1 %. 2021. gadā siltumenerģijas patēriņa samazinājumi ir nelieli, tikai janvārī siltumenerģijas patēriņš ir samazinājies par 6 %, salīdzinot ar bāzes līmeni, bet pārējos mēnešos samazinājums bija mazāks par 2 %.



3.16. att. Kopējais siltumenerģijas patēriņš, salīdzinot ar bāzes vērtību (2018.-2019. gadu vidējais).

Elektroenerģijas patēriņa trendi

Nozīmīgs kritums elektroenerģija patēriņā pirmkārt, ir novērojams pirmā *COVID-19* pandēmijas viļņa laikā, kad elektrības patēriņš kopumā 240 ēkās nokritās par 27 % aprīlī un par 23 % maijā. Vēlāk 2020. gada vasarā, kad lielākā daļa ierobežojumi tika atcelti, elektrības patēriņš sasniedza ierasto līmeni, pat nedaudz pieaugot jūnijā. Otrajā pandēmijas vilnī (sākot ar oktobri) elektrības patēriņš atkal bija zemāks, taču samazinājums vairs nebija tik liels – 7 % oktobrī, 10 % novembrī un ziemas sezonā (2021. gada janvāris – maijs) sasniedza vidēji 17 % patēriņa kritumu (skatīt 3.17. attēlu).

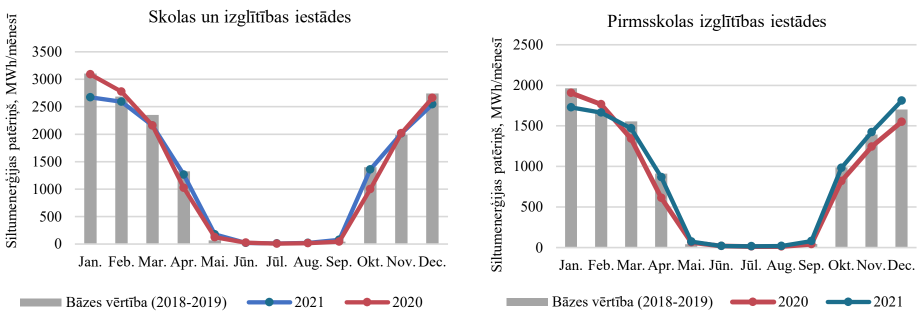


3.17. att. Elektroenerģijas patēriņš visās ēkās, MWh/mēnesī.

Ikmēneša siltumenerģijas patēriņš pašvaldību publiskajās ēkās

Skolas un izglītības iestādes. Kopējais siltumenerģijas patēriņš skolās un citās izglītības iestādēs (46 ēkas) samazinājās par 5,5 % 2021. gadā un 5,3 % 2020. gadā salīdzinot ar bāzes līniju (skatīt 3.18. attēlu). Augstākais patēriņa samazinājums tika konstatēts 2020. gada aprīlī un oktobrī – 23 % un 28 %. Ņemot vērā, ka 2020. gada aprīlī visas skolas bija slēgtas un mācības noritēja attālināti, enerģijas patēriņa samazinājums visdrīzāk ir saistīts ar *COVID-19* pandēmijas ietekmi. 2021. gadā augstākais siltumenerģijas patēriņa kritums bija vērojams janvārī – 14 % un martā – 8 %.

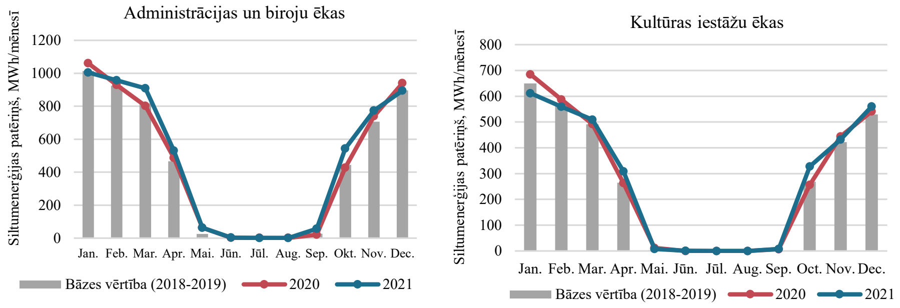
Pirmsskolas izglītības iestādes. Pirmsskolas izglītības iestādēs (53 ēkas) siltumenerģijas patēriņa samazinājums bija lielāks 2020. gadā, kad aprīlī tas sasniedza 33 %, oktobrī – 17 %, bet novembrī un decembrī – 11 % un 9 % salīdzinājumā ar bāzes līmeni (skatīt 3.18. attēlu). 2021. gada janvārī tas samazinājās par 12 %, bet pārējos apkures mēnešos, enerģijas patēriņa samazinājums bija zem 6 %. Kopumā siltumenerģijas patēriņš 2020. gadā bija par 9 % mazāks, savukārt 2021. gadā par 2 % mazāks, salīdzinājumā ar bāzes līmeni. Samazinājums 2020. gadā varētu būt saistīts ar Covid-19, jo daudzi vecāki brīvprātīgi izvēlējās bērnus nevest uz bērnudārzu. Kā arī, nereti viena *COVID-19* pozitīva cilvēka gadījumā grupā visa bērnu grupa kļuva par kontaktpersonām un atradās karantīnā, kas varēja radīt situāciju, kad daudzi bērnudārzi lielāko daļu *COVID-19* pandēmijas strādāja ar samazinātu noslodzi, kas iespējams ļāva taupīt enerģiju.



3.18. att. Siltumenerģijas patēriņš ar klimata korekciju izglītības un pirmsskolas izglītības iestādēs, MWh/mēnesī.

Administrācijas un biroju ēkas. Kopējais siltumenerģijas patēriņš administrācijas un biroju ēkās (47 ēkas) 2021. gadā palielinājās par 8 % un 2020. gadā par 3 %, salīdzinot ar bāzes līmeni (skatīt 3.19. attēlu). Tikai 2020. gada martā un oktobrī siltumenerģijas patēriņš samazinājās par 2 % un 4 %. Citos mēnešos siltumenerģijas patēriņš ēkās pieauga vidēji no 1 % līdz 22 %. Covid-19 ietekme siltumenerģijas patēriņu administratīvajās ēkās praktiski neietekmēja.

Kultūras nami un citas kultūras iestādes. Kopējais siltumenerģijas patēriņš kultūras iestāžu ēkās (25 ēkas) 2021. gadā palielinājās par 4 % un 2020. gadā par 3 % salīdzinājumā ar bāzes līmeni (skatīt 3.19. attēlu). Arī ikmēneša siltumenerģijas patēriņš ir pieaudzis vidēji par 2 % 2020. gadā un 6 % 2021. gadā, salīdzinot ar bāzes līmeni. Salīdzinot *COVID-19* ierobežojumus, būtu sagaidāms, ka enerģijas patēriņš samazināsies vismaz tādā pašā apmērā kā skolās, jo apturēta jebkāda veida pulcēšanās tika gan skolās, gan kultūras iestādēs.

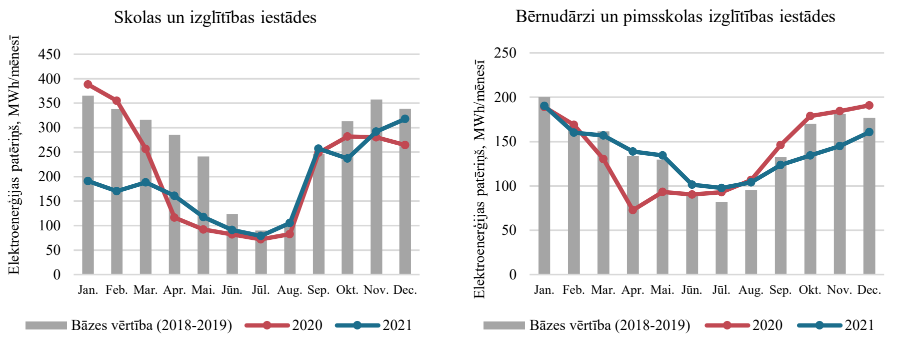


3.19. att. Siltumenerģijas patēriņš ar klimata korekciju, administrācijas un ofisu ēkās, un kultūras iestāžu ēkās, MWh/mēnesī.

Ikmēneša elektroenerģijas patēriņš pašvaldību publiskajās ēkās

Skolas un izglītības iestādes. Kopumā elektroenerģijas patēriņš samazinājās par 19 % 2020. gadā un 29 % 2021. gadā visās četrās pašvaldībās. Vislielākais samazinājums bija 2020. gada aprīlī un maijā, kad pirmā *COVID-19* viļņa laikā tika slēgtas skolas un izglītības iestādes, sasniedzot 59 % un 62 % salīdzinājumā ar bāzes līmeni (skatīt 3.20. attēlu). Kopumā 2021. gada dati liecina, ka būtisks samazinājums noticis visos mēnešos, kad bija spēkā nacionālie *COVID-19* ierobežojumi. 2021. gada pavasara semestrī (janvāris-maijs) mēneša vidējais samazinājums bija 47 %, bet rudens semestrī (septembris-decembris) 11 %, kas arī, visticamāk, ir saistīts ar *COVID-19* ierobežojumiem, kā rezultātā būtiski samazinājās noslogojums skolās.

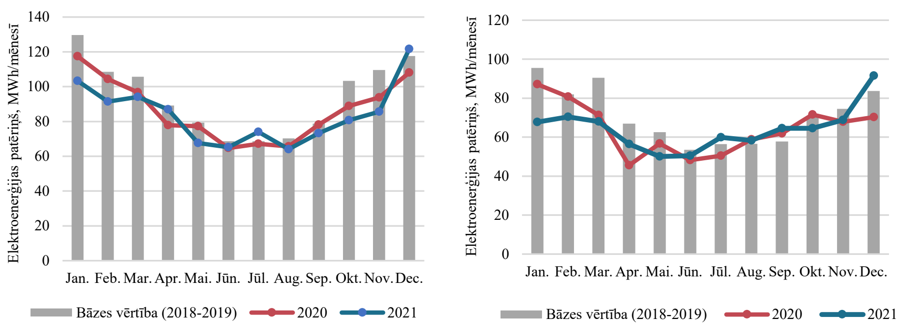
Pirmsskolas izglītības iestādes. Ikmēneša elektroenerģijas patēriņa dati bērnudārzos un pirmsskolās liecina par lielu samazinājumu pirmā *COVID-19* viļņa laikā, kad elektroenerģijas patēriņš martā samazinājās par 19 %, aprīlī – 46 %, bet maijā - par 28 % salīdzinājumā ar bāzes līmeni (skatīt 3.20. attēlu). Otrs periods, kad novērots būtisks samazinājums bija 2021. gada oktobrī un novembrī, kad elektroenerģijas patēriņš samazinājās par 21 % un 20 %. Kopumā 2020. un 2021. gadā kopējais elektroenerģijas patēriņš samazinājās vidēji par 4 % salīdzinājumā ar bāzes līmeni.



3.20. att. Elektroenerģijas patēriņš izglītības iestādēs un pirmsskolas izglītības iestādēs, MWh/mēnesī.

Administrācijas un biroju ēkas. Daudz mazākas svārstības vērojamas administrācijas un biroju ēku elektroenerģijas patēriņa datos. Pirmā *COVID-19* viļņa laikā novirzes ir daudz mazākas, salīdzinot, piemēram ar izglītības iestādēm. Tas varētu būt skaidrojams ar to, ka šajās ēkās daļa cilvēku *COVID-19* pandēmijas laikā turpināja apmeklēt darba vietu (skatīt 3.21. attēlu), lai gan ierobežotā apjomā. Tomēr 2020. gada aprīlī elektroenerģijas patēriņš samazinājās par 13 %, salīdzinot ar bāzes līmeni, un 2020. gada oktobrī un novembrī – par 14 %, bet decembrī – par 8 %. 2021. gadā lielākais samazinājums vērojams oktobrī un novembrī – 22 %, savukārt decembrī elektroenerģijas patēriņš pieauga par 3 %, salīdzinot ar bāzes līmeni. Kopējais elektroenerģijas patēriņš administrācijas un biroju ēkās 2020. gadā ir samazinājies par 8 %, bet 2021. gadā – par 11 %, salīdzinot ar bāzes līmeni.

Kultūras nami un citas kultūras iestādes. Kultūras iestāžu ēkās (skatīt 3.21. attēlu) 2020. gada martā elektrība samazinājās par 21 %, aprīlī – par 32 %, maijā – par 9 % un jūnijā par 10 % salīdzinot ar bāzes līmeni. 2020. gada pirmajā pusē (janvāris-jūnijs) vidējais mēneša samazinājums bija 14 %, bet 2021. gadā – 18 %. 2020.gada rudenī enerģijas patēriņš novembrī bija 9 %, bet decembrī – 16 %, un 2021.gadā elektroenerģijas patēriņš oktobrī samazinājās par 9 %, novembrī – 8 %, bet decembrī pieauga par 9 %. Kopumā elektroenerģijas patēriņš 2021. un 2020. gadā samazinājies par 9,4 % salīdzinājumā ar bāzes līmeni.



3.21. att. Elektroenerģija patēriņš administrācijas, biroju un kultūras iestāžu ēkās, MWh/mēnesī.

3.6. Energopārvaldības sistēmas ieviešana pašvaldībās Eiropā

Energopārvaldības sistēmas ieviešanas process pašvaldībā ir vienreizējs process, taču sistēmas uzturēšana, pilnveidošana un paplašināšana ir ilgstošs un pastāvīgs process, kas līdzi nes arī savus izaicinājumus. Divu gadu garumā tika veikts pētījums 28 ES pašvaldībās, kur tika ieviesta sertificēta energopārvaldības sistēma, un 20 no 28 pašvaldībām, kuras plānoja iegūt EPS sertifikāciju saskaņā ar *ISO 50001* standartu, ieviesa un sertificēja EPS savā pašvaldībā, kas ir 71 % no visām pašvaldībām (papildus 2 pašvaldības bija gandrīz noslēgušas sertifikācijas procesu). Kā arī 15 no 28 (54 %) pašvaldībām jau bija veikušas otro energopārvaldības ikgadējo ziņojumu. Kopumā 28 iesaistītajās pašvaldībās enerģijas patēriņš bija 187 GWh, kas iekļauts šo pašvaldību energopārvaldības sistēmu robežās. Un gadu pēc EPS ieviešanas kopējais enerģijas patēriņš jau bija par 15 GWh zemāks. Ieviešanas gaitā gūtie enerģijas ietaupījumi liecina par to, ka EPS ieviešana pati par sevi stimulē ietaupījumu, ļaujot atbildīgajiem atrast tās pašvaldības infrastruktūras daļas, kur ir liels enerģijas ietaupīšanas potenciāls.

Kopumā 20 pašvaldībās, kas jau ieviesa EPS saskaņā ar *ISO 50001* standartu, tika ieplānoti 92 konkrēti energoefektivitātes pasākumi. No šiem 55 % bija tehniski pasākumi, 30 % organizatoriski un institucionāli pasākumi un 15 % izglītojoši pasākumi. Tas liecina, ka EPS ieviešana uzreiz veicina kompleksu pasākumu ieviešanu iekļaujot gan tehniskus, netehniskus, gan atbalstošus un izglītojošos pasākumus, kā tas tiek rekomendēts citos pētījumos [111]. Divas aptaujas tika veiktas EPS ieviešanas dažādos posmos un kā galvenie izaicinājumi tika identificēti – vēsturisko datu ieguve, ikmēneša datu monitorings, kas saistāms ar grūtībām motivēt un veidot izpratni atbildīgajiem pašvaldības darbiniekiem, finanšu un cilvēkresursu trūkums, kā arī augstākā līmeņa vadības iesaistes nodrošināšana pasākumu ieviešanai.

Četru gadījumu izpēte – Francijas, Itālijas, Spānijas un Latvijas pašvaldības.

Cieza ir pilsēta ar aptuveni 35000 iedzīvotāju. Energopārvaldības sistēmā tika iekļautas 4 publiskās ēkas un ielu apgaismojums, kas ir pašvaldības teritorijā un pārziņā (skatīt 3.11. tabulu). EPS ieviešanas procesu pašvaldība uzsāka 2019. gada februārī un pabeidza līdz tā paša gada beigām. Būtiskākie izaicinājumi EPS ieviešanas procesā bija normatīvo aktu prasību ievērošana, ņemot vērā ēku vecumu, kā arī cilvēkresursu trūkums un finanšu resursu trūkums EPS pasākumu ieviešanai. Galvenie pasākumi, kas tika ieviesti EPS pirmajā gādā bija kvēlspuldžu nomaiņa uz *LED* spuldzēm, darbinieku un iedzīvotāju izglītošana, kā arī energosertifikāta iegūšana 4 pašvaldības ēkām, kuras tika iekļautas EPS.

3.11. tabula

Galvenā informācija par 4 pašvaldībām, kurās veikta gadījuma izpēte

Pašvaldība	**Darba grupas dalībnieku skaits**	**Publiskās ēkās**	**Ielu apgaismojums**	**Pašvaldības transports**	**Ikgadējais enerģijas patēriņš (EPS robežās) (MWh/a)**	**Enerģijas patēriņa samazinājums 1. gadā (MWh/a)**
Cieza, Spānija	4	4	Iekļauts	-	2180	207
Rubano, Itālija	12	24	Iekļauts	-	5444	56
Saldus, Latvija	6	90	Iekļauts	180 transporta līdzekļi	12970	779
Montauban, Francija	10	3	Daļēji iekļauts	-	1600	263

Rubano ir Itālijas pilsēta ar aptuveni 16500 iedzīvotāju. Rubano pašvaldība EPS sistēmā iekļāva 24 publiskās ēkas, ielu apgaismojumu (2500 gaismekļi), 8 saules paneļu iekārtas un trīs kolektoru iekārtas. Jāņem arī vērā, ka pašvaldība savu objektu enerģijas patēriņa uzraudzību bija uzsākusi jau 2010. gadā pēc Mēru pakta parakstīšanas. Enerģijas patēriņa monitorings tika īstenots Ilgtspējīgas enerģētikas rīcības plāna ietvaros un apkopotā veidā tika analizēts reizi divos gados. EPS ieviešanu pašvaldība sāka 2018. gada septembrī un ieviešanu pabeidza 2019.

gada septembrī. Uzsākot *ISO 50001* sertifikācijas procesu, pašvaldībai jau bija sertificēta kvalitātes vadības sistēma saskaņā ar *ISO 9001*. Kā galvenais izaicinājums ieviešanas procesā bija darba grupas izveide EPS ieviešanai un uzraudzībai, kura garantētu nepārtrauktību ilgtermiņā, periodisku un savlaicīgu energoefektivitātes un noviržu kontroli, kā arī spētu integrēt savā darbā augstākās vadības pārstāvjus. Izaicinājumus radīja arī divu paralēlu sistēmu *ISO 9001* un *ISO 50001* salāgošana, lai nebūtu pārmērīgi jāmaina pastāvošās procedūras un organizāciju pašvaldībā. Pasākumi, kas tika īstenoti EPS rīcības plāna ietvaros ietvēra apgaismojuma modernizāciju pārejot uz *LED* apgaismojumu sporta laukumos un ēkās, pašvaldībai piederošo sporta zāļu un ģērbtuvju mehāniskās ventilācijas sistēmu uzstādīšana, ielu apgaismojuma darbības un vadības kontroles ieviešana, EPC līguma izmantošana energoefektivitātes pasākumu iepirkumos. Papildus tika organizētas arī informatīvās kampaņas skolās un bibliotēkās par enerģijas taupīšanu un patēriņa paradumiem.

Saldus ir pašvaldība Latvijā, kurā dzīvo aptuveni 22 000 iedzīvotāju un energopārvaldības sistēmā tika iekļautas 90 sabiedriskās ēkas, ielu apgaismojums, un pašvaldības autoparks. Saldū enerģijas patēriņa dati tika apkopoti kopš 2015. gada un EPS ieviešana tika uzsākta 2018. gada augustā. *ISO 50001* sertifikātu pašvaldība saņēma 2019. gada jūnijā. Kā galvenie izaicinājumi tika identificēti vēsturisko datu apkopošana un ikdienas procedūru ieviešana, atbilstoši standartam. EPS ietvaros tika ieviesti tādi pasākumi kā apgaismojuma aizstāšana ar *LED* gaismekļiem, *HVAC* sistēmu optimizācija un ieregulēšana atsevišķās ēkās, kā arī informatīvie pasākumi izpratnes, par enerģijas lietošanas paradumiem un enerģijas taupīšanu, celšanai.

Montauban pašvaldība Francijā (pilsētas un aglomerācijas iedzīvotāju skaits 77000) sākotnēji vilcinājās ieviest *ISO 50001*, baidoties, ka tas prasīs pārāk daudz laika, no darba grupas dalībniekiem, kuru grafiks jau tā ir piepildīts. Tomēr izvērtējot plusus (sistematizēta pārvaldības pieeja, pasākumu identificēšana) un mīnusus (laiks, finanšu resursi u.c.) tika pieņemts lēmums sistēmu ieviest ar ierobežotām sistēmas robežām. Šāda pieeja ļāva ieviest sistēmu mazākā apjomā, ar mazāku sākotnēji ieguldīto laika un finanšu resursu, bet sistēmu paplašināt laika gaitā. EPS sistēmā sākotnēji tika iekļautas 3 pašvaldības ēkas, 4 ielu apgaismojuma posmi ar 843 gaismekļiem (8 % no visa ielu apgaismojuma). Kopējais enerģijas patēriņš EPS robežās ap 1600 MWh gadā (~8 % no kopējā pašvaldības patēriņa).

Izveidoto darba grupu veidoja divi darbinieki – energopārvaldnieks un finanšu speciālists, citi darbinieki tika piesaistīti pēc nepieciešamības. Paralēli sistēmas ieviešanai darba grupas dalībniekiem īpašu uzmanību pievērsa visu iesaistīto darbinieku izpratnes celšanai par enerģijas patēriņa paradumiem un taupīšanu. Viens no lielākajiem šķēršļiem, bija izprast enerģijas uzskaites sistēmu ņemot vērā, ka pēc vairākkārtējām renovācijām un pārbūvēm sistēmu plāni ne vienmēr tika sakārtoti un skaidri norādīts, kuri skaitītāji kādu patēriņu uzskaita. Pirmajā EPS gadā pašvaldība Montauban pašvaldība ieviesa 11 pasākumus, ietaupot 263 MWh enerģijas. EPS ievešana arī motivēja ieviest jaunus principus pašvaldības pārvaldībā arī ārpus EPS sistēmas, piemēram, energoauditu veikšana pirms tiek veikti jebkādi energoefektivitātes darbi pašvaldības infrastruktūrā, jaunu darbinieku piesaistē tika ņemtas vērā zināšanas par enerģijas taupīšanu.

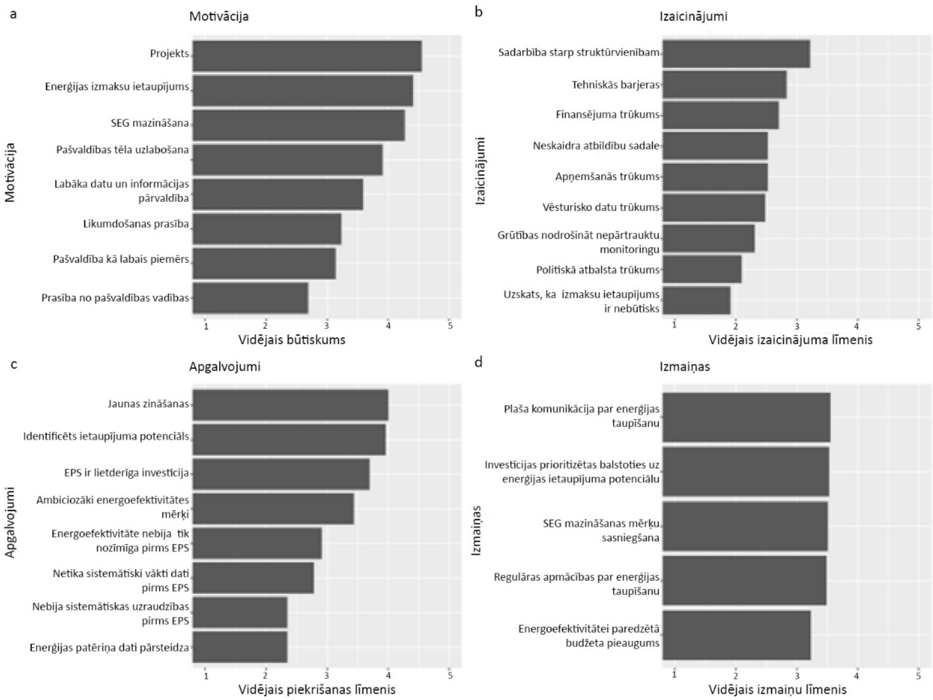
Energopārvaldības sistēmas ieviešanas izvērtējums.

Kad lielākā daļa pašvaldību jau bija ieviesušas un sertificējušas savas energopārvaldības sistēmas tika aptaujāti gan pašvaldību energopārvaldnieki (skatīt 3.22. attēlu), gan speciālisti (skatīt 3.23. attēlu), kas strādāja ar šīm pašvaldībām. Aptaujas veikšanas brīdī 83 % no energopārvaldniekiem, kas aizpildīja anketu, strādāja pašvaldībā, kurai jau bija iegūts energopārvaldības sertifikāts. Uz jautājumu vai viņi uzskata, ka pašvaldība veiks atkārtotu energopārvaldības sistēmas sertifikāciju 21 % atbildēja, ka pilnīgi noteikti un 47 % atbildēja, ka visdrīzāk veiks. Tas nozīmē, ka divas trešdaļas projektā iesaistīto pašvaldību uzskata EPS par ilgtermiņa investīciju un saredz sniegtos ieguvumus, kā nozīmīgus. Kā galvenie iemesli, kāpēc pašvaldība izlēma ieviest EPS tika minēti: projekta atbalsts, labāka enerģijas patēriņa datu ieguve un enerģijas patēriņa ietaupījums, kā arī enerģijas izmaksu samazinājums un SEG emisiju samazinājums. Vairāki respondenti norādīja arī tādus motivējošos aspektus, kā izpratnes paaugstināšana lēmumpieņēmēju un kolēģu vidū, investīciju energoefektivitātes pasākumos prioritizēšana, kā arī pašvaldība kā labais piemērs ilgtspējīgas pārvaldības prakses ieviešanā.

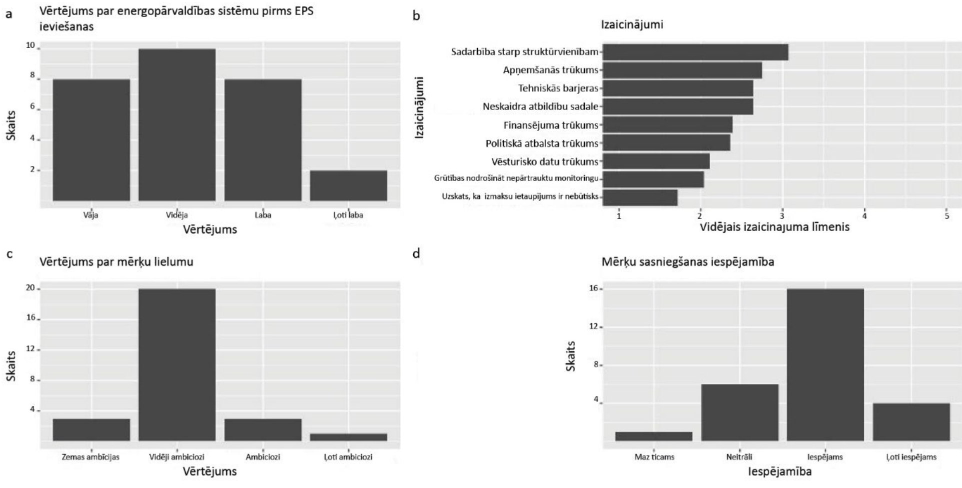
Kā viens no biežāk minētajiem izaicinājumiem energopārvaldnieku vidū bija datu ieguve, gan vēsturisko datu savākšana, gan ikmēneša datu apkopošana jau pēc sistēmas ieviešanas. Identificēti tika arī organizatoriskie izaicinājumi (darbinieku iesaiste, sanāksmju organizēšana u.c.), lēmumu pieņēmēju atbalsta trūkums, kā arī resursu (cilvēkresursu un finanšu) trūkums. Gan speciālisti, gan energopārvaldnieki kā grūtāk pārvaramos šķēršļus norādīja sadarbības nodrošināšanu starp dažādiem pašvaldības departamentiem, kā arī dažādus tehniskos izaicinājumus, piemēram, enerģijas skaitītāju nodrošinājums. Speciālisti papildus norādīja arī tādus izaicinājumus, kā kvalificētu darbinieku atrašana, vai esošā personāla kompetenču celšana kā vienus no būtiskākajiem izaicinājumiem.

Energopārvaldniekiem tika doti arī vairāki apgalvojumi, kuriem tika lūgts norādīt, cik lielā mērā tie apgalvojumiem piekrīt. Augstākā piekrišanas pakāpe bija tādiem apgalvojumiem, kā EPS ieviešana sniedza jaunas zināšanas, EPS ieviešana ļāva identificēt enerģijas patēriņa samazināšanas potenciālu jaunās vietās, kā arī EPS ieviešana ir bijusi lietderīga investīcija jau aptaujas veikšanas brīdī. Respondenti nebija pārliecināti par to vai EPS ieviešana ir motivējusi izvirzīt ambiciozākus energoefektivitātes mērķus. Taču energopārvaldnieki arī nebija pārliecināti par apgalvojumu, ka energoefektivitāte nebija nozīmīgs faktors lēmumu pieņemšanā pirms EPS ieviešanas, un nepiekrita apgalvojumiem, ka pašvaldībā nebija sistemātiska enerģijas patēriņa uzraudzība, un ka pašvaldības enerģijas patēriņa dati bija pārsteidzoši.

Aptaujas ietvaros, energopārvaldniekiem tika arī lūgts novērtēt vai EPS ieviešana ir padarījusi noteiktus notikumus vairāk vai mazāk iespējamus. Visi dotie notikumi tika novērtēti, kā "aptuveni tik pat iespējams" vai "vairāk iespējams". Notikumi, kas bija doti ir plaša pašvaldības komunikācija par enerģijas taupīšanu, pašvaldības investīciju prioritizēšana balstoties uz enerģijas ietaupījuma potenciālu, pašvaldības SEG mērķu sasniegšana, regulāru apmācību rīkošana pašvaldības darbiniekiem par enerģijas taupīšanu un pašvaldības budžeta energoefektivitātes pasākumiem palielināšana.



3.22. att. Energopārvaldnieku novērtējums par a) motivācija ieviest EPS (n = 22), b) izaicinājumi EPS ieviešanā (n = 23; apgalvojumam "ietaupījums ir nenozīmīgs" n = 22), c) finanšu ietaupījums EPS ieviešanas rezultātā (n = 23), d) izmaiņas EPS rezultātā (n = 23; apgalvojumiem "SEG samazināšanas mērķi", "komunikācija" un "budžeta pieaugums" n = 22).



3.23. att. Speciālistu novērtējums par a) energopārvaldību EPS (n = 28), b) problēmām EPS izveidē (n = 28), c) mērķu vērienīgumu (n = 27), d) mērķu sasniegšanas iespējamību (n = 27).

Kopumā speciālisti pašvaldību enerģijas pārvaldību pirms EPS ieviešanas tikai 36 % pašvaldību novērtēja, kā labu vai ļoti labu, bet 29 % pašvaldību enerģētikas pārvaldība tika novērta kā vāja. Kopumā speciālisti uzskatīja, ka bez projekta atbalsta 79 % pašvaldību EPS visdrīzāk neieviestu, kā galvenos šķēršļus minot cilvēkresursu un finanšu resursu trūkumu. Savukārt pēc EPS ieviešanas speciālisti norādīja, 74 % pašvaldību iespējams vai ļoti iespējams savus enerģētikas mērķus sasniegs, kā arī 74 % pašvaldību ir izvirzījušas vidēji ambiciozus enerģētikas mērķus (sk. 3.23. attēlu).

SECINĀJUMI UN PRIEKŠLIKUMI

1. Ilgtspējīgas enerģētikas un klimata rīcības plānu izstrāde ir nozīmīgs pirmais solis pretī enerģētikas un klimata mērķu sasniegšanai. Promocijas darbā secināts, ka plāna izstrāde pati par sevi negarantē, ka pasākumi tiks ieviesti un mērķi sasniegti. Pašvaldības bieži piesaista ārējos ekspertus, lai veiktu datu analīzi un izstrādātu plānu, rezultātā pašvaldības darbinieku iesaiste ir ierobežota un neveicina plāna ieviešanu dzīvē. Kā viens no izaicinājumiem Ilgtspējīgas enerģētikas un klimata rīcības plāna izstrādē ir sadarbības veidošana starp dažādiem pašvaldības departamentiem un struktūrvienībām. Tāpēc plāna izstrādes gaitā ir jārīko regulāras darba grupas sanāksmes, kuru laikā ir detalizēti jāpārrunā esošās situācijas un datu analīzes rezultātu būtiskākie aspekti, kā arī potenciālie pasākumi, mērķi un atbildību sadale. Biežāka komunikācija veicinās arī pašvaldības darbinieku izpratni par klimatneitralitātes un klimatnoturības jautājumiem.
2. Eiropas Savienības klimata politikā līdztekus klimata pārmaiņu mazināšanas politikai tiek akcentēta arī pielāgošanās klimata pārmaiņām. Līdz ar to enerģētikas plānošanā arī pašvaldību līmenī ir nepieciešams integrēt pielāgošanās aspektus. Ņemot vērā to, ka pielāgošanās jomā pasākumu ieguvumus un efektivitāti izmērīt ir sarežģīti (visbiežāk to nevar izteikt ietaupījuma vai emisiju samazinājuma izteiksmē), tika izstrādātā daudzkritēriju pasākumu atlases metode, kas ļauj novērtēt pasākumu ieguvumus attiecībā pret to izmaksām.
3. Pasākumu, kas vērsti uz pielāgošanos klimata pārmaiņām, specifika rada arī papildu izaicinājumus komunikācijā pašvaldības iekšienē un ar dažādām sabiedrības grupām. Plaša ieinteresēto pušu iesaiste plāna izstrādes procesā palīdzēs paaugstināt gan pašvaldības darbinieku, gan sabiedrības izpratni un atbalstu pielāgošanās pasākumu ieviešanai.
4. Balstoties promocijas darba izstrādes gaitā iegūtajos rezultātos, ir izstrādāta vienota pieeja (2. att.) sistemātiskai Ilgtspējīgas enerģētikas un klimata rīcības plānā iekļauto pasākumu ieviešanai pašvaldībā, kas 2022. gada septembrī sākta aprobēt 44 ES pašvaldībās (*OwnYourSECAP* projektā).
5. Lai testētu uzvedības maiņas pasākumu ietekmi uz ēku enerģijas patēriņu, 61 pašvaldības ēkā Eiropas pašvaldībās tika noorganizētas enerģijas taupīšanas sacensības, kas ir viens no efektīviem veidiem enerģijas lietotāju uzvedības maiņai. Sistemātiski ieviešot uzvedības maiņas pasākumus 61 ēkā, vidēji tika sasniegts elektroenerģijas patēriņa samazinājums par 7,6 %, 43 ēkās siltumenerģijas patēriņa samazinājums par 6,7 %, kas liecina par to, ka ēkas lietotāju paradumiem ir būtiska ietekme uz ēkas enerģijas patēriņa rādītājiem.
6. Veicot energopārvaldības sistēmas ieviešanas procesa kvalitatīvo un kvantitatīvo analīzi Latvijas un Eiropas pašvaldībās, var secināt, ka EPS ir piemērots instruments pašvaldībām, lai būtiski uzlabotu enerģētikas jomas pārvaldību savā infrastruktūrā un sāktu sistemātiskas darbības klimaneitralitātes mērķu sasniegšanai. Daugavpils pilsētas pašvaldībā pēc EPS ieviešanas izdevās ietaupīt 12 % siltumenerģijas pašvaldības ēkās trīs gadu laikā. Pētot EPS ieviešanu 28 ES pašvaldībās, tika identificētas vairākas

pašvaldības, kam izdevās ietaupīt pat 10 % enerģijas jau pirmajā gadā. Kopumā 28 iesaistītajās pašvaldībās EPS robežās iekļautās infrastruktūras enerģijas patēriņš bija 187GWh, un viena gada laikā to izdevās samazināt par 15 GWh, neveicos lielas investīcijas. No pārvaldības viedokļa būtiskākie ieguvumi, ieviešot EPS, ir detalizētas un skaidras sistēmas izstrāde, kas ietver skaidru atbildību sadali, precīzas procedūras gan datu vākšanai, gan apstrādei, gan pasākumu plānošanai un ieviešanai, kas ļauj viegli identificēt to pašvaldības infrastruktūru, kurā ir augsts enerģijas ietaupīšanas potenciāls.

7. Pētot *Covid-19* ierobežojumu ietekmi uz enerģijas patēriņu pašvaldību ēkās, tika identificēts, ka daļā ēku enerģijas patēriņš nevis samazinājās, bet pat pieauga. Piemēram, kultūras iestāžu ēkās siltumenerģijas patēriņš vidēji pieauga par 4 % 2021. gadā un 3 % 2020. gadā, savukārt biroju un administrācijas ēkās 2021. gadā siltumenerģijas patēriņš pieauga par 8 %, 2020. gadā – par 3 %. Elektroenerģijas patēriņā novērojami periodiski patēriņa kritumi, kas saistāmai ir pandēmijas ierobežojumiem. Ja ēkas noslodze būtiski neietekmē ēkas enerģijas patēriņu, ir nepieciešams izvērtēt ēkas bāzes enerģijas patēriņu un tā lietderīgumu.
8. Kopš 2022. gada augusta energopārvaldības ieviešana pašvaldībās Latvijā ir obligāta prasība, lai nodrošinātu sistemātisku energoefektivitātes paaugstināšanu pašvaldību infrastruktūrā. Ņemot vērā to, ka promocijas darbā secināts, ka energopārvaldības sistēmas ieviešana var sniegt būtisku enerģijas ietaupījumu un atmaksāties jau viena gada laikā, šāda prakse var tikt pārņemta arī citās Eiropas valstīts.
9. Promocijas darba hipotēze ir apstiprināta. Energopārvaldības sistēmas ieviešana veicina cikliskas un sistemātiskas rīcības klimata un enerģētikas jomā institucionalizāciju pašvaldības ikdienas procesos.

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Assessment of the Implementation of Sustainable Energy Action Plans at Local Level. Case Study of Latvia

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***Abstract* – The need for sustainable energy management at the municipal level is growing, in order to meet EU climate goals. Multiple initiatives have been launched to support municipalities in energy planning and strategy development process. Despite available support, research shows mixed results about implementation of plans and strategies. This research paper analyses what targets municipalities set, how they monitor implementation of their sustainable energy action plans (SEAPs) and searches for the most important factors that have enabled or hindered the implementation of local SEAPs at Latvia. The article shows that, in some cases, there is evidence that SEAP development is a project-based activity, supported by external experts. From municipal personnel point of view, it is a project that ends with approved SEAP, but not a part of their future daily routine. Eventually implementation of the plan is difficult, because municipalities lack experience in daily management of energy data, distribution of responsibilities and implementation of procedures. Municipalities also tend to exclude important stakeholders in their SEAPs, like, private sector, household sector and transport sector, which lead to lower targets and lower achievements in GHG reduction.**

***Keywords* – Energy management; energy planning; municipality; sustainable energy action plan**

1. INTRODUCTION

By facing more and more climate change issues around the globe each year, the management of climate change has become major concern at European Union (EU) and scientific world [1]. On September 25th 2015, the UN General Assembly adopted The 2030 Agenda for Sustainable development, where 17 Sustainable Development Goals and 169 targets were defined [2]. By adopting this Universal Agenda, world leaders listed climate change as one of the priorities. In December 2015 at the Paris climate conference (Conference of Parties to the UN Framework Convention on Climate Change – COP21) 195 countries adopted a global climate deal, the so-called Paris Agreement, agreeing to keep the global average temperature rise below 2 ºC [3]. In December 2018 at the UN climate change Conference of Parties (COP24) at Katowice, world leaders agreed on measures for implementing the Paris agreement. Shortly before COP24 at Katowice, the European Commission adopted a European strategic long-

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term vision for a prosperous, modern, competitive and climate neutral economy "A clean Planet for all" stating that Europe can be climate-neutral by 2050 [4].

Many argue that cities are the most important actors at reaching climate goals, as the urban areas are consuming roughly two thirds of global primary energy consumption [5], [6]. Although in countries like Latvia, where around a half of the population is living outside big cities, energy planning and energy management in rural areas is crucial for meeting climate goals. Rural municipalities face even more issues with sustainable energy planning, because of scattered and decreasing population density and lack of internal municipal funding. Often towns and villages are struggling with maintaining district heating (DH) systems, as many residential buildings start to use alternative heat sources or renovates the buildings (increasing energy efficiency) resulting in significantly lower heat consumption. Decreased heat demand from DH can result in increased specific heat losses and prices [7]. Bariss et al. has found that increasing income and resulting growth in energy consumption can be an impediment for reduction of energy consumption [8], especially when all the rural areas are determined to develop.

In 2008, the Covenant of Mayors (CoM) initiative was launched to provide support for local municipalities which volunteer to reduce greenhouse gas (GHG) emissions; since then 7755 municipalities, both big and small, have joined the initiative [9], [10]. CoM has been successful with inclusion of small cities, especially in countries that lack comprehensive national frameworks, by providing tools and knowledge for energy planning [11]. But still several problems of SEAP implementations have been indicated in literature. Researchers Ivner and Gustaffson indicated that, even if municipality do follow up their SEAP, most likely only implementation of actions will be monitored, but not the impact of those actions. They argue that energy issues have to become a natural part of daily work [12]. Kamenders et.al emphasize a lack of expertise among municipal personnel [13], while Melica et al., concluded that small cities can successfully participate in climate initiatives if support by Covenant Territorial Coordinators (CTC) are provided (expert organizations or local governments like regions or provinces). The research showed that 98 % of all SEAPs submitted to CoM in Spain was developed with support from CTC, 93 % in Belgium and 70 % in Italy [11]. This shows the huge importance of external support for small municipalities.

The objective of this study is to analyse implementation of SEAPs in order to investigate if the approach of SEAPs is successful, what kind of targets have been set and how SEAPs have been monitored. As well, what are the most important factors that enabled or hindered the implementation of SEAPs. This study aims to increase knowledge of stakeholders (technical experts, energy managers, municipal officials and policy makers), so that they can make better decisions and design more effective procedures for reaching SEAP targets. Information have been collected through a survey in the form of a questionnaire, literature review and analyses of SEAPs.

2. METHODOLOGY

During this study an online in-depth questionnaire and SEAPs of all involved municipalities in Latvia were used. The study was organized under the framework of a H2020 funded project Compete4SECAP. The project Compete4SECAP aims at assisting local authorities to introduce an energy management system and initiate systematic implementation of climate mitigation and adaptation measures at the local level.

In Latvia there are 119 municipalities of which 110 are towns with rural areas or only rural areas and 9 are cities. Although only 15 municipalities have joined CoM, more than 40 local authorities have developed and approved their SEAPs. It is worth to notice that all SEAPs are developed with massive support from expert organizations and EU projects (like Conurbant, SEAP+, Meshartility, 50000&1 SEAP, etc.). To collect the data used in this study, the municipalities (energy managers or person responsible for SEAP implementation) have been approached. From 42 municipalities, 11 agreed to answer an in-depth questionnaire about their SEAP and implementation process. Characteristics of municipalities included in this study are described in Table 1.

Questionnaire consisted of six parts – basic profile of the municipality, targets, data availability, SEAP implementation, monitoring and energy management system. Altogether 43 questions were included in the questionnaire. Collected data were complemented by information available from the approved SEAPs. Qualitative analysis was used to process and explain data. Structure of the questionnaire process is shown in Fig. 1.

For analysing the results, municipalities were divided in 4 groups based on population size – large municipality (>50 000 residents), medium municipality (30 000–50 000 residents), small municipality (10 000–30 000 residents), very small (<10 000 residents). Both large municipalities are cities and all others are towns with rural areas.

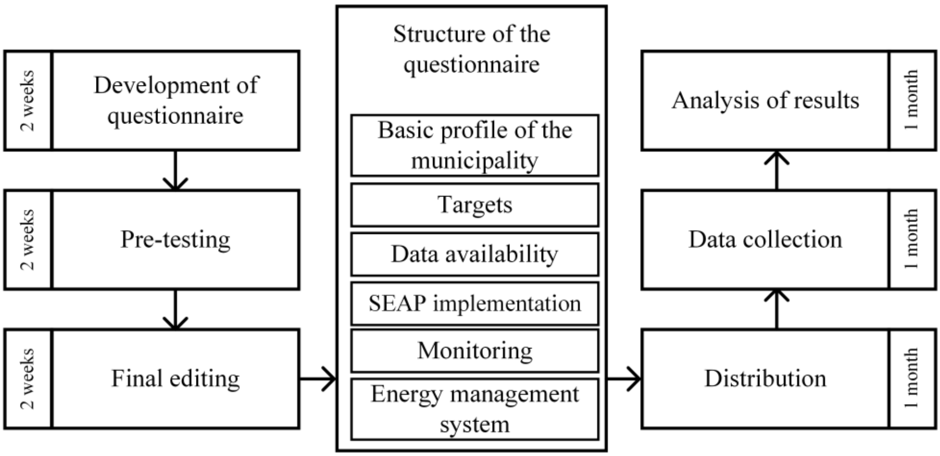

Fig. 1. Structure of the questionnaire process.

The period covered by SEAP varies among the 42 municipalities. All CoM signatories have developed their SEAPs before 2017 covering actions until 2020. Other municipalities have developed their SEAPs recently (in 2018) and the actions are planned until 2025.

TABLE 1. CHARACTERISTICS OF MUNICIPALITIES

Municipality	Size of municipality	CoM Signatory	SEAP period
A	Large	CoM	2014–2020
B	Large	CoM	2016–2020
C	Medium	CoM	2013–2020
D	Medium	CoM	2011–2020
E	Small	–	2016–2020
F	Small	–	2014–2020
G	Small	–	2015–2020
H	Small	CoM	2016–2020
J	Small	CoM	2013–2020
K	Small	–	2018–2025
L	Very small	CoM	2013–2020

3. RESULTS

3.1. Determined Targets at Municipalities

As Table 2 shows, all municipalities have committed themselves to a general CO_2 reduction target, and most of them have defined additional sector-specific targets. Both large and small municipalities set ambitious targets. The highest CO_2 targets have been set by small municipalities, but at the same time the lowest targets also. None of the two medium-sized municipalities have any additional targets mentioned.

All municipalities setting additional targets mostly plan to reduce energy consumption in sectors directly managed by municipal bodies; other sectors are encouraged to reduce energy consumption, without taking responsibility for achieving goals. From those who have set sector specific targets, all have committed themselves to reduce energy consumption at buildings owned by the municipality, five of them have committed to reduce energy consumption in energy production sector, but only one has decided to reduce energy consumption in transport and public lighting sectors.

The targets in all municipalities but one is set until 2020, with the base year varying from 2000 to 2016. This is mainly due to the fact that after several territorial reforms, municipalities still struggle with the collection of reliable historical data.

TABLE 2. DETERMINED TARGETS AT SEAPS OF EACH MUNICIPALITY

Municipality		**CO_2 saving, %**	**Target year**	**Base year**	**Other targets**
Large	A	35	2020	2006	1. Reduce energy consumption in buildings owned by municipality by 10 % 2. To encourage reduction in energy consumption in residential sector by 5 % 3. Reduce energy consumption in energy production sector by 5 % (base year 2012)
Large	B	10	2020	2010	1. Reduce CO_2 emissions by 40 % until 2030 2. Reduce energy consumption in buildings owned by municipality by 10 % (base year 2014) 3. To encourage reduction in energy consumption in residential sector by 5 % 4. Reduce electricity consumption by 5 % for public lighting (base year 2015) 5. Reduce electricity consumption by 5 % for public transport (base year 2015)
Medium	C	20	2020	2008	–
Medium	D	20	2020	2000	–
Small	E	40	2020	2010	1. Reduce CO_2 emissions by 45 % until 2030 2. Reduce energy consumption in buildings owned by municipality by 10 % 3. To encourage reduction in energy consumption in residential sector by 5 % 4. Reduce energy consumption in energy production sector (base year 2014)
Small	F	10	2020	2012	1. Reduce CO_2 emissions by 30 % until 2030 2. Reduce energy consumption in buildings owned by municipality by 10 % 3. To encourage reduction in energy consumption in residential sector by 5 % 4. Reduce energy consumption in energy production sector by 5 % (base year 2015)
Small	G	20	2020	2010	1. Reduce energy consumption in buildings owned by municipality by 5 % (base year 2014) 2. To encourage reduction in energy consumption in residential sector by 5 % 3. Reduce energy consumption in energy production sector by 5 % (base year 2012)
Small	H	40	2020	2008	1. Reduce energy consumption in buildings owned by municipality by 20 % 2. To encourage reduction in energy consumption in residential sector by 10 % (base year 2014)
Small	J	20	2020	2010	–
Small	K	20	2025	2016	1. Reduce energy consumption in buildings owned by municipality by 10 % (base year 2016) 2. To encourage reduction in energy consumption in residential sector by 5 % 3. Reduce energy consumption in energy production sector by 5 % (base year 2016)
Very small	L	20	2020	2007	–

3.2. Data Availability at Municipalities

The most significant areas where feedback about data availability in the municipal level were requested:

- CO_2 inventory;
- Energy consumption data;
- Data of energy costs.

Six (2 large, 4 small) out of eleven municipalities have compiled a CO_2 or GHG-inventory, five of which noted that they do it on a regular basis. During the survey participants were also asked (subjectively – 1 very important, 3 – moderately, 5 – not important) to rate how important the inventory is for development and implementation of SEAP measures. Answers varied significantly. While only two municipalities assessed CO_2 or GHG-inventory as very important, most rated it as moderately important. Municipalities without inventories rated this aspect from 1–3 (1 very important, 3 – moderately, 5 – not important), but municipalities that have compiled inventories gave rates from 1–5.

In order to assess energy data availability, municipalities were asked what kind of data they collect and how often. It seems that this is still an important issue as two municipalities (medium and very small) do not collect any data about public buildings. Four municipalities collect data for each building separately, three municipalities collect aggregated data for several buildings, and in two municipalities energy data are collected separately, but for some aggregated.

Half of the municipalities collect energy data and energy costs, however the other half only energy consumption data. In four municipalities data is collected by direct meter readings, and in other four digital transmissions (smart meters) of data is used, one municipality pointed out that they use a different technology. All municipalities collect monthly data except for one municipality which collects data annually.

Municipalities were also asked to comment on the main challenges concerning the generation and collection of energy-relevant data in the public sector. Most comments were about the human factor – responsible persons make mistakes, forget, miss deadlines. Also, many procedural issues were mentioned, like collection of data is forgotten because of lack of procedure in cases of sick leave or other issues, no common methodology for collection of data, etc.

3.3. SEAP Implementation

To understand what commitments municipalities are ready to take for implementing the SEAP, questions about the human resources and financial resources dedicated for the SEAP were asked. It is expected that better results will have at the municipalities with more personnel involved, and more financial resources dedicated for SEAP activities.

As Table 3 shows, all municipalities except D, have officially delegated responsibility to implement SEAP to some department or administrative body, but the level of position responsible for it vary significantly. While most of municipalities have assigned a responsibility to a department or a director of department, for two municipalities executive directors are responsible, which can indicate a lack of responsibilities at the everyday management level. From five respondents that gave answer about a number of people responsible for SEAP implementation, one municipality (G) has assigned responsibilities to ten persons, other four (A; C; J; K) municipalities have one person. Some activities that have been supported by expert organizations are used. Municipalities pointed out that support from experts were used for developing SEAPS and energy audits, finding solutions for improving energy efficiency in buildings etc.

TABLE 3. RESPONSIBILITIES AND FUNDING FOR SEAP IMPLEMENTATION

Municipality		What department or administrative body is responsible for the implementation of the SEAP/SECAP in your Local Authority?	Could you please estimate the number of staff being responsible for the implementation of the SEAP/SECAP?	Could you please estimate the share of labour costs of the staff responsible for the implementation of the SEAP/SECAP funded by third party funds?	For which tasks are external consultants and research institutions predominantly involved (if at all)?
A	Large	Deputy Executive Director (regarding properties)	1	0 %	Mostly the Department of Development is working with SEAP issues. For some specific tasks external consultants are hired, like local University
B	Large	City Council, Department of Development		0 %	Experts are involved for performing energy audits, for certification of energy management system and development of planning documents
C	Medium	Infrastructure development department	1	0 %	–
D	Medium	–		–	–
E	Small	Energy manager		–	–
F	Small	Deputy Executive Director (regarding properties and environment)		0 %	Consultations from state owned financial institution “Altum” about insulation projects of multi-apartment houses
G	Small	Executive Director	10	1–10 %	–
H	Small	Technical project manager of department of economic activities		11–25 %	Municipality is a partner in the “Life Adaptate” project, during which development of SECAP (sustainable energy and climate action plan) is planned
J	Small	Executive Director	1	0 %	–
K	Small	Department of planning and development	1	76–100 %	–
L	Very small	SEAP working group		0 %	The external consultants are involved in finding solutions for improvement of municipal building energy efficiency, to perform the energy audit and do research on the initial situation

Only one municipality (municipality B) from all questioned municipalities was able to specify allocated budget for SEAP implementation, others gave only an estimate. It is worth noting, for municipality B 67 % of all budget for SEAP was planned to be covered by EU funds and only 9 % by a municipal budget. Other municipalities explained that annual municipal budget is not coordinated within SEAP, but instead within a local development plan. However, some activities overlap also with SEAP activities, so in many cases implementation of SEAP is a side effect from the municipal budget standpoint. Other municipalities also commented that a lot of third-party funding is used for investments in bigger infrastructure projects.

Ten out of eleven municipalities have established a working group dedicated to SEAP implementation. However, meeting frequency of working groups is rather low: in two municipalities (B and G), the energy team meets once a year, at municipality H meetings are organised on a quarterly basis. Others noted meetings are not regular but based on necessity. Municipality C, has not established an energy team, however they have established two separate working groups. One targets energy efficiency in multi-apartment buildings whereas the second one focus on other climate and energy issues.

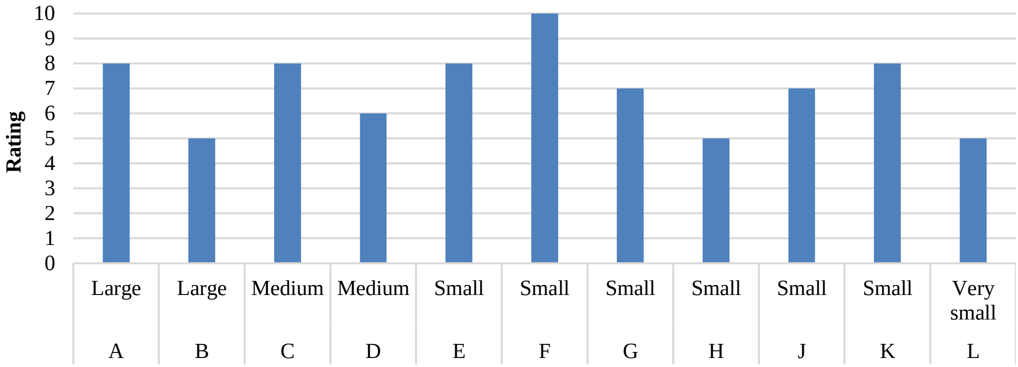

Fig. 2. Ratings of political support for implementing climate and energy related measures from 1 (lowest) to 10 (highest).

Municipalities were asked to rate the political support on a scale from 1 to 10. As Fig. 2 shows, municipalities identify that political support is from 5 to 10. Such results could be closely related to the budget dedicated for SEAP implementation, but not only. Municipality F has noted that climate and energy issues are integrated within daily routines of all municipal departments and are not budgeted or analysed separately. This makes it hard to assess if high political support is backed up by substantial actions. While municipality B rate political support for climate and energy issues only with 5, they were the only ones able to provide information on the budget of the implemented measures. They also commented that municipality should involve more specialists for implementing energy management system, invest more in smart solutions for data collection and energy saving and dedicate more resources for organizing energy saving campaigns. Municipality A remarked that capacity of one person is not enough for managing the whole energy sector. Municipalities G, H, J noted that there are not enough investments made in the energy sector, and that there are restrictions for municipalities to take long term loans, which reduces the ability for municipalities to conduct larger investments. Municipalities D, L mostly commented about the lack of proper communication between municipal departments, and the lack of awareness among municipal employees about energy and climate targets.

Municipalities were asked to list three main activities of their SEAPs, see Table 4.

TABLE 4. MAIN ACTIVITIES INCLUDED AT SEAPS

Municipality		**Action A**	**Action B**	**Action C**
A	Large	To establish data online management and monitoring system	Renovation projects for all schools. At some schools it includes energy efficiency measures – automatic control or radiators, new ventilation solutions	Renovation projects of particular buildings
B	Large	Energy efficiency measures at buildings funded by ERDF	Modernization of tram infrastructure	To expand public lighting and renovate existing one, funded by municipal budget
C	Medium	To increase energy efficiency of public buildings	To build boiler house powered by wood chips	Energy efficiency measures at apartment buildings. ("Labs nams" Ltd. has been created to support the process)
D	Medium	The renovation of preschool educational institution "Pasaciņa" is in progress, of "Pepija" has been finished	Transportation sector – 2 electrical cars bought in 2016	Construction of heating and water supply for two streets, construction of new heat pipes to connect three new streets to existing district heating network
E	Small	–	–	–
F	Small	Energy efficiency project of municipalities New castle (cultural heritage) and energy efficiency project of culture centre, financed by third-party funding	Development of energy-efficient requirements for procurement of new vehicles	Energy efficiency project of elementary school (project finished in 2017)
G	Small	To introduce Energy Performance Contracting principles, for renovation projects		
H	Small	To collect and analyse energy data	To replace existing municipal fleet with new, more energy-efficient vehicles	Replace street lights with more efficient ones
J	Small	Renovation and insulation of municipal buildings	Partly to change public lighting bulbs to LED	Procurement of 2 electric automobiles
K	Small	The Energy action plan 2018–2025 has been developed	The energy management system working group is established	
L	Very small	–	–	–

The main activities included in SEAPs mostly included renovation projects for municipal buildings or public lighting. This shows that municipalities deeply focus on municipal infrastructure instead of including different sectors. Some municipalities like, A, H, K, only starts to analyse and properly collect data, which could lead to better decisions in the future. Municipalities J, B and D are the only ones who declared actions related to the transport sector. Even though municipalities tend to include measures only related to their own infrastructure, many of them indicate lack of financial resources. Most importantly, municipality D indicated the risk of low-quality energy audits and low quality renovation projects, which can cause lower energy savings resulting in low efficient investment. Miezis et al. has also highlighted the problem with low quality construction works in Latvia, that reduces trust in renovation projects and potential energy savings [14].

3.4. Monitoring and Energy Management System

Monitoring is an essential part of energy management. Only two municipalities C and L answered negatively on the question about whether the local authority monitors the state of implementation and/or impacts of measures. Municipalities B, E, H, K, and D only monitor implementation of SEAP, but implementation and impact of measures or activities are monitored at municipalities A, F, G, and J.

From 11 only three municipalities do not have any experience with the design and implementation of an energy management system. Municipal councils of all small and large municipalities have adopted a resolution about the adoption of energy management and have an energy manager in place, from which six have developed an energy management manual and five (both large – A; B; and small – F; G; H) have an energy management system in place.

For municipalities A and B, implementation of a certified energy management system (EnMS) is required by the Energy Efficiency Law. A number of municipalities (with population above 10 000 and territory development index above 0.5 (development index is generalised indicator, based on eight different statistical indicators)) are required to implement EnMS, however they are not obliged to certify. For other municipalities development, implementation and certification of EnMS is voluntary. According to survey results, five municipalities have not implemented EnMS despite the legal requirements.

Scope and boundaries of the EnMS vary among five municipalities. It should be noted that all municipalities with the EnMS in place, have organized informative campaigns concerning energy management activities and all of them do CO_2 or GHG inventory on a regular basis. As boundaries of the EnMS vary among municipalities and in most of the municipalities EnMS has only recently been introduced, it is hard to assess the impact of the EnMS on the overall implementation of the SEAPs compared to municipalities without EnMS in place. More analysis on long term and short term gains from EnMS is required.

4. DISCUSSION AND CONCLUSIONS

Implementation of SEAPs has been analysed in 11 different Latvian municipalities. Results show that most of the municipalities still struggle a lot with reaching their energy and climate goals, although municipalities in Latvia tend to be very cautious with commitment towards high energy and climate targets. They all have a CO_2 reduction goal, as it is the main reason for developing SEAP at all, but by analysing sector-specific goals it is not clear whether local authorities have identified which sectors are the most important in reducing CO_2, and whether they understand how the CO_2 target could be reached. Also, all municipalities set higher goals for sectors they have full control, like energy efficiency in municipal buildings. But when it comes to the private sector, local authorities avoid taking any responsibility of energy consumption trends and set very low targets. This can be due to a lack of knowledge and understanding how to influence and support change of behaviour in their communities. Also, it could be explained by the lack of involvement of stakeholders at target setting phase and selection of the measures. Gustafsson et al. already highlighted the issue of unwillingness to adopt and implement strategies, when municipalities exclude important stakeholders from target setting process, resulting in targets which municipalities do not have a control of, or not setting a targets at all [15]. In some cases, there is evidence that when the development of SEAP is heavily supported by external experts, there is no real motivation inside the municipality to adopt the strategy which leads to the opinion that a lack of funding is what keeps them from reaching their goals. Most of the studied municipalities could not distinguish how much financial resources is used for SEAP activities and for most of them there is no specific budget for it. SEAP implementation is seen as a side effect from the municipal budget point of view, and only activities that overlap or can be easily integrated in activities of local development plan are conducted. Implementation of other activities is considered only when external funding is available. As the analysis highlighted in a few examples (struggle with data collection, data analysis) municipalities lack qualified personnel for energy management. This contributes to the fact that some municipalities analyse only realized measures, but not their impact on the amount of greenhouse gas emissions.

This research has led to the conclusion that municipalities lack knowledge how to set responsibilities and procedures to create the continuity of SEAP in their daily processes. In small rural municipalities, short-term project-based external support from experts does not solve the knowledge deficiency in the long-term. To meet ambitious climate and energy goals in the rural regions of Latvia, comprehensive and affordable tool should be developed for municipalities to enable them to control their energy consumption and most importantly, to enable them to understand the data for acting accordingly. One of such is systematic energy management, however further in-depth research should be done in order to analyse the full effect of SEAP and EnMS implementation on long-term energy performance.

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Top Energy Saver of the Year: Results of an Energy Saving Competition in Public Buildings

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Abstract – Non-residential buildings in the European Union consume more than one third of the building sector's total. Many non-residential buildings are owned by municipalities. This paper reports about an energy saving competition that was carried out in 91 municipal buildings in eight EU member states in 2019. For each public building an energy team was formed. The energy teams' activities encompassed motivating changes in the energy use behaviour of employees and small investments. Two challenges added an element of gamification to the energy saving competition. To assess the success of the energy saving competition, an energy performance baseline was calculated using energy consumption data of each public building from previous years. Energy consumption in the competition year was monitored on a monthly base. After the competition the top energy savers from each country were determined by the percentage-based reduction of energy consumption compared to the baseline. On average, the buildings had an electricity and heat consumption in 2019 that was about 8 % and 7 %, respectively, lower than the baseline. As an additional data source for the evaluation, a survey among energy team members was conducted at the beginning and after the energy competition. Support from superiors, employee interest and motivation and behaviour change as assessed by energy team members show a positive, if weak or moderate, correlation with changes in electricity consumption, but not with changes in heat consumption.

Keywords **– Energy use behaviour; non-residential buildings; workplace**

1. INTRODUCTION

Non-residential buildings are an under-researched area. The fact that the latest year for which data on the energy consumption of non-residential buildings can be found in the EU buildings database is 2014 emphasizes this point. In 2014 non-residential buildings in the European Union consumed more than 1640 TWh of energy [1]. This was more than one third of building sector's total energy consumption. When it comes to non-residential buildings, one important stakeholder are local authorities. They own and operate a considerable number of non-residential buildings. Among these are administrative buildings like the city hall and

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buildings for municipal departments, kindergartens and schools to educate younger citizens, cultural buildings like museums and assembly halls as well as health buildings like hospitals and health centres. An obvious approach to lower the energy consumption of these buildings is to renovate them by increasing the energy efficiency of the heating system, the building envelope and windows. While this will be necessary to attain long-term energy demand and greenhouse gas emission goals, an intermediate approach can be to influence the energy use behaviour of persons using these buildings, i.e. the people working and studying in them.

One of the objectives of the Horizon 2020 project Compete4SECAP, funded by the European Commission, was to conduct an energy saving competition in public buildings to see to what extent strategies of this kind can help to lower energy demand of municipalities. Local authorities from eight member states of the European Union participated in the project Compete4SECAP, namely Croatia, Cyprus, France, Germany, Hungary, Italy, Latvia and Spain.

This paper reports on the energy saving competition implemented in 2019 and its results. It is structured as follows: first, literature about interventions to change energy use behaviour in non-residential buildings is reviewed. Afterwards, we present the activities that have taken place during the energy saving competition and give background information on the buildings the energy saving competition took place in. The next section describes how we evaluated the energy saving competition – both with regard to energy savings attained as well as the survey conducted among the members of the energy teams that were tasked with promoting the energy saving competition in their buildings. Results for energy savings attained during the energy saving competition and from the survey are elaborated in the subsequent section. The paper concludes with lessons learnt, a discussion of the study's limitations and further research needs.

1.1. Literature Review

User behaviour has a non-negligible importance for energy consumption. Today, even building simulations aim to take user behaviour into account [2]. Interventions to change energy use behaviour have the potential to help reduce energy demand, avoid greenhouse gas emissions and reduce energy costs. Various interventions that intent to change user behaviour in residential buildings have been studied. Reviews find that non-price interventions can reduce energy consumption [3] and that energy savings between 2 % and 20 % are possible [4]. Yet, many studies try to change energy use behaviour in residential buildings, and similar interventions in non-residential buildings are studied less often. Staddon *et al.* review 22 studies of interventions to change energy use behaviour in the workplace [5]. As the Compete4SECAP energy saving competition took place in buildings, to which people come either to work or to study (for more details see the subsequent section), studies dealing with interventions to change energy use behaviour at the workplace are of high relevance. The fact that the intervention to change energy use behaviour happens at the workplace has several consequences. In most cases, energy cost savings will not work as monetary incentive. Furthermore, employees trying to change their energy use behaviour could experience what Bull and Janda [6] name competing priorities. Considering the various duties and tasks employees must perform, the repercussions of their actions on energy consumption are given low priority. Based on focus groups and interviews in one public authority in the United Kingdom, Bull and Janda [6] note that this is an existing concern. On the other hand, there are factors associated with workplaces and schools that can help to make interventions more successful. One of these factors is their communal nature.

Staddon *et al*. [5] point out that workplace behaviour is driven by social and group norms. Thus, a lasting change of these norms can induce abiding reductions in energy consumption. Staddon *et al*. also refer to a sense of community within organisations that interventions can leverage to achieve larger impacts [5]. Awards and incentives given publicly constitute a further element that can be used for interventions in a workplace-setting and may make them more effective.

Staddon *et al.* [5] developed a classification of interventions, which will be used subsequently to classify the interventions during the Compete4SECAP energy saving competition. For this reason, the most important types of interventions will be defined in detail below [5]:

- Education: "Increasing knowledge or understanding";
- Persuasion: "Using communication to induce positive or negative feelings or stimulate action";
- Incentivisation: "Creating expectation of reward";
- Environmental restructuring: "Changing the physical or social context";
- Modelling: "Providing an example for people to aspire or imitate";
- Enablement: "Increasing means/reducing barriers to increase ability or opportunity".

Of the 22 studies Staddon *et al*. [5] review, just one makes use of only one type of intervention, while the others use three or more interventions. It is also important to note that the borders between interventions are not delineated distinctly. One and the same instrument may at times constitute two different interventions or even more.

Looking at the energy savings achieved during these studies, one can find wildly differing success of the interventions [5]. Seven studies report energy savings of 20 percent or more. Though, it has to be noted that five of these studies achieved the energy savings by introducing an element of automation.

Many of the studies reviewed by Staddon *et al*. [5] utilised internal challenges, competitions and comparisons of the saving success between colleagues as interventions. Gustafson and Longland [7] describe a behavioural program using many of the instruments that have been also used during the Compete4SECAP energy saving competition. Individual colleagues have been appointed conservation floor captains (comparable to the building energy teams in Compete4SECAP), floor challenges have been conducted, stickers and posters provided information and persuasion and energy saving tips were emailed on a regular base. Energy consumption reduced by 5 % after the first year of the intervention and an additional 4 % after the second year [7]. Metzger *et al*. [8] found that an energy saving competition in an administrative building in the United States lowered electricity consumption by 6 %. The competition took place over a period of four months. Many studies reporting about interventions to change energy use behaviour were conducted within universities. Murtagh *et al*. [9] describe a trial that targeted office workers in a university building. The intervention was to install energy use monitors, give feedback on individual energy use and tips how to save energy. Over the four-week study period, Murtagh *et al*. measured a significant reduction of electricity consumption by up to approximately 16 % [9]. Looking to explain reduction success by surveying participants and conducting focus groups, Murtagh *et al*. [9] only found a significant relationship between attitudes to energy conservation and energy use. It is important for the interpretation of survey results to be discussed subsequently that Murtagh *et al*. [9] note that self-reported energy use behaviour had no relationship with actual energy use behaviour in their sample. The study by Dixon *et al.* [10] is notable to the extent that they conduct a controlled trial of a comparative feedback campaign in a university setting. Dixon *et al*. [10] identify significant reductions in energy consumption in five of the six buildings that were treated with the intervention, amounting to 6.5 % in total. They also observe that the perception of descriptive norms, i.e. the extent to which respondents believe that others are undertaking energy conservation behaviour, significantly increased during the intervention [10]. This is a good sign that group norms can be changed during interventions and lead to improved energy use behaviour. Petersen *et al*. [11] describe an energy saving competition in university dorms that had more than 300 000 participants during the two-year study. A survey was conducted to identify factors that help to explain success in the competition. Awareness of the competition and motivation to participate in the competition had a significant positive correlation with the reduction in electricity use. Petersen *et al*. [11] also find a positive correlation between the perception of the degree to which other students are motivated to participate in the competition. Overall reductions of electricity consumption attained in the study by Petersen *et al*. were 4 % [11]. Further information on studies utilising energy saving competition can be found in Vine and Jones [12], who review energy saving competitions in residential and non-residential settings.

The Compete4SECAP energy saving competition built on experiences made during an earlier Horizon2020 project named save@work. The energy saving competition during save@work took place in 176 public buildings in nine European countries. The instruments employed during this energy saving competition are similar to those described in the subsequent section. Reductions in energy consumption were observed in 73 % of the buildings and energy consumption decreased by 8 % on average and by 20–25 % in the best performing buildings [13]. While the save@work project strictly focused on energy competitions and most of the activities were implemented by experts in collaboration with local authorities, the scope of the COMPETE4SECAP energy saving competition was different. Here the energy saving competition was implemented as part of efforts to introduce an energy management system for the local authorities. The responsibility for running the energy saving competition was assigned to energy managers of these local authorities. Therefore, researcher effort and time devoted to the energy saving competition was considerably lower than during the earlier project.

2. METHODS

The subsequent subsections describe the methods that have been employed in implementing the energy saving competition and in evaluating its results. Data to evaluate the energy saving competition's success mainly comes from two sources. Data on energy consumption for all non-residential buildings taking part in the competition has been collected continuously during the competition. Additionally, two surveys among energy team members have been conducted in the first months of the energy saving competition and after the energy saving competition has ended.

2.1. The Energy Saving Competition

The activities of the energy saving competition can be clustered into three groups:

1. Preparations: Selection of the participating buildings, collection of reference data, appointment of the building level energy team members, development of support materials, and training of the energy team members;
2. Implementation phase: Monthly reading of the energy meters and the local activities the energy teams performed to actively involve their colleagues working in the same building with the continuous professional support from the project partners in the form of facilitating

internal challenges and organizing motivational workshops;
3. Evaluation and award ceremony for the winners.

2.2. Preparations

Prior to the announcement of the energy saving competition the project partners had developed generic rules for the competition (number of participating buildings per local authority, types of buildings allowed to enter the competition, evaluation system, awards, etc.). In the next step three 'office style' public buildings were chosen in every participating local authority. In few of the Compete4SECAP countries buildings other than typical office buildings were chosen for the competition. Examples for this are schools and kindergartens (classified as education buildings), assembly halls and libraries (classified as cultural buildings), health centres (classified as health buildings) and even one research institution (classified as research building). We also had to observe drop-out during the competition: One municipality dropped out of the energy saving competition due to staff shortages. Another municipality eliminated one building from the competition due to imminent renovation measures. Table 1 gives an overview of the number of local authorities and buildings taking part in the energy saving competition until its end.

TABLE 1. BASIC DATA ON BUILDINGS IN THE ENERGY SAVING COMPETITION

Country	**No. of local authorities in competition**	**No. of buildings in competition**	**Classification of buildings**	**Total floor area of buildings in competition**	**Baseline electricity consumption**	**Baseline heat consumption**
Croatia	4	12	Administration, education	17 701 m^2	1139.1 MWh	1678.2 MWh
Cyprus	4	12	Administration, culture, education, health, research	24 527 m^2	1015.8 MWh	*Not applicable**
France	4	12	Administration, culture, education	42 440 m^2	1767.9 MWh	2885.6 MWh
Germany	3	9	Administration	16 513 m^2	568.0 MWh	1049.0 MWh
Hungary	4	10	Administration	25 094 m^2	1248.6 MWh	2725.2 MWh
Italy	3	9	Administration, culture, education	21 126 m^2	338.3 MWh	2220.4 MWh
Latvia	4	15	Administration, culture, education	18 180 m^2	462.2 MWh	2223.4 MWh
Spain	4	12	Administration, culture, education, health	38 416 m^2	2838.7 MWh	*Not applicable**
Total	**30**	**91**		**203 997 m^2**	**9378.6 MWh**	**12 781.8 MWh**

Note: *Not applicable means that all buildings in the energy saving competition are not equipped with a heating system.

An energy team was formed in each building, including at least two employees, in order to implement the energy saving competition locally. The team members collected the historical reference energy consumption data for the respective buildings compared to which the energy saving had to be realised by the end of the competition year.

Meanwhile the project partners developed a great variety of supporting materials the local energy teams could utilise and choose from, including several templates as reminders (stickers and door/window hangers, posters). In addition, each public authority was given a set of tools (energy and/or indoor climate meters and recorders) to help identify the energy saving opportunities and to monitor the results of the buildings. The templates for visual materials were translated to the national languages by the project partners.

Finally, a one-day-long training was provided by the project partners to the members of the energy teams at the beginning of the competition, during which special attention was paid to motivational activities that could be used during the competition to involve employees in energy saving activities. Another objective of the training was to give energy teams' knowledge and skills on how to make a simple energy audit or inspection of a building. A 40-pages-long Strategic Handbook was developed to provide specific methodological and conceptual input to the local public volunteers.

2.3. Implementation

Each energy team prepared an annual action plan detailing what type of actions and methods they intended to use for involving their fellow workers in their own buildings. These activities included the utilization of the support materials the project partners had provided, the monthly collection and reporting of the energy use data, communication of the competition results, etc.

Supplementing these local efforts, the project partners organized at least two internal challenges (topic related quizzes, photo contest, best energy saving practices as posts on social networks etc.) for the public employees during the energy saving competition period. The winners of the internal challenges were awarded by small, symbolic prizes. Furthermore, local or national motivational workshops were also organized for all energy team members in the second half of the competition year in order to exchange experiences, discuss problematic issues and so far, achieved energy saving results as well as to give motivation to continue the energy saving competition.

The instruments utilised during the Compete4SECAP energy saving competition are classified according to the types of interventions developed by Staddon *et al*. [5]. It must be noted that instruments could be either targeted at the members of building energy teams or both target groups of the energy saving competition (i.e. employees and building energy team members). Table 2 shows the results of this classification.

TABLE 2. INSTRUMENTS UTILISED DURING THE COMPETE4SECAP ENERGY SAVING COMPETITION

Instrument	**Intervention**	**Target group**
Energy savings tips	Education, Persuasion	Both
Motivational workshops	Education, Persuasion	Energy team members
Internal challenges	Incentivisation, Modelling	Both

Monthly newsletter (incl. data on energy savings achieved to date)	Education, Persuasion, Modelling	Both
Checklist to identify energy saving potentials	Education	Energy team members
Information materials (door hangers, posters, stickers, etc.)	Persuasion, Environmental restructuring	Both
Technical materials (thermometers, air quality monitors, power strips, etc.)	Environmental restructuring, Enablement	Both

2.4. Evaluation and Award Ceremony

After the one-year-long energy saving competition the final energy use data was collected and the best performing buildings were awarded on a national level in the framework of an awarding ceremony combined with a national conference, where the winners shared their experience, tricks and success methods with not only the employees of the participating local authorities but also other interested parties (other municipalities, representatives of the press, NGOs, expert bodies, etc.). A very important element of the competition subsequent to evaluation is celebration which ought also to receive attention so participants are motivated to continue the acquired energy saving behaviour.

2.5. Collection of Energy Consumption Data and Calculation of Energy Savings

A general methodology was developed to determine monthly and annual energy savings during the energy saving competition in public buildings in eight countries. First, historical energy consumption data for each public building were gathered. For this purpose, each of the local authority (LA) compiled specific data collection templates with monthly data on heat and electricity consumption and average outdoor temperature for the last three years. In order to ensure reliable and credible data analysis and results, monthly data were collected.

If data were missing or not available for three years, historical data for the previous year or two-year period, before major changes (e.g. renovation of the building envelope) was used. Buildings with data for less than one year or 12 months were excluded. It was also defined that a building could still participate if only data for either electricity or heat consumption was available. However, savings during the competition were calculated only for the type of energy for which historical data was available.

After the collection of the historical (reference) energy consumption and outdoor air temperature, baseline energy consumption was derived for each building. Two separate baselines were created, one for electricity and one for heating in relation to outdoor air temperature. Outdoor air temperature was used as it is one of the main factors influencing energy consumption of buildings. Total energy consumption is the sum of electricity and heat baselines.

During the competition period (January – December 2019) LA representatives recorded heat and electricity consumption ($Q_{\text{competition}}$) and outdoor air temperature data separately for each month and entered them into an energy monitoring system. Once monthly data was inserted, baseline consumption (Q_{baseline}) is calculated by using the formulas created during historical (reference) data analysis.

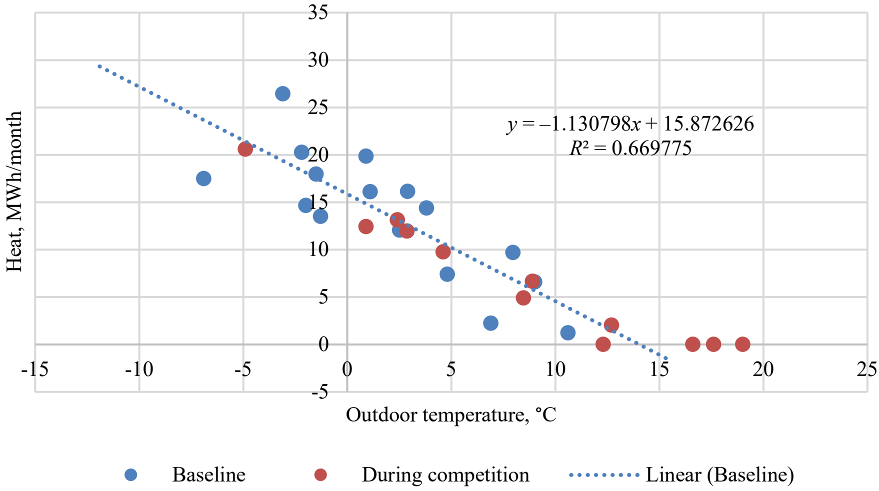

Fig. 1. An example of heat energy baseline determination.

Q_{baseline} is calculated as y in the equation seen in Fig. 1, where x is the outdoor temperature. When $Q_{\text{competition}}$ is determined during the competition, absolute monthly and yearly energy savings (Q_{savings}) are calculated by using Eq. (1).

$$Q_{\text{savings}} = Q_{\text{baseline}} - Q_{\text{competition}}, \text{ MWh/month} \tag{1}$$

Accumulated energy savings are calculated in order to estimate the total energy savings during the respective period of the energy competition. It allows also participants of the competition to follow energy saving results and take further actions. The calculation of Q_{savings} is repeated each month. To calculate the cumulative or total savings ($Q_{\text{total\_savings}}$) during the competition period all individual monthly energy saving results are summarized.

To determine the winner of energy saving competition, Q_{savings} are expressed in percentage (q_{savings}) by using Eq. (2).

$$q_{\text{savings}} = \frac{Q_{\text{savings}}}{Q_{\text{baseline}}} \cdot 100, \text{ \%} \tag{2}$$

Energy savings, expressed in percentage, were used to compare buildings irrespective of their size and type. This allows to accurately determine the winner of the energy saving competition.

2.6. Surveys among Energy Team Members

Members of the energy team were asked to participate in two surveys. The first wave of the survey among energy team members was conducted in February and March 2019. The second wave of the survey was conducted after the energy saving competition had ended in January and February 2020. The questionnaires were drafted in English and have been translated by members of the project consortium to their respective national language. One of the goals of the survey was to assess the extent to which differences in certain qualitative variables can help to explain differences in the success during the energy saving competition. To do this, we use the following items from the second wave of the survey:

- The energy team members' rating of their superiors' interest in the energy saving competition, their motivation to support it and its success as well as the extent to which they supplied necessary resources on a five-point agreement scale (strongly disagree to strongly agree);
- Energy team members were asked to estimate how interested their colleagues have been in the energy saving competition, how motivated they have been to contribute to the energy saving competition and to which extent they have changed their energy use behaviour. To do this, respondents entered percentage shares on a five-point scale ranging from e.g. very motivated to not motivated. This type of questions is similar to those used by Petersen *et al*. [11];
- Energy team members were asked to assess how helpful the materials distributed by the project teams have been on a five-point scale from not helpful to very helpful and rate the materials on a scale from very dissatisfied to very satisfied.

Based on survey results we construct five scores. To do this, we assume that the level of measurement of the scales we use in the survey is interval. These are the five scores we will consider in the analysis:

- Support from superiors: The calculation of this score is based on three items: "My superiors were interested in the energy saving competition and its success", "My superiors were motivated to support the energy saving competition and its success" and "My superiors did supply resources (money and time) we asked for". Answers are transformed into numbers using the values in Table 3. The score for an individual energy member is calculated by averaging. The maximum score is 5 (strongly agree with all three items), the minimum score is 1 (strongly disagree with all three items). If more than one energy team member from a building answers this question, we derive the score for a building by calculating the average of all scores from energy team members from this building;
- Interest: This score is calculated using the estimate share of colleagues that have been very interested, interested, and so on (see Table 3). The score for interest is the weighted mean of the values in Table 3, where the shares given by respondents are the weights. The maximum score possible is 5 (100 % of colleagues are very interested), the minimum score is 1 (100 % are not interested). If more than one energy team member from a building answers this question, we derive the score for a building by calculating the average of all scores from energy team members from this building;
- Motivation: This score is calculated in the same way as "Interest";
- Behaviour change: This score is calculated in the same way as "Motivation";
- Helpful material: This score is calculated using the assessment of the helpfulness of the materials distributed by the Compete4SECAP team. Respondents were asked to assess eight materials. A score was calculated for every energy team member who assessed at least five. The maximum score possible is 5 (100 % of the materials evaluated are rated "very helpful"), the minimum score is 1 (100 % of the materials evaluated are rated "not helpful at all"). If more than one energy team member from a building answers this question, we derive the score for a building by calculating the average of all scores from energy team members from this building.

TABLE 3. CALCULATION OF SCORES

	Support	Interest	Motivation	Behaviour change	Helpful material
5	Strongly agree	Very interested	Very motivated	To a great extent	Very helpful
4	Agree	Interested	Motivated	Somewhat	Helpful
3	Undecided	Fairly interested	Fairly motivated	Little	Moderately helpful
2	Disagree	Slightly interested	Slightly motivated	Very little	Slightly helpful
1	Strongly disagree	Not interested	Not motivated	Not at all	Not helpful

Based on the findings discussed in the literature review, we expect:

- A positive correlation between the support from superiors and energy savings. Superiors supporting the energy saving competition publicly will help to mitigate the problem of competing priorities [5];
- A positive correlation between the interest of colleagues and energy savings. Interest in the energy saving competition is seen as a proxy for willingness to change energy use behaviour;
- A positive correlation between the motivation of colleagues and energy savings. Motivation is also seen as a proxy for willingness to change energy use behaviour;
- A positive correlation between observed behaviour change and energy savings. Though, it has to be noted that in this case the correlation will only be positive if a) employees change their energy use behaviour and b) energy team members are able to observe and assess it correctly;
- A positive correlation between how respondents assess the material distributed by the Compete4SECAP team and energy savings. This can be interpreted as indicator for the role the materials distributed by the Compete4SECAP partners had in the success during the energy saving competition.

We use Spearman's rank correlation coefficient ρ_s, i.e. Pearson's correlation coefficient for rank values, to assess correlation. We use the built-in function of R [14] to calculate ρ_s and test if the correlation is significantly different from zero.

3. RESULTS

3.1. Energy Consumption during the Energy Saving Competition

Results of energy savings competition are determined on three levels – buildings, municipalities and countries. In interpreting the results, we will mainly concentrate on percentage changes compared to the baseline. In three of the countries participating in the Compete4SECAP energy saving competition the methods described in the preceding section could not be followed entirely. In one of the countries, competition activities began late. In the others, occupancy and use of buildings changed and a technical defect caused an abnormal change in electricity consumption. Furthermore, in some cases it has been much harder than expected to collect reliable energy consumption data. Therefore, we concentrate our analysis on 61 buildings from Croatia, France, Hungary, Latvia and Spain for which we are reasonably sure that the methods described above have been followed.

We have recorded data for changes in heat consumption from 43 buildings. The other 18 buildings in our sample are not equipped with a heating system.

TABLE 4. CHANGE OF HEAT CONSUMPTION COMPARED TO BASELINE CONSUMPTION

n	**Mean**	**Median**	**Standard Deviation**	**Max**	**Min**
43	–6.7 %	–4.5 %	16.8 %	23.6 %	–39.8 %

While the average reduction of heat consumption by 6.7 % is consistent with the results of earlier studies, we also find a high standard deviation of 16.8 % (see Table 4). The maximum value in the dataset is an increase of heat consumption by 23.6 %. The minimum value is a decrease of heat consumption by 39.8 %. This is twice the maximum value that a review found for likely savings due to combination intervention [4] and therefore considerably higher than values typically found in the literature. Yet, we know of a case in which the energy saving competition gave the impetus to lower the set point of the heating system by several degrees Celsius. This does result in substantial savings. Therefore, we decide to not discard any of the remaining values as outliers. This leaves us with 43 observations in Table 4. Fig. 2 shows the changes in heat consumption grouped by country.

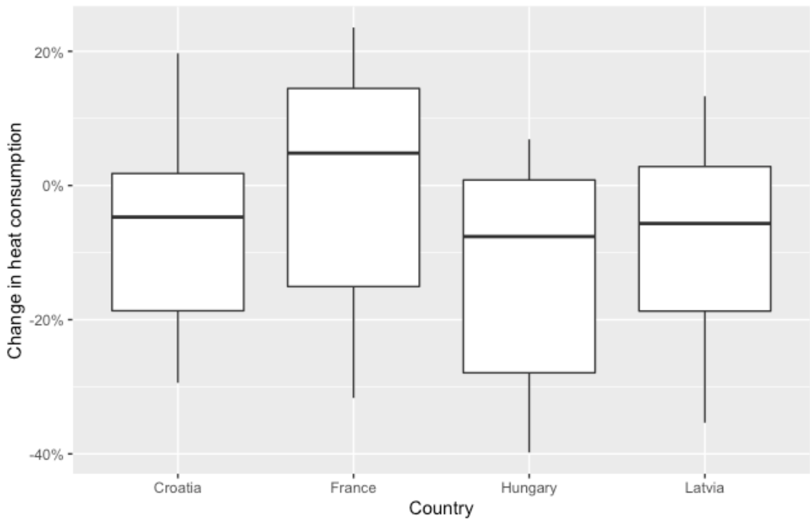

Fig. 2. Change in heat consumption by country.

Fig. 2 illustrates that the success of the energy saving competition differs between the countries in the competition. It also underlines that there have been large differences in the extent and direction of changes in heat consumption even within countries. In every country we find buildings that have a higher heat consumption in the year of the energy saving competition compared to the baseline. In France the median value amounts to an increase in heat consumption. Compete4SECAP project partners could identify possible reasons for this increase in heat consumption. These reasons range from a lack of resources the energy teams had to raise awareness to the substitution of energy team members during the competition. Yet, with the available data it was not possible to pinpoint definite reason in each individual case.

Data for the change of electricity consumption was available for 61 buildings. This data is summarized in Table 5.

TABLE 5. CHANGE OF ELECTRICITY CONSUMPTION COMPARED TO BASELINE CONSUMPTION

N	**Mean**	**Median**	**Standard Deviation**	**Max**	**Min**
61	–7.6 %	–7.5 %	12.6 %	23.9 %	–34.8 %

On average, electricity consumption of buildings in the energy saving competition was reduced by 7.6 %. The standard deviation is lower than in the case of heat consumption, but still large with 12.6 %. Again, the minimum value (i.e. the largest decrease) in the sample is considerably larger than the value for combination interventions found in the literature [4]. Yet, as in the case of changes in heat consumption we decide against discarding any result as outlier. Fig. 3 shows the changes in electricity consumption grouped by country.

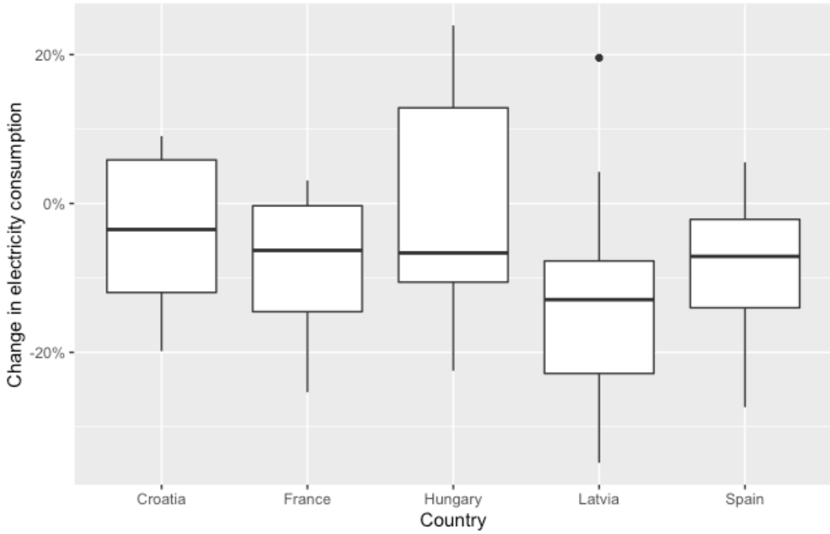

Fig. 3. Change in electricity consumption by country.

As in the case of heat consumption, Fig. 3 illustrates that changes of electricity consumption in the year of the energy saving competition differ widely even within countries. In four countries (France, Hungary, Latvia and Spain) at least one building achieved a reduction of its electricity consumption by 20 % or more in the year of the energy saving competition. As was the case for heat consumption, each country saw buildings that had a higher electricity consumption in the competition year compared to the baseline. Possible reasons for this are similar to those named in the case of heat consumption.

Table 6 shows the results of energy saving competition in absolute terms as well as the change in energy consumption (i.e. heat and electricity combined) for each of the five countries. Please note that the results in Tables 4 and 5 and Fig. 2 and 3 are evaluated on the level of buildings while the change in energy consumption in Table 6 is evaluated on the country level.

TABLE 6. NET ELECTRICITY AND HEAT SAVINGS IN THE YEAR OF THE SAVING COMPETITION

Country	$n_{electricity}$	Net electricity savings	n_{heat}	Net heat savings	Change in energy consumption
Croatia	12	32.8 MWh	8	122.0 MWh	–5.5 %
France	12	220.3 MWh	11	122.0 MWh	–7.4 %
Hungary	10	131.5 MWh	10	260.2 MWh	–9.9 %
Latvia	15	55.9 MWh	14	163.6 MWh	–8.1 %
Spain	12	194.2 MWh	–	–	–6.8 %
Total	**84**	**631.9 MWh**	**56**	**791.2 MWh**	**–8.4 %**

3.2. Survey Results

The second wave of the survey was conducted in January and February 2020, i.e. after the energy saving competition had ended. The survey was completed by 135 energy team members, of which one did not name the building he or she was responsible for. The remaining 134 energy team members came from 52 buildings, which corresponds to 57 % of all the buildings in the energy saving competition. We have calculated the five scores that have been defined above for all 52 buildings:

- Support from superiors: Most respondents agreed that their superiors were interested in the energy saving competition, motivated to support it and were supplying the resources the energy teams asked for. The arithmetic mean for the support score is 3.7, its standard deviation 0.8. The maximum value is 5, the minimum value 1.7;
- Interest: Most respondents estimated that a considerable share of their colleagues was at least fairly interested in the energy saving competition. The arithmetic mean for the interest score is 3.3, its standard deviation 0.9. The maximum value is 5 (i.e. one energy team member estimated that 100 % of his/her colleagues were very interested), the minimum value is 1.3;
- Motivation: Again, most respondents thought that a large share of their colleagues was at least fairly motivated to support the competition. The arithmetic mean for the motivation score is 3.3 (s = 0.9, max = 5, min = 1.3). The small differences between the interest and motivation score may signal that it was hard for respondents to discriminate between interest and motivation;
- Behaviour change: Respondents were even more positive that their colleagues changed their energy use behaviour. The arithmetic mean for the behaviour change score is 3.6 (s = 0.8, max = 5, min = 1.55);
- Helpful material: The helpful material score could only be calculated for 51 buildings. Overall, respondents considered the material distributed by the Compete4SECAP team

as helpful. The arithmetic mean for the helpful material score is 3.7 (s = 0.7, max = 5, min = 2.1).

We calculate Spearman's rank correlation coefficient for the correlation between the change in electricity and heat consumption and our scores separately and then test if each correlation is significantly different from zero. In calculating correlations, we only use data from five countries (Croatia, France, Hungary, Latvia and Spain) for the reasons explained above. We find all but one rank correlation coefficient to have the expected sign. The correlation between the change in electricity consumption and the helpful material-score is negative, but very weak and not significantly different from zero. The correlations between the other scores and the change in electricity consumption are weak or moderate, but significantly different from zero. Correlations between the change in heat consumption and the scores all have the expected sign, but are very weak or weak and not significantly different from zero. Table 7 shows the results of the analysis. These findings can be explained with the thesis that changes in electricity consumption were to a stronger degree caused by changes in user behaviour than changes in heat consumption. This assumes that the scores are proper indicators for changes in user behaviour.

TABLE 7. SPEARMAN'S RANK CORRELATION BETWEEN SCORES AND ENERGY SAVINGS

	$n_{electricity}$	$\rho_{s, electricity}$	n_{heat}	$\rho_{s, heat}$
Support from superiors	37	0.38*	25	0.09
Interest	37	0.42**	25	0.35
Motivation	37	0.56***	25	0.22
Behaviour change	37	0.38*	25	0.27
Helpful material	37	0.01	25	0.22

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4. DISCUSSION

Our study corroborates several findings from the literature. Energy saving competitions can help to save considerable amounts of energy just through small investments and changes in the energy use behaviour of employees. In our study, electricity and heat consumption has been lowered by on average 8 % and 7 %, respectively, in the year of the energy saving competition. This finding is consistent with earlier studies, though also at the lower end of likely energy savings due to combination interventions to change energy use behaviour [4]. The large standard deviation of changes in electricity and heat consumption we found in our sample is notable.

That the energy saving competition achieved energy savings is an important finding especially due to the fact that it was mainly executed with the local authorities' resources. Launching energy competitions as one of the actions of energy management system in municipalities delivers the same results as in other cases and can be introduced on an annual basis. Energy managers become important players to ensure direct energy savings in their public buildings with the training materials, energy monitoring and motivational instruments already available.

For energy saving competitions to be successful at the workplace, engagement of all employees working in a building is helpful. Energy team members, who answered our survey, mostly saw their colleagues as interested in the competition, motivated to support it and changing their energy use behaviour considerably. This is documented by the average of the respective scores being between 3 (fairly interested, motivated, etc.) and 4 (interested, motivated, etc.). Most respondents also felt supported by their superiors, which is important in light of the competing priorities discussed by Bull and Janda [6]. The scores for support from superiors, interest, motivation and behaviour change of employees as assessed by energy team members exhibit a positive (if weak or moderate) correlation with the change in electricity consumption. The correlations between these aforementioned scores and the change in heat consumption are very weak or weak and not significantly different from zero. The support materials distributed by the Compete4SECAP team have been shown to be helpful as documented by an average score of 3.7. Yet, how helpful the materials were in the eyes of the energy team members was not correlated with the changes in electricity and heat consumption.

Nevertheless, there are several limitations of our study that have to be kept in mind when interpreting the results. It was not possible to follow the competition protocol to the fullest extent in every country. Collecting reliable energy consumption data for calculating baselines and saving success was harder than expected. The fact that reliable data on energy consumption can be hard to access or collect in the case of public buildings underlines that energy management system could be of great help to municipalities. The data from only five countries could be used in our analysis and large changes in energy consumption (±20 %) do occur in the sample. Various reasons why these changes are probably due to actual variations and not due to measurement errors have been identified, but an unambiguous reason in every case could not been pinpointed. Another limitation is that the survey could only be conducted among energy team members. Therefore, there is only an impression of how interested, motivated, etc. most people working in a building seemed to others and not how they in fact felt. Energy savings have been corrected for outdoor temperatures, which make the estimation of energy savings more reliable and is a big advantage compared to other studies that have not done this. Nevertheless, a gold standard for estimating the impacts of energy saving competitions would be to have a randomised controlled trial, where buildings are randomly assigned to the trial group and a control group of buildings that do not take part in the energy saving competition. This was not possible in our project.

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Implementation of Certified Energy Management System in Municipality. Case Study

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***Abstract* – The European Union has taken the course to become climate neutral by 2050. To reach that target significant changes in all sectors are necessary, resulting in increasing regulatory pressure on energy producers, consumers and other sectors. Increasing legal requirements was also one of the reasons why the city of Daugavpils (population of 82 000) took a decision to implement an Energy management system (EnMS). In the boundaries of EnMS Daugavpils included more than 100 public buildings, public transportation and public lighting. This research paper presents results of the EnMS implementation, main drivers and barriers that Daugavpils has faced and overcome in the implementation process, and also assesses the benefits the city of Daugavpils has gained from EnMS. The success rate of EnMS in such an organisation as a municipality is based on the awareness and knowledge of the municipality's employees and support from the municipality leaders. The case study of Daugavpils shows energy savings of 12 % in the public building sector after implementing EnMS.**

***Keywords* – Energy efficiency; energy management; energy management systems; energy planning; ISO 50001; sustainable energy action plans**

1. INTRODUCTION

In the last decade, environmental and climate issues have significantly affected the decision-making process for policy makers, market and industry professionals. Many different policy instruments have been created to address climate issues, for example regulatory and economic tools carried out by governments, like laws, taxes, emission trading systems, and voluntary agreements, like certification schemes, labels, etc. [1], [2] One of the most applied tools for reducing environmental impact is the Environmental Management system (EMS) [3], [4]. While there can be many different EMS, even individually designed ones, the most widely known are ISO 14001 and European Union's EMAS (Eco management and auditing scheme). Implementation of these schemes helps organizations to be compliant with the growing regulatory requirements and to communicate environmental performance with the public [5]. Following the success of the Environmental management system, ISO 50001 Energy management system (EnMS) was launched in 2011. The aim of the standard is to enable organizations to establish the systems and processes necessary to continually improve energy performance, including energy efficiency, energy use and energy consumption [6]. EnMS helps energy efficiency measures become a part of daily processes, rather than individual energy efficiency projects [7].

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Backlund *et al.* has concluded that by improving energy management practices, it is possible to save up to 20 % of energy and that energy efficiency measures without proper energy management practices do not ensure the best results [8], [9]. Pelser *et al.* have found that it is possible to reduce electricity consumption at a cement plant by 25 % using the ISO 50001 approach and without additional investments in equipment [10]. Some countries have already introduced legislative requirements to introduce ISO 50001 in large industries [11]. Bottcher and Müller has studied the German automotive industries and found that implementation of ISO 50001 does contribute to better carbon performance, which is associated with better economic performance of the company. They also argue that the advantages of ISO 50001 compared to ISO 14001 are that the former is narrower and more focused on specific targets, and thus more comparable and measurable. Another advantage is that it requires more involvement of top management [12]. Phan and Baird has highlighted that there is variation in the extent of use of EMS across different industries, however all have been granted the same certificate [13]. Other authors also highlight that some organisations use ISO 14001 more as a marketing tool, while real environmental performance is mostly symbolic [14], [15].

ISO 50001 is applicable to any type of organization, from huge industrial enterprises to small organizations, and it is compatible with ISO 14001 and ISO 9001 due to its similar structure. It has international recognition; therefore, it is widely used [16]. Also ISO-maintained data shows that the number of issued certificates in Europe has increased significantly, from 5526 certificates in 2014 to 17 655 certified systems in 2017 [17]. Research shows that in countries with the highest number of certifications, the main reasons to adopt ISO 50001 are the presence of legislative norms to reduce GHG emissions and prior adoption of ISO 9001 and ISO 14001. If an organisation has already introduced any other ISO standard, it is easier to introduce new ones [18].

One of the approaches that has been used in many public and private buildings is the "Building Energy Management System" (BEMS) [19]–[23]. In most cases, BEMS includes smart systems, and analysis of energy use in buildings in relatively high detail and it is mostly used in huge buildings or building complexes. It can, however, become a heavy approach when applied to a large number of buildings, which can be widely spread across a bigger territory as in the case of municipalities. When a municipality has to manage energy in more than 100 buildings, as well as street lighting and transport, a more holistic and universal approach has to be used, to control the system centrally.

In recent years, municipalities have started to apply ISO 50001 methodology to their energy planning, showing promising results, that implementation of ISO 50001 in municipalities might foster energy savings faster [24], [25]. Data show that payback time of the implementation of EnMS in a municipality can be even less than a year [26].

Currently, approximately 20 municipalities in Europe have received an ISO 50001 certificate (no precise statistics are available, therefore the assumption is based on measures taken by EU funded projects, like "Energy for Mayors", "compete4SECAP", "5000&1 SEAP"). One of the main drivers to introduce EnMS in municipalities is a growing national pressure to achieve GHG and energy efficiency targets. In Latvia, for example, one of the problems identified is predominant reliance on the availability of EU funding, which contributes to negative fluctuations of costs (when external funding is available costs tend to increase) [27] and this issue can be addressed through sustainable planning.

Though the number of certified companies is increasing, the number of certified municipalities is still low. There are more than 9500 municipalities around Europe that have joined the Covenant of Mayors (CoM) initiative. Most of them have a potential to introduce

EnMS, however there is currently very few evidences whether and why municipalities should introduce EnMS for their assets.

The aim of this paper was to research and present the current status of EnMS performance in one municipality. To do so, three research questions were identified:

1. What is the precondition for implementation of EnMS?
2. What are the main benefits from implementation of EnMS in a municipality?
3. What are the most important factors for EnMS to successfully function?

The case study was used to research these questions. The studied municipality – city of Daugavpils – is the first municipality in Europe that certified ISO 50001 with the broadest boundaries. Analysis is limited to data gathered by municipality within EnMS since 2016 and historical data since 2014. An individual interview with the energy manager of Daugavpils city was carried out to understand the procedural practices. Daugavpils has a population of approximately 82 000. The results are not applicable to very large or very small cities. The choice of research methods is explained in the Methodology section.

2. METHODOLOGY

2.1. Background

Many European municipalities, including all CoM signatories, use Sustainable energy and climate action plans (SECAP) as a tool for addressing climate change and energy targets. CoM reports show that in many cases SECAP implementation has resulted in significant reduction of CO_2 emissions and energy consumption [28], [29]. But as Petersen argues, while leading municipalities show good results, less active municipalities struggle with meeting the energy and emission targets set in SECAP [30]. Therefore, effectiveness of SECAP methodology can be argued.

As energy planning for most of municipalities in Latvia is not mandatory, there is no defined framework of sustainable energy planning. Nevertheless, it is expected that municipalities act on increasing the share of renewable energy and reducing energy consumption. Research shows that in Latvia there is great potential for developing other renewable technologies, instead of biomass combined heat and power plants (CHP) [31], and great emphasis is placed on development of 4^{th} generation district heating systems [32], [33]. However, previous research shows that many municipalities lack the experience and knowledge to implement measures included in SECAP. Therefore, it is important to examine what instruments can motivate municipalities to implement approved SECAPs. From this perspective, EnMS according ISO 50001 is one of such instruments for municipalities with limited knowledge and experience as the standard provides clear structure and procedures for the introduction of a systematic reduction of energy consumption in public assets.

2.2. Theoretical Framework

The theoretical framework of this research paper is based on methodology proposed by Kamenders *et al*. (see Fig. 1) [26]. It was selected as the most appropriate and to the date as the only methodology to analyse the efficiency of EnMS in municipalities. This theoretical framework consists of four main phases.

The first phase is to ensure the political commitment of the municipality towards mid-term and long term local, regional, national and/or international energy and climate targets. It means that the municipality acknowledges the national goals and shows a willingness to act on them.

The second phase is the planning phase, when the municipality analyses the current situation, and based on the results of the analysis, sets annual quantitative and qualitative targets. The current situation analysis is carried out by the municipality itself or outsourced. Initially historic data are gathered to be used as a baseline for comparison. The municipality identifies actions to be implemented in order to achieve the targets.

The third phase is implementation and operation of the EnMS, which includes implementation of identified actions and procedures, e.g. regarding monthly data collection and assessment of deviations. According to this framework, implementation includes all the principles of energy management, including data collection and monitoring.

The last phase is checking, which includes internal audits, assessment of the results and measurements to identify strengths and weaknesses of the established system. In this phase, further corrective and preventive actions are taken.

The timeline of all four phases is one year. Based on the results from the checking phase, the municipality revises its commitment and sets new annual targets. This ensures that the overall energy management system is adaptive to new realities and necessities, and this adaptation process can be based on reliable data.

In this research paper, the theoretical framework is applied to analyse the case study of Daugavpils (see Section 3.3).

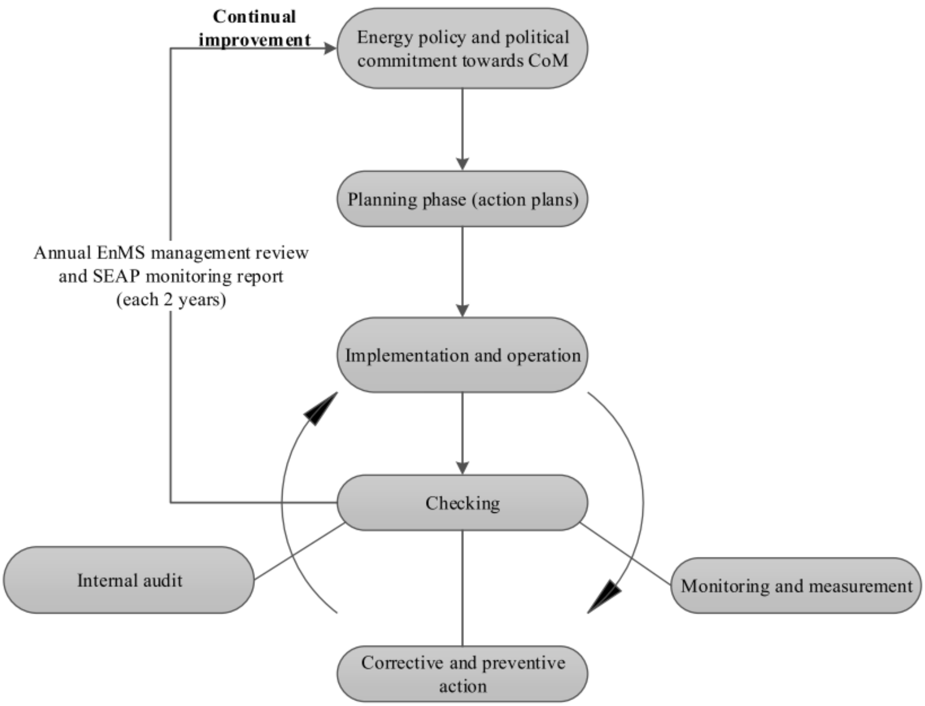

Fig 1. Methodology of the integrated EnMS and SECAP approach [26].

2.3. Background of the Municipality

The city of Daugavpils is the second largest city in Latvia with a population of 82 604 (at the beginning of 2019) [34]. It is located in the southeast of Latvia, close to borders with Lithuania and Belorussia. The municipality employs around 5910 persons. In 2015, the total heat consumption in public buildings was ~47.7 GWh; average specific heat consumption 185 kWh/m^2 a year. Total electricity consumption in public buildings was 17.1 GWh, electricity for street lighting was ~5.6 GWh. Energy consumption for public transport was ~13 GWh (buses, minibuses, trams) [35].

In 2016, Daugavpils signed the Covenant of Mayors and has participated in the 2017 CEM Energy Management Leadership award and received the Energy Management Insight Award for helping to build awareness of ISO 50001 and for contributing to global knowledge of energy management implementation.

2.4. Quantitative Data Collection

This study used multiple data collection and analysis methods, like desk research, policy document analysis, quantitative data analysis and a questionnaire. Two main policy documents were analysed "Daugavpils Sustainable Energy Action plan until 2016–2020" and "Energy management system manual for the city of Daugavpils", as well as annual ISO audit reports. Additionally, the questionnaire was used in a previous publication by Jekabsone *et al.* [36]. The questionnaire was completed by the energy manager of the city of Daugavpils, and it provided qualitative data about the EnMS implementation process.

All the energy data used in this article were collected by municipality personnel via an energy monitoring platform introduced in the municipality according to EnMS procedures. The municipality issued an order for technical personnel in the public buildings to ensure monthly energy data entry into the energy monitoring platform.

Technical personnel submit heat, electricity and hot water consumption data. The energy manager submits data on monthly energy tariffs and average outdoor air temperature. Heat energy consumption data are climate-corrected using a national methodology, which is based on ISO 13790:2008 that gives calculation methods for assessment of the annual energy use for space heating and cooling of a residential or non-residential building [37], [38]. Data analysis and visualization is available in the platform according to ISO 50001 requirements and local legislation. In case of each building, the platform calculates and reports monthly deviation in energy consumption.

In this research paper, only EnMS in public buildings were studied.

Data of the five-year period (2015–2019) has been analysed to understand the quantitative results of measures taken by the municipality. Daugavpils municipality has included almost all the municipal infrastructure in the EnMS, which makes their system the largest certified EnMS in Latvia. EnMS covers a significant part of sectors included in SECAP.

Currently the municipality has a database of energy consumption data since 2012.

Data of 2012–2015 were gathered during the first planning phase as historic data. Since 2016, the municipality started collection of actual monthly data through the online energy management platform. Additional information about buildings was requested from the energy manager of Daugavpils.

2.5. Analytical Framework

Based on the theoretical framework, assessment of the EnMS was performed in four phases through evaluation of the following aspects:

Phase 1: motivation of the city to develop EnMS (and SECAP);
Phase 2: setting EnMS (and SECAP) boundaries and targets;
Phase 3: introducing and organising EnMS implementation process;
Phase 4: assessing the monitoring and implementation process, including communication between departments and other stakeholders during implementation.

Within phase 1, the challenges the municipality faced regarding energy efficiency are explained, while in phase 2 the chosen targets and boundaries are analysed. In phase 3 the main steps for implementing the EnMS are explained. Phase 4 shows how the energy data were exchanged and organized before and after the implementation of the EnMS.

3. Analysis and Results

During 2015 and 2016, the city of Daugavpils worked in parallel on the development of both the SECAP and EnMS. The EnMS manual defines procedures for implementation, operation and monitoring of the EnMS, while SECAP defines strategic climate mitigation targets and actions in all the territory of the municipality. Both documents were approved by the city council in 2016. At the end of 2016, the city of Daugavpils received the ISO 50001:2012 certificate.

The estimated total budget for implementation of SECAP was 61 million EUR, from which 67 % was planned from EU funding, 19 % from the budgets of municipal enterprises, 9 % from the municipal budget, 5 % national government funding.

The share of the overall municipal budget dedicated to the public sector is 51–75 %.

3.1. Phase 1: Motivation of the City to Develop EnMS (and SECAP)

Between 2010 and 2014 multiple public building renovation projects were implemented in Daugavpils, mainly in education facilities. Upon completion, almost none of the projects met the expected energy consumption. This was one of the issues that led to the conclusion that energy efficiency should be addressed more diligently. Afterwards other challenges were identified, like:

– Lack of energy consumption data and its analysis;
– No responsibilities assigned to energy management, no energy manager;
– Selection of energy efficiency measures were “project-based” lacking a systematic approach and there was no methodology on how to select the buildings for renovation;
– Data collection was chaotic and with low transparency (hard to track down energy data and costs).

All these observations led to the conclusion, that energy management would lead to better decision-making and would save financial resources.

The municipality started the development of EnMS in late 2015 and early 2016. The whole process took about one year and the timeline of the main steps of the process is illustrated in Fig. 2. The city of Daugavpils received important support and training from external experts.

After the city initiated introduction of the EnMS in its assets, a new Energy Efficiency Law was approved in Latvia in 2016. The Law was based on the EU Energy Efficiency Directive [39] and introduced a new mandatory norm for the nine largest cities in Latvia (including the city of Daugavpils) to implement and certify EnMS. This was an important factor that accelerated the process.

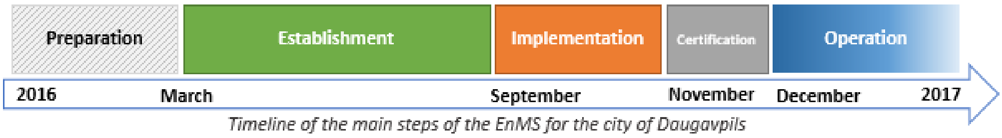

Fig. 2. Main steps of the EnMS implementation process [40].

3.2. Phase 2: Setting EnMS (and SECAP) Boundaries and Targets

The city of Daugavpils was working in parallel on its EnMS and SECAP. The main focus areas of SECAP are centralised heat energy production, energy savings in buildings, energy savings of street lighting and public transport. Energy performance of the private sector is included briefly in the form of informative measures, without strong commitments to gain results.

Initially the boundaries of the EnMS included 100 public buildings, public street lighting system with 9183 luminaires and total length of the system of 351 km as well as public transport with over 90 vehicles for 32 bus and 3 tram routes. In 2018 the boundaries were extended and now includes an additional 25 public buildings.

The share of each sector before EnMS implementation in 2015 is shown in Fig. 3. The largest sector is heating in public buildings (49 % of all energy consumption), 11 % is electricity consumption in buildings, 28 % is public transport, and only 10 % is public lighting [41].

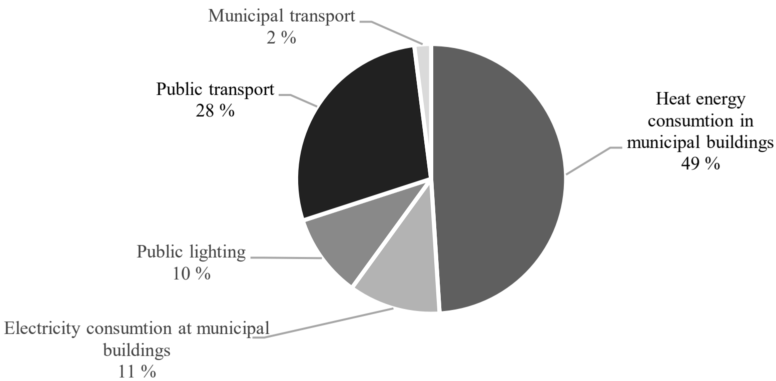

Fig. 3. Distribution of municipal energy consumption in Daugavpils in 2015.

If SECAP sets mid- and long-term targets, targets in EnMS are defined by the municipality annually. SECAP of Daugavpils sets a strategic goal to reduce CO_2 emissions by 40 % until 2030 in the whole territory of the city. EnMS was chosen as one of the tools to move towards this target.

In the meantime, the targets of EnMS in the first year (2016) were considerably grounded, i.e. to implement and certify the system, to identify 10 public buildings with the highest specific heat consumption, and to analyse the patterns and behaviours of the energy users in these buildings. Additionally, targets were also set for street lighting and the public transport sector. As only partial historical data were available for these sectors, the objective was to ensure monthly data collection. Quantitative targets related to the reduction of energy consumption were set starting from 2017.

Even though implementation of the EnMS in Daugavpils at that stage was a mandatory requirement, municipalities were free to set the boundaries of EnMS. In contrast to other cities, the city of Daugavpils decided to have large boundaries, including public buildings, street lighting and public transport.

3.3. Phase 3: Introduction and Organisation of the EnMS Implementation Process

The planning and implementation process of EnMS consists mainly of three steps – development of manual and procedures, issuing orders of responsibilities and organizing training for involved employees. The ISO 50001 standard itself doesn't require to develop a manual of the system, but as municipalities often have a high rotation of employees, this step is essential for maintaining the system without losing overall knowledge. After the manual and procedures were set, official orders were issued to technical personnel, defining how to collect and submit data. After this process, multiple trainings were organised for employees involved in the system, to motivate them by giving the understanding of the whole system and its targets.

3.4. Phase 4: Assessing Monitoring and Implementation Process, including Communication between Departments and Other Stakeholders during Implementation

Before the EnMS was implemented in Daugavpils, heat and electricity consumption data were gathered only at the building level. The appointed person of each building sent the readings of the energy meters to the energy supplier on a monthly basis. Based on the bill from the energy supplier, each building paid the bill. The annual energy budget of each building was ensured by the municipality and was based on the average costs in the previous year. Energy costs were not analysed separately from other costs in the building. At that time nobody in the building was informed about energy consumption on a regular basis, and in most of the cases data were not compiled even annually. The flow of energy data and financial resources in 2015 are shown in Fig. 4.

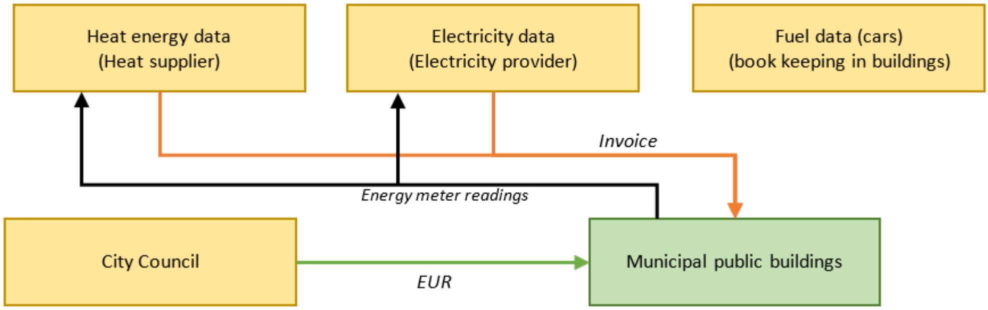

Fig. 4. Energy consumption data management system in Daugavpils municipal buildings before EnMS.

After the EnMS was introduced, new data information flow was introduced so the information would be gathered centrally, and analysed on a regular basis (see Fig. 5). Based on the results, feedback to buildings should be provided and reports to SECAP working group delivered to feed the decision making.

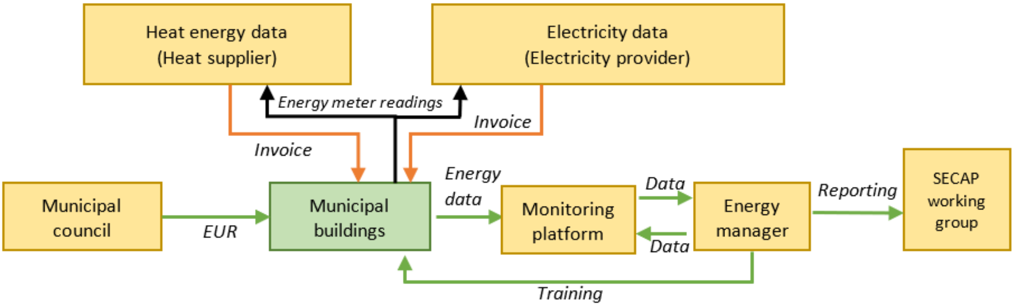

Fig. 5. Energy consumption data management system in Daugavpils municipal buildings after EnMS.

The administrative body that is responsible for SECAP and EnMS implementation is the Department of Development of the Daugavpils City Council. Approximately 218 persons are involved in EnMS to some extent, all the personnel costs are funded by the municipality. External experts are involved only for specific tasks where municipal personnel are not qualified, like, energy audit and ISO certification audit. Daugavpils also started to employ an energy manager – the person responsible for EnMS monitoring, maintenance, analysis of results and annual reports. The necessity of an energy manager was already identified by Dzene *et al*. in an article about the implementation of a centralized monitoring and energy management system [24].

Historical data were gathered during the development of SECAP, but within EnMS, Daugavpils started the systematic and continuous collection of monthly data. Daugavpils chose to use the Online Energy Monitoring Platform, a tool for data collection and analysis. Municipal employees have to insert data regularly, and the tool automatically calculates the deviations and analyses data tendencies. The energy manager then checks the data every month and acts on deviations, according to procedures. As other authors have discovered, the maintenance of monitoring is often the most complicated part of EnMS [42], [43], therefore a ready to use tool for calculations can play a significant role in success of EnMS.

The data of municipal buildings is gathered for each building separately where possible, if not aggregated data for multiple buildings are collected. Data that is collected is heat and electricity consumption, and it is done mostly by manual readings of energy meters. Monthly average temperatures and average tariffs are submitted by the energy manager. Municipality have indicated that the main obstacles concerning the collection of energy relevant data have been mistakes by personnel – faulty data readings, missing data because employee forgot to read the meter or was on sick leave, and no other person was assigned to the task. After facing these obstacles, the municipality improved its procedures, each person received clear guidelines on how the reading should be done, on what date and who should do it, if the person directly responsible is not able to read the measurements.

Few other obstacles were identified by the energy manager after implementation of EnMS, like low motivation of personnel involved in EnMS, lack of knowledge within municipal employees about energy efficiency of buildings, public lighting and transport and low understanding of EnMS data. These issues were addressed by organizing educational workshops and seminars for employees.

Some challenges with data collection and system management were identified during the certification audit in 2019. Mainly lack of human resources caused delays in reporting and data input. It has been suggested by auditors to improve the system on how information from employees is collected about suggestions of system improvements and to update energy strategies and policies on a regular basis. The results of the audit also showed that employees in all buildings and departments are informed and have knowledge about energy performance of the building, as a result of the EnMS implementation.

3.5. Analysis of Energy Data of Municipal Buildings

The ISO 50001:2018 standard stimulates organisations to introduce a systematic approach towards the efficient and rational use of energy. To assess the results, organisations should use key performance indicators. In case of buildings, one of the key performance indicators is specific energy consumption. It is essential to differentiate specific heat consumption and electricity consumption. Moreover, when applicable, climate corrected annual heat energy consumption should be used.

As the city of Daugavpils has more than 120 buildings in their EnMS, it is not enough to use performance indicators. Additional comparative analysis shall be made to select significant energy users, i.e. priority buildings.

Fig. 6 and Fig. 7 show a method how municipal buildings can be divided in four different groups to be approached accordingly. Data from the city of Daugavpils in 2015 and 2019 are used. Boundaries of these groups can be adjusted, depending on the energy data and how many buildings the municipality needs to include.

The main idea is to find the buildings with the highest energy efficiency potential, by dividing all buildings in four groups depending on their total energy consumption and specific heat energy consumption. The borders of the groups are defined according to the targets of the municipality, respectively lines (red dashed lines in Fig. 6) are drawn as close to the lower left corner as it is needed to distinguish enough buildings.

The least number of actions are required for buildings in the 3rd group, as they don't use much energy and are considerably efficient, which means that there is relatively small potential for energy savings. Also the 4th group can be considered as the one which doesn't require an action, but as these are buildings with large energy consumption, even a small decrease in specific energy consumption can ensure huge savings in terms of money. The 1st group of buildings are the ones with smaller total energy consumption, but very high specific energy consumption, which means that these buildings have a lot of potential for energy efficiency. The goal would be that all the buildings would reach the level of efficiency to be classified in the 3rd group. The group with the highest energy efficiency potential is group 2, as these buildings have high specific and total energy consumption. Often in these buildings even small energy efficiency measures can give significant benefits. Therefore, strategically the best decision is to invest in these buildings. And, in time, the buildings should be regrouped, and the borders should be moved closer to the lower left corner of the graph, for setting new priorities.

In case of Daugavpils, 5 buildings were in the 2nd group in 2015. One of the successful examples is building 5 – a specialized school with an area of 5844 m^2, which was renovated in 2013, but did not meet the expected energy efficiency level. The municipality introduced the regulation and automatization of the heating system, and eventually this building moved from the 2nd to 3rd group. Consumption in this building reduced from 1273 MWh in 2015 to 899 MWh in 2019, respectively specific consumption reduced from 218 kwh/m^{2}year to 154 kwh/m^2 year. Renovation has been started in the first building (care centre for the elderly) in 2019. At the 2nd, 3rd and 4th building, no significant actions have been taken, these buildings are the water management facility, tuberculosis hospital, and public transport station.

There were 3 buildings in the 3rd group. Positive improvements can be seen in all of them because of small improvements that have been done. The 6th and 7th were renovated in 2013–2014, but did not meet the target energy efficiency, but after EnMS implementation, the situation has improved.

Also 2 buildings in the 1st group were identified, because of very high specific heat consumption. Building 9 is a public sauna, which hasn't been addressed in terms of energy efficiency. Building 10 was renovated in 2013–2014, and did not meet the energy efficiency targets.

In all 10 buildings total energy savings in 2019 have been 11 %, compared to 2015.

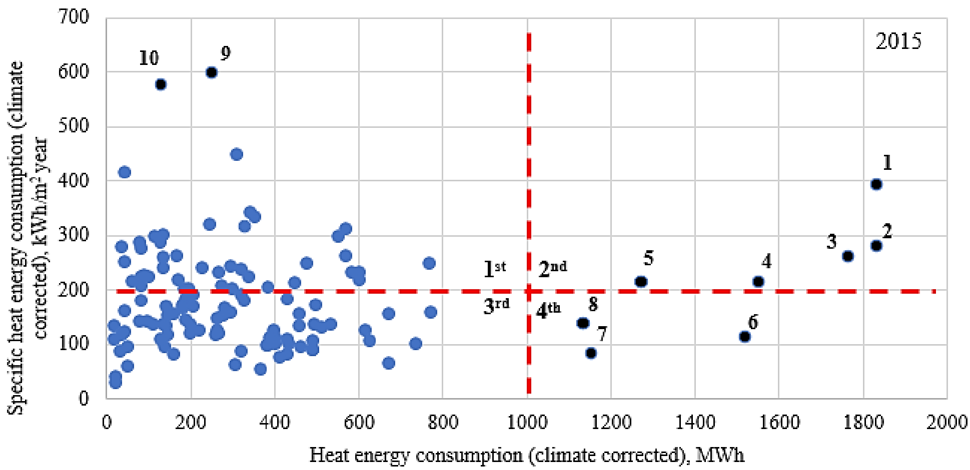

Fig. 6. Heat energy consumption at 123 municipal buildings of the city of Daugavpils in 2015.

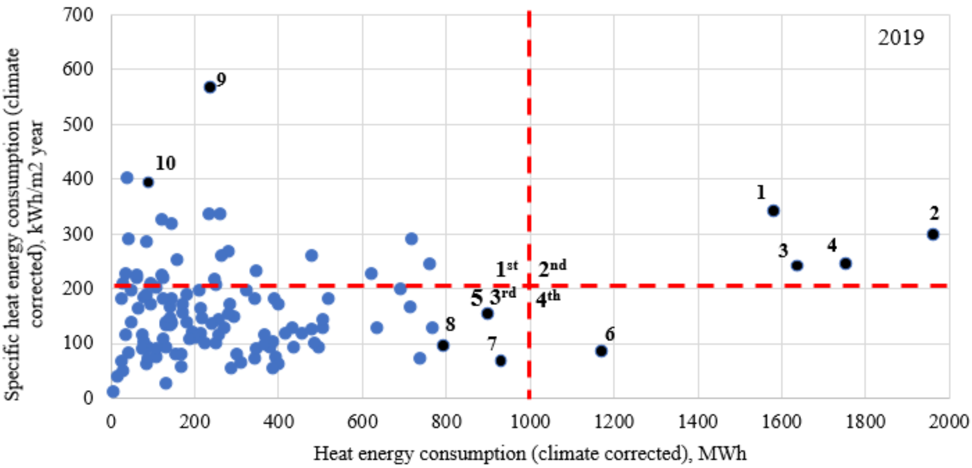

Fig. 7. Heat energy consumption at 123 municipal buildings of the city of Daugavpils in 2019.

One building – the city hospital – was excluded from the graph, because of its significantly higher energy consumption – 5240 MW in 2015 and 4288 MW in 2019 (climate corrected). The respective specific heat energy consumptions were 137.8 and 112.8 kWh/m^{2}year. Nevertheless, this building should also be addressed, as it has the biggest energy consumption in the municipality.

Since the EnMS was introduced, nine buildings (schools and kindergartens) have been renovated. Energy performance of these buildings before and after renovation is shown in Fig. 8. Energy consumption in most of the buildings has been significantly reduced. Energy savings in 2019 in 9 renovated buildings were 47.7 %. However, the full potential has not yet been achieved in three buildings where specific heat energy consumption is still above 150 kWh/m^2 year (buildings 3, 5 and 9). This indicates, that more action should be taken.

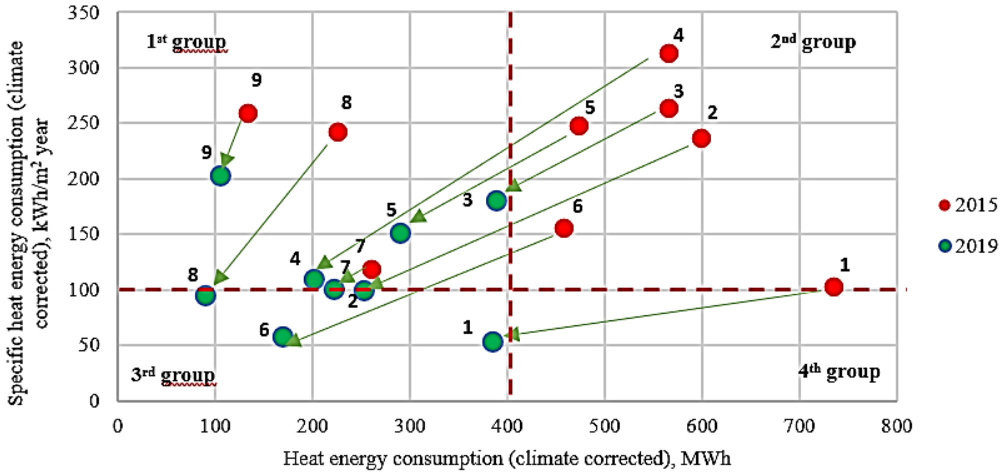

Fig. 8. Heat energy consumption at 9 municipal buildings of the city of Daugavpils which were renovated during 2016–2018.

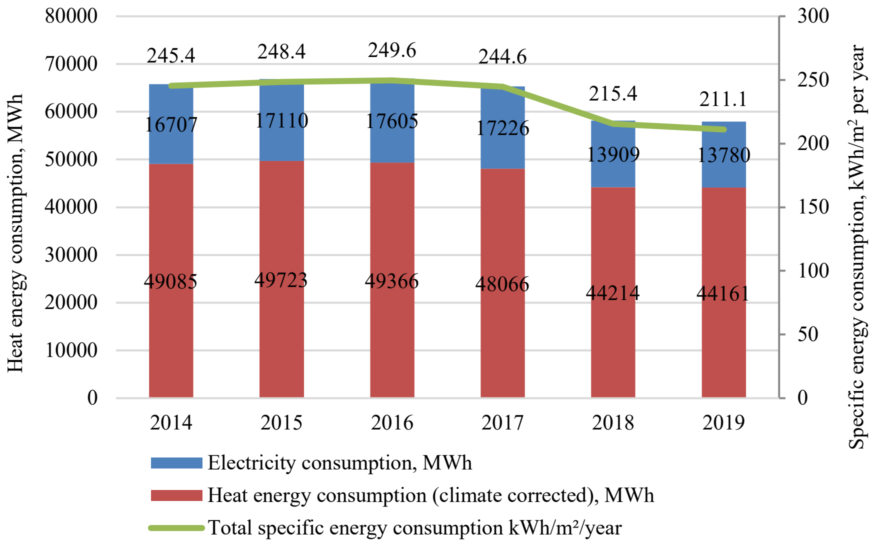

Fig. 9. Total energy consumption of 123 municipal buildings in Daugavpils (in 2014 and 2015 only partial historical data are available and energy consumption was higher).

Since implementation of the energy management system in 2016, heat energy consumption in all 123 buildings together has been reduced by 12 % or 5.2 GWh (climate corrected data). Electricity consumption in 2019 has decreased by 8 % compared to 2016.Also, only since 2016 full set of data for all buildings are available and data for 2014 and 2015 are partial, explaining the increase in energy consumptions from 2014 to 2016.

3.6. Cost Savings and EnMS Implementation Costs

Every year the Daugavpils municipality spends around 5.5 to 6 million EUR for energy in public buildings (heating and electricity). In 2019 due to the energy savings, costs for energy were reduced by 8 % compared to 2016, when EnMS was implemented. This was achieved even though electricity costs increased during these years.

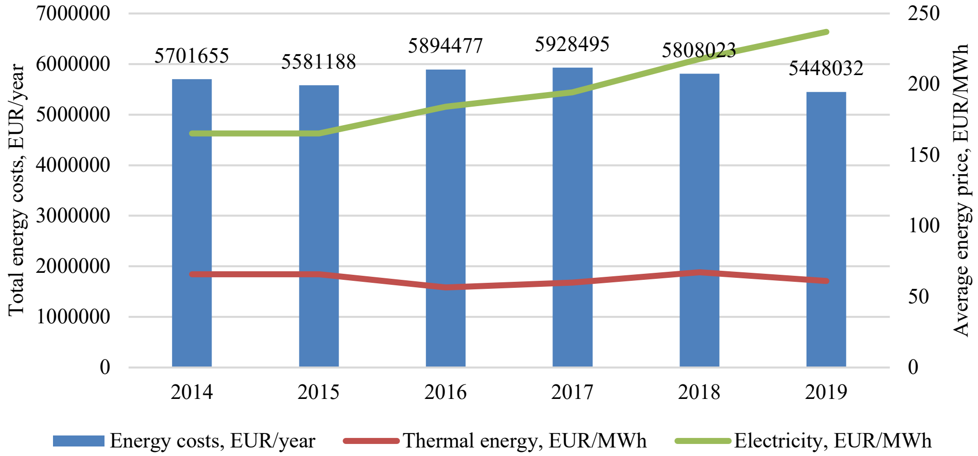

Fig. 11. Energy costs in 123 municipal buildings in the city of Daugavpils.

According to the information received from the Daugavpils energy manager, implementation of EnMS and certification of the system has cost approximately 12 thousand euros. Investments paid off in less than one year.

4. Discussion

Previous research has shown that in many cases municipalities are encouraged to develop sustainable energy and climate action plans, but eventually they do not know how to properly work with data and make evidence-based decisions. In contrary, the city of Daugavpils has not only developed SECAP but has also created a system for data collection and analysis, and continues to improve and extend the system. A few strategic decisions have allowed them to move forward with sustainable development.

Daugavpils chose to use EnMS as a tool for addressing energy issues, as the municipality has very diverse needs. In this case application of BEMS approach could become too heavy and knowledge intensive for such a large system of more than 100 buildings. Success of Daugavpils' case could be explained by transparency and adaptability of the system, allowing for its gradual expansion and improvement.

The first research question was – what is the precondition for implementation of EnMS? In case of Daugavpils, the most significant factors were two, one was that the administration of the municipality acknowledged that energy efficiency measures do not reach the expected results. The other factor was legislative requirements that came into force shortly before the municipality implemented EnMS.

The second research question concerned the benefits of implementation of EnMS. In case of Daugavpils, success can be defined first of all by energy and financial savings. In the meantime, the system has also ensured a structure and knowledge to municipality for future decisions. From the very beginning, Daugavpils included within the system most of the city's infrastructure from three main sectors – public lighting, public transport and municipal buildings. They successfully certified the system according to LVS EN ISO 50001:2012, and are gradually adding more objects to the system. Daugavpils has managed to reduce heat energy consumption by 12 % compared to 2016 in the building sector. Most importantly, the municipality has started to use data for decision making. According to SECAP one of the targets for 2020 was to reduce heat energy consumption in public buildings by 10 %, comparing to 2014, and this target has been achieved already in 2019 reaching a 11 % reduction (comparing 2016 to 2019, reduction is 12 %). Real data for public lighting and transport have also been collected. As the historical data were based on many theoretical assumptions, and real data were not available, detailed analyses of these two sectors are not included in this article. For these two sectors, the main goal was to start collecting real data to understand the actual situation and to enable future decision making based on this data.

The third research question was – what the most important factors for EnMS are to successfully function. In the case of Daugavpils, one of the most important success factors, was the appointment of an energy manager, and very specific allocation of responsibilities among employees. Most importantly, the distribution of responsibilities was done by official order of the executive director, giving a signal from municipal leaders that there is support for EnMS in the city council.

Even though EnMS implementation in Daugavpils can be considered as successful, heating data analysis show that not always the largest and most inefficient buildings are chosen for renovation, even though data is available and acknowledged. A significant factor in the decision-making process is the availability of financial support from different funds and programmes. Therefore, in recent years renovation projects were implemented mostly in educational buildings.

Since previous research about the application of ISO 50001 in municipalities is limited, this research paper gives significant insight on the effectiveness of using an energy management system approach in municipalities. Further research should be done, to find how EnMS could be implemented in smaller municipalities or more rural municipalities, and how street lighting and public and municipal transport data could be analysed.

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Getting Municipal Energy Management Systems ISO 50001 Certified: A Study with 28 European Municipalities

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Abstract: Managing energy use by municipalities should be an important part of local energy and climate policy. The ISO 50001 standard constitutes an internationally recognized catalogue of requirements for systematic energy management. Currently, this standard is mostly implemented by companies. Our study presents an approach where consultants supported 28 European municipalities in establishing energy management systems. A majority (71%) of these municipalities had achieved ISO 50001 certification by the end of our study. We also conducted two surveys to learn more about motivations and challenges when it comes to establishing municipal energy management systems. We found that organizational challenges and resource constraints were the most important topics in this regard. Based on the experiences in our study we present lessons learned regarding supporting municipalities in establishing energy management systems.

Keywords: local climate and energy policy; energy management; ISO 50001; motivations; challenges

1. Introduction

Municipalities are widely seen as important actors when it comes to mitigating climate change. Consequently, a large number of municipalities have committed to ambitious energy and climate policy goals. Many municipalities do so by joining transnational initiatives for climate action such as the Covenant of Mayors (CoM). By joining the CoM, municipalities not only commit to mitigation targets, but also develop Sustainable Energy and Climate Action Plans (SECAP). An important mode of governance in these plans is what Palermo et al. [1] named "municipal self-governing." By analyzing the baseline inventories submitted by new signatories of the CoM, Bertoldi et al. [2] found that activities under direct municipal influence are responsible for, on average, 5% of a city's emissions. This includes the emissions caused by municipal buildings, public lighting, the municipal fleet, public transportation, as well as waste and waste water management. An important measure to deal with these emissions is to introduce or improve energy management [1]. With an energy management system (EnMS) an organization can establish energy targets and processes to achieve those targets. An important standard in this regard is ISO50001:2018, which gives guidance on the elements of an energy management system [3]. The ISO 50001 standard defines a good practice standard for energy management, and models of energy management going beyond its requirements have also been discussed in the literature [4]. Energy management systems adhering to the ISO50001:2018 standard can be certified by external organizations. To date, EnMS based on this standard have mostly been implemented by companies. The number of municipalities in the European Union holding an ISO 50001 certificate is very low [5]. Based on data from the ISO survey 2019, there were 18,227 valid ISO 50001 certificates at the end of 2019 [6], of which only 34 were from the public administration sector.

Scientific literature on energy management systems based on the ISO 50001 standard is scarce. Most papers on ISO 50001 EnMS deal with energy management systems in companies, for which even a standardized protocol for energy assessment has been developed [7]. Regarding energy management in industrial companies, several assessment models have been proposed and put to test [8]. In general, high hopes have been placed on the possible impacts of successful energy management. Against the backdrop of the European Union's 2030 climate and energy policy framework [9], ISO 50001 EnMS can contribute to attaining the EU-wide energy efficiency targets. McKane et al. [10] estimated annual primary energy savings of 16 Exajoule (EJ) and a reduction in greenhouse gas (GHG) emissions of 1 gigaton in the year 2030 assuming that 50% of global industrial and service sector energy consumption is managed according to ISO 50001 by then. In their scenario, cumulative energy cost savings amount to nearly USD 700 billion (2016 net present value). This shows that energy management in itself can contribute considerably to energy savings and mitigation. Although the ISO 50001 standard is mainly focused on energy use and energy consumption, the standard allows us to consider the consumption of renewable energy generated within the scope and boundaries of EnMS as a separate objective [3]. Thus, a widespread use of ISO 50001 could also contribute to the EU-wide use of renewable energy and sustainable energy development [11,12], which is important in light of the EU's energy and climate policy framework [9]. António da Silva Gonçalves and Mil-Homens dos Santos discussed possible changes to the ISO 50001:2011 standard that could help to increase the standard's impacts related to sustainable development [13]. The high salience of climate change and strong efforts to mitigate emissions have been found to be an important factor in ISO 50001 EnMS adoption [14].

As a main objective of the study was to collect data on the importance of certain challenges in establishing EnMS and motivations to do so, earlier results in this regard are especially pertinent to the study. Rampasso et al. [15] reviewed scientific literature on challenges in implementing an ISO 50001 EnMS and only found 17 articles dealing with this topic. The challenges they found most often were lacking resources (financial, technical, or personnel), data problems (e.g., problems with determining the energy baseline), human resource deficiencies, and lack of leadership support. Wulandari et al. [16] discussed motivations for establishing an ISO 50001 energy management system, difficulties, and benefits based on a survey of 57 Spanish companies. They identified increasing energy efficiency, raising employee awareness for energy-use behavior, and the leadership's initiative as the most important motivations for introducing an ISO 50001 EnMS. To their respondents, data collection and management as well as limited financial resources were the hardest difficulties [16]. Marimon and Casadesús [17] further analyzed the same dataset with respect to the companies' motivations for establishing an energy management system, the difficulties encountered during the process, and the benefits of the energy management system. Using exploratory factor analysis, they identified social requirements, ecology drivers, and competitive advantage as latent variables. Among the variables measured for social requirements were incentives from the government, ecology drivers such as the mitigation of GHG emissions, and also energy efficiency and energy costs, whereas competitive advantage was measured by items such as image improvement and requirements of clients [17]. Ecology drivers were found to have the highest importance, followed by competitive advantage and social requirements. Regarding difficulties in establishing the energy management system, Marimon and Casadesús [17] distinguished operational difficulties (e.g., data collection issues, inadequate economic resources) and organizational difficulty (e.g., weak leadership commitment and benefit uncertainty) and found operational difficulties to be a little more important (though still low). To the respondents in their sample, ecological benefits (e.g., energy savings and better environmental performance) were more important than production benefits (e.g., productivity and process optimization). Karcher and Jochem [18] analyzed the results of a survey among 121 companies from Germany that had established a certified ISO 50001 energy management system. A large majority (84%) of these companies were from the manufacturing sector. In their sample, the reduction of energy costs was the main motivation for establishing an energy management system. Making use of subsidies, employee acceptance, and image advantages were additional motivators. Regarding the process of establishing and getting the energy management system certified, Karcher and Jochem [18] found that for more than half of the responding companies, involving external consultants was important. Fiedler and Mircea [19] also emphasized that consultant support is helpful in establishing an energy management system and pointed out that suitable software is very useful for collecting and monitoring energy data. De Sousa Jabbour et al. [20] highlighted that ISO 50001 energy management systems can also contribute to better considering sustainability in procurement decisions. Most of the scientific literature on ISO 50001 energy management systems covers results from companies. The use of energy management systems by public administrations in general and municipalities in particular is an under-researched area. Dzene et al. [21] pointed out that energy management systems based on the ISO 50001 standard can lead to real energy savings by municipalities. Therefore, an energy management system can contribute to attaining municipal energy and climate goals and fulfilling the aims stipulated in SECAPs. Establishing an energy management system can both form ground for appointing an energy manager with responsibility for the energy consumption under direct control of the municipality and streamline the collection and analysis of energy consumption data. In their case studies this was something Dzene et al. [21] found to not have been optimal before the energy management system's establishment. Based on a case study for Latvia, Beihmanis and Rosa [22] gave guidelines for implementing energy management systems and stressed that having an energy team of municipal employees tasked with establishing the energy management system and equipped with the necessary resources has high priority. Kamenders et al. [23] noted that having no energy manager, small financial resources, and missing or incomplete data are major challenges to overcome on the way to a functioning EnMS. They also emphasized that assistance by consultants experienced with energy management systems can be of critical importance. Jekabsone et al. [5] reviewed the case study of the Latvian city of Daugavpils, where the authors supported the municipality in implementing an energy management system. The implemented energy management system was certified according to ISO 50001 in 2016. More than 100 public buildings, public street lighting, and the public transportation system are within the boundaries of the EnMS. In the case study by Jekabsone et al. [5], the EnMS helped identify public buildings with high specific and absolute energy consumption and prioritize energy efficiency measures, including renovation. In 2019, the heat consumption of public buildings was 12% lower and electricity consumption 8% lower than in 2016.

The results presented in this paper were generated within the project Compete4SECAP that was funded by the European Union within the Horizon 2020 framework. The municipalities participating in our study were from seven European countries: Croatia, Cyprus, France, Hungary, Italy, Latvia, and Spain. The first main objective of this study was to test whether a substantial number of municipalities could establish an energy management system fit to be certified according to the ISO50001:2018 standard with the help of external assistance. A second question in this regard was whether an EnMS constitutes a systematic approach that facilitates energy savings. The paper aims to contribute to the state of research by exemplifying the process of introducing energy management systems for municipalities. It also presents results on the share of municipalities that obtained ISO 50001 certification within the study period and data on energy savings that were possible even at an early stage of improvements of energy management. Four case studies serve to describe the examples of the EnMS that were established and impacts achieved by the end of the study period in greater detail.

The third main objective of the study was to collect data on motivations for establishing energy management systems, challenges encountered during the process, and energy management's potential benefits in the case of municipalities. As EnMS have mainly been established in private companies and not municipalities, data on motivations, challenges, and benefits exist for private companies but are novel for municipalities.

The structure of the paper is as follows: The Methods section details the external support the municipalities received in establishing the energy management system. Two surveys, which were conducted in 2020, are described in the Methods section as well. The result section gives data on the number of municipal energy management systems in place at the end of the project, their boundaries and scope, and, where available, changes in energy consumption observed in 2019. The Results section also reports the results of the two surveys. The paper closes with conclusions from our research and discusses lessons learned.

2. Materials and Methods

Developing an EnMS for a local authority is a one-time process, however, operation and improvement of it is continuous. The initial process is time consuming and in most of the cases municipalities need to have external assistance to establish an EnMS. The relevance of external assistance has already been identified in the case of companies [18,24]. As Figure 1 shows, the main activities within our study can be divided into pre-certification activities, post-certification activities, and evaluation. At the beginning of our study, we invited municipalities to join. Municipalities had to appoint energy managers and teams responsible for establishing the energy management system. In this work they were supported by consultants. The pre-certification phase ends with the certification audit. After the certification the EnMS is operated continuously and improved iteratively. A surveillance audit facilitates improving the EnMS. A consultant keeps supporting the municipalities during this phase when needed. The importance of continuous improvement of energy management practices was stipulated in the ISO 50001 standard [3], but was also widely discussed in earlier scientific studies on energy management [4,8].

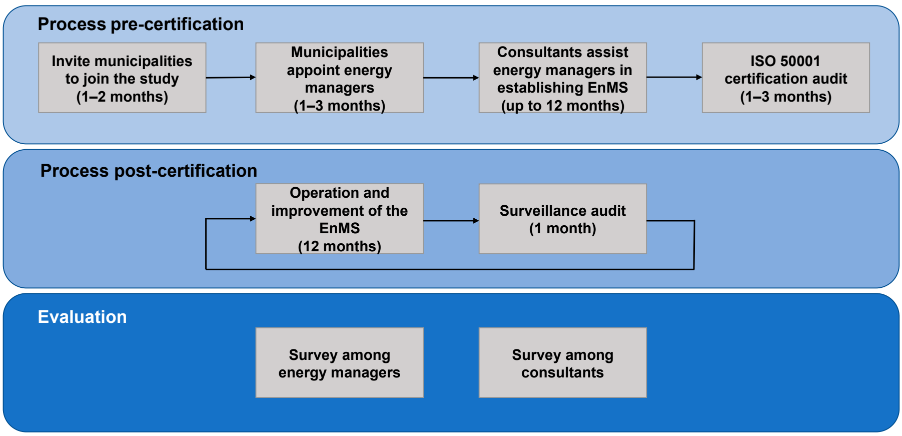

Figure 1. Activities during the study.

To evaluate the process of establishing the EnMS two surveys were conducted: one among the energy mangers, the other among the consultants supporting the municipalities. Originally it was planned to only conduct the surveys in the post-certification phase. Due to delays in some municipalities, their energy managers and consultants were surveyed in the pre-certification phase.

2.1. Consultant Support

The day-to-day work of municipal workers, combined with their lack of experience with EnMS, makes the support of an external consultant desirable [21]. In addition, an external and independent view allows for a better design of the procedures that make up the EnMS. The municipalities were supported in the process of establishing an EnMS in several ways:

- A guidebook on EnMS gave detailed information on the requirements an ISO 50001 EnMS has to fulfil as well as how to implement and operate one.
- Municipal energy managers and their energy teams were supported in developing an energy policy, with the energy review including the identification of significant energy-using sites (e.g., street lighting or large municipal buildings) and the definition of baseline values, and determining targets and actions for the energy improvement period. Street lighting has been identified as an energy use that allows for retrofits that are relatively easy to implement and promise relatively large decreases in energy consumption [25]. Regarding improving the energy efficiency of public buildings, earlier studies found information and awareness about energy use in public buildings an important prerequisite, although not necessarily sufficient [26].
- All of this information and related procedures were combined in the EnMS manual, compatible with the ISO 50001:2018 standard.
- An internal audit was conducted with a standardized template developed for the study. This internal audit encompassed a detailed questionnaire with which the energy managers and energy teams could check whether they had taken all the important steps before the certification audit. The questionnaire could also be used after the certification audit to monitor the continuous adherence to the standards.
- An online energy monitoring platform that was adapted to national requirements facilitated the monitoring and analyses of municipal energy consumption by providing a standardized method and reducing the effort associated with energy monitoring. That proper software facilitates energy management was already found in earlier studies [19].
- Municipalities were assisted in certification cost assessment and the evaluation of the offers received by certification bodies. Energy managers and their teams were supported in preparing the certification audit and during the certification audit itself, if necessary.

In short, we ensured that external assistance was continuously available to the energy managers and their teams both before and after the certification audit.

2.2. Survey among Energy Managers

Once the EnMS were implemented and operational, an online survey was conducted among the energy managers responsible for the energy management system between May and October 2020. In most cases, an interviewer walked the respondent through the questionnaire. In some cases, the respondent entered the responses by themselves. Respondents were not asked to name the municipality they were working for based on the assumption that this would make it easier for them to give honest assessments even when they were critical of the resources their superiors gave them. The survey had the following goals:

- Collect data on the municipality's motivation to establish an energy management system. Respondents were first asked to name the three important motives. Afterwards, we showed them possible motivations and asked them to rate their importance on a five-point scale from "not important" to "very important." We phrased the items based on the results by Marimon and Casadesús [17]. The motivations we named referred to social requirements (e.g., demands by councilors, legal requirements, the project Compete4SECAP), ecology and economy drivers (e.g., reducing energy costs, mitigating GHG emissions), and something akin to competitive advantage (e.g., being a role model for local companies, rationalization of inefficient workflows).

- Collect data on challenges in establishing an energy management system. Again, respondents were asked to spontaneously name the three challenges that were hardest to overcome. Afterwards, respondents rated how hard it was to overcome certain challenges on a five-point scale from "not at all" to "extremely." The items we used were based on topics discussed in the literature [17] and ranged from data collection (e.g., missing historical data, too few meters) to organizational difficulties (e.g., cooperation between a large number of departments, little political support) to benefit uncertainty (i.e., possible energy cost savings are seen as negligible). Organizational difficulties such as limited cross-departmental cooperation [27] and getting energy-related projects on the political agenda [28] were identified as major barriers in the scientific literature on municipal energy and climate policy.
- Several questions and items were aimed at assessing the benefits and impacts of the energy management system as energy managers see them. Items referred to, for example, the monitoring of energy data before the establishment of the EnMS, whether the EnMS motivated the municipality to set more ambitious energy-saving targets, and whether the EnMS led to greater consideration of the role of energy efficiency in making procurement decisions. Respondents were asked to state their level of approval on a five-point scale from "strongly disagree" to "strongly agree." Furthermore, respondents also estimated whether and how the EnMS changed the probability of certain events happening on a five-point scale from "much lower" to "much higher." Here we named, for example, regular training on energy conservation behavior for employees. Possible benefits named in the survey reflected that energy management should not only address technologies, but also administrative and staff-related practices [24]. Additional items for this question were the prioritization of investments based on their energy-saving potential and a higher budget for energy efficiency. A study of Swiss companies with high energy consumption showed that better energy management made it more likely that a company would approve an investment in energy efficiency [29]. The importance of adequate resources for energy efficiency retrofits of public buildings was emphasized in the relevant scientific literature [26].
- In addition, we queried data on the size of the team responsible for the EnMS and some other factual statements, for example, whether the EnMS had already been certified and regarding the energy performance improvement period.

Respondents answered closed assessment questions on a five-level scale. We assumed the levels to be equidistant and therefore treated the answers as interval scaled. We converted the answers to numerical values as defined in Table 1. Accordingly, we report the arithmetic mean $\overline{x}$ and standard deviation s for each item in the Results section. The data was analyzed and figures were created with the tidyverse collection for R [30]. Because of the small size of the sample, we could not perform an exploratory factor analysis similar to Marimon and Casadesús [17] to identify possible latent variables [31].

Table 1. Scales used in the survey and respective numerical values.

	Motivation	Challenge	Statement	Change
1	Not important	Not at all	Strongly disagree	Much lower
2	Slightly important	Slightly	Disagree	Lower
3	Moderately important	Moderately	Undecided	About the same
4	Important	Very	Agree	Higher
5	Very important	Extremely	Strongly agree	Much higher

2.3. *Survey among Consultants*

An additional online survey among the consultants supporting the municipalities in establishing an EnMS was conducted in November and December 2020. The goal was to also obtain an outside perspective on the municipalities' energy management. Given that the consultants were not employed by the municipalities, we reasoned that they might be more impartial in their assessment. Consultants were asked to give their assessment of various topics:

- the state of the energy management before the process to establish an EnMS began and how surprising the results of the energy review were;
- how hard it was to overcome the challenges in the consultants' view;
- whether they believed the municipality would have introduced the EnMS without their support;
- the scope and boundaries the municipalities chose for their EnMS;
- the ambition of the municipalities' energy targets and action plan;
- the likelihood of attaining the targets for the energy performance period; and
- the likelihood that the municipality would commission the recertification audit.

Consultants gave their assessment for each municipality they supported individually. Wherever we used five-point scales, the answers were converted to numerical values using the conversion factors from Table 1.

3. Results

3.1. Results of EnMS Establishment

By the end of our study (end of 2020), 20 of the 28 municipalities aiming for an ISO 50001 certified EnMS had achieved certification. This equals 71%. Two municipalities had completed the certification audit, but were still waiting for the certificate. Furthermore, 15 of the 28 municipalities (54%) had already completed the second management review by the end of December 2020. The 28 municipalities had an annual energy consumption of nearly 187 GWh, within the scope and boundaries of the energy management systems. Energy consumption of the 28 municipalities within the boundaries and scope of the EnMS was already lower by 15 GWh in 2019. By the end of 2019 not every municipality had achieved certification, but every municipality had started the process to establish the EnMS. The year 2019 is the latest year for which data are available. The savings we found hinted at the process of establishing an EnMS in itself, allowing not only for saving potential to be identified, but also already facilitating some savings to be realized.

In total, the action plans in the 20 municipalities that had achieved ISO 50001 certification by the end of 2020 encompassed at least 92 actions. Of these actions 55% were technical measures, 30% organizational/institutional measures, and 15% educational measures. This shows that the EnMS established within our study simultaneously acted on technological, non-technological, and support aspects, as urged in the scientific literature [24]. Technical measures comprise the replacement of equipment, organizational measures enable a better monitoring and control of energy consumption, and educational measures lead to greater awareness about energy-use behavior and educating municipal employees. Table 2 gives an overview of the type of actions the EnMS action plans contain.

Table 2. Measure categories and examples of actions in the EnMS action plans.

Category	Subcategory	Examples of Actions	Share
Educational measures	Raising awareness and education	Trainings, energy saving competition, information campaigns, motivational workshops	15%
Technical measures	Energy efficient appliances	Replacement of inefficient appliances	55%
	Heating, ventilation and air conditioning (HVAC)	Replacing air conditioning (AC) or ventilation system, installation of thermostatic valves, building automation	

Table 2. *Cont.*

Category	Subcategory	Examples of Actions	Share
	Lighting	Replacing incandescent light bulbs with light-emitting diodes (LED), refurbishment/replacement of street light control systems	
	Refurbishment of buildings	Refurbishment of doors and windows, insulation, green roofs	
	Renewable energy	Installation of solar panels	
Organizational measures	Monitoring and control of energy consumption	Operational procedures, use of energy monitoring platform, analysis of energy-use patterns	30%

3.2. Four Cases from France, Italy, Latvia, and Spain

The following section presents four cases of local authorities that established an ISO 50001 certified energy management system within our study. Table 3 summarizes core data for the four cases.

Table 3. Data for the case studies.

Scope and Boundaries						
Municipality	**Energy Team Members**	**Public Buildings**	**Street Lighting**	**Municipal Fleet**	**Annual Energy Consumption within Scope (MWh/a)**	**Reduction of Energy Consumption Year 1 (MWh/a)**
Cieza, Spain	4	4	Included	-	2180	207
Rubano, Italy	12	24	Included	-	5444	56
Saldus, Latvia	6	90	Included	180 vehicles	12,970	779
Montauban, France	10	3	Partly included	-	1600	263

Cieza is a Spanish city with about 35,000 inhabitants. The EnMS that was set up within our study has four public buildings and a street lighting system within its scope and boundaries. The process to establish the energy management system began in February 2019. Certification was achieved by December 2019. The most important challenges we encountered during the process were complying with regulatory provisions because of the old facilities of the municipality, the lack of human resources for the establishment of the equipment, and the lack of economic resources for planning measures in the EnMS, which is something that has become even more difficult during the COVID-19 pandemic. Measures that were implemented within the energy management system's action plan were converting incandescent bulbs to LED, raising awareness, and obtaining energy certificates for the four buildings included in the EnMS.

Rubano is an Italian city with about 16,500 inhabitants. Its EnMS comprises 24 public buildings, a street lighting system (2500 lamps), eight photovoltaic plants, and three solar thermal plants. The municipality began monitoring the energy consumption of its assets as early as 2010. The activity was launched after joining the Covenant of Mayors initiative signed by the municipality in 2009. The monitoring continued over the years and was presented in the Sustainable Energy Action Plan (SECAP) and in the subsequent biennial monitoring of this plan. In September 2018 the municipality began the process of establishing an EnMS and achieved certification by September 2019. By the time the process to establish EnMS was started, Rubano already had an ISO 9001 quality management system in place. During the process of establishing the EnMS, the main challenges were to set up an internal group dedicated to the activity of the EnMS (energy team) that could guarantee continuity in the long term, guarantee a periodic and timely control of energy performance and deviations, integrate the constant presence of top management representatives to the working group, and being able to integrate two parallel systems for quality and energy management without excessively changing internal procedures and organization within the municipality. The measures that were realized as part of the EnMS action plan included lighting retrofit with transition to LED technology in sport facilities, installation of mechanical ventilation systems for changing rooms and gyms owned by the municipality, operational and management control of public lighting, and closing a procurement and construction (EPC) contract aimed at improving the efficiency of the systems. Furthermore, information and training campaigns on energy-use behaviors in schools and municipal libraries were conducted.

Saldus is a Latvian municipality with about 22,000 inhabitants. The municipality's energy management system has 90 public buildings, street lighting, and the municipal fleet within its scope and boundaries. Saldus initiated detailed energy data collection as early as 2015, and the process to establish a standardized energy management system started in August 2018. It obtained the ISO 50001 certificate in June 2019. The main challenges in this process were historical data gathering, involvement of the energy users to collect and submit actual monthly energy data, and the introduction of daily routines according to the standard. Among the measures that were implemented as part of the EnMS were the replacement of incandescent light bulbs with LED, adjusting and optimizing the settings of HVAC systems in several buildings, and actions to raise awareness about the importance of user behavior and incentivize energy conservation behavior.

The City of Montauban and Grand Montauban (city and conurbation of 77,000 inhabitants) hesitated to implement an ISO 50001 EnMS. The energy team was unsure how much time they could devote to it, knowing that their schedule was already busy. By weighing the pros (formalized management method, identification of actions, etc.) and cons (time, financial costs, etc.), Montauban finally committed to establishing an EnMS with limited scope and boundaries. This solution enabled them to adopt the ISO 50001 method without major investments in terms of internal resources, and with the aim of subsequently expanding the scope of the EnMS. The initial perimeter corresponds to three buildings spread over two sites of the local authority and four public lighting cabinets comprising 843 light points (8% of the total). The total energy consumption within the EnMS's scope and boundaries amounts to approximately 1600 MWh (8% of the municipality's total).

The team responsible for setting up the EnMS consisted of two employees (the energy manager and an economist responsible for optimizing the energy consumption). If necessary, they involved other employees (responsible for street lighting, buildings, resources, communication, etc.). This inter-departmental cooperation was crucial because municipalities offer various services that have an impact on energy performance. In addition to the technical aspect of the EnMS, the energy team showed a particular interest in raising awareness by mobilizing the agents of each site of the perimeter (called "energy referents") and by organizing regular meetings. One of the main difficulties was understanding the distribution of meters as many renovations have taken place without systematically updating the plans and diagrams. During the first year of implementation of its EnMS (2019), Montauban carried out 11 actions to achieve their objectives, which enabled the municipality to save 263 MWh of energy. In addition to the actions implemented within the scope of the EnMS, this approach set in motion new procedures that extend to the entire community (systematic performance of energy audits before work is carried out, integration of energy skills during all recruitment, etc.). The EnMS finally allowed Montauban to have a clear organization in terms of energy management, including roles, reporting, and projections, and to identify numerous improvement actions.

3.3. Results of the Survey among Energy Managers

In total, we received responses from 23 energy managers. Given that 28 municipalities were working on establishing an ISO 50001 energy management system during the project, this equals a response rate of 82%. It has to be noted that some energy managers filled in the survey before the energy management system was certified. At the time of the survey, 83% of the responding energy managers were working for a municipality that already had their EnMS ISO 50001 certified. When asked whether they believed that the municipality would commission the recertification audit after three years, 19 energy managers, that is, those from municipalities that already held an ISO 50001 certificate at the time of the survey, answered. Of those, 21% responded that the municipality would definitely commission the recertification audit. Forty-seven percent answered that it probably would. This means that for more than two-thirds of municipalities the EnMS is a long-term investment and left us hopeful that even in the cases in which establishing the EnMS was mainly motivated by the project, the activities will be carried on after the project has ended. On top of this, 26% believed that recertification was at least possible. Every municipality with an ISO 50001 certified EnMS also defined targets for the energy improvement period. Figure 2 shows the expected change in energy consumption within the scope of the EnMS depending on the length of the energy improvement period. Every respondent expected the municipality's energy consumption to decrease. In general, higher decreases are expected when the energy improvement period is longer.

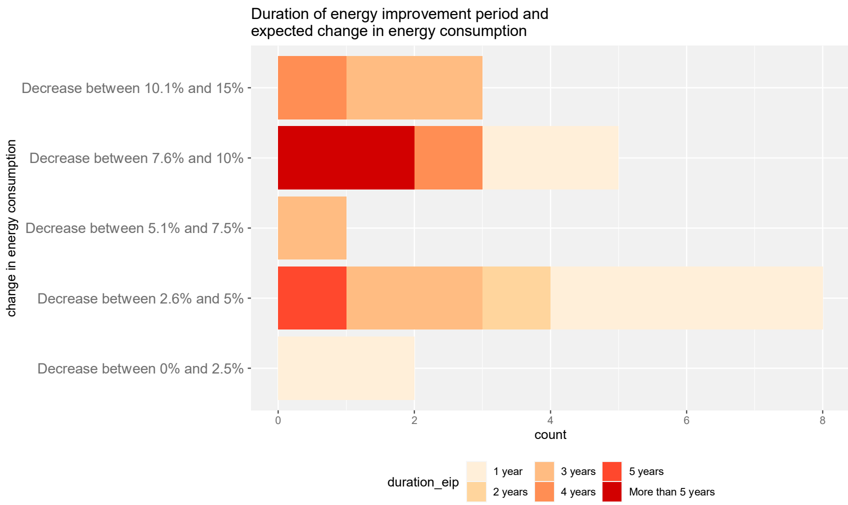

Figure 2. Duration of energy improvement period and expected change in energy consumption (n = 19).

When respondents were asked to name the three most important motives for introducing the EnMS, the most frequent answers were getting better data on energy consumption and saving energy. Some respondents stated energy savings as a goal in itself, whereas others referred to energy cost savings or GHG emission reduction. Other motivations named by the respondents were raising awareness, both among decision makers and co-workers, more efficient workflows, and prioritization of investments and measures. Furthermore, more than one respondent mentioned the local authority being a role model. With the exception of raising awareness, these motives were among the items of the closed question. Figure 3a shows the motivations sorted by level of importance.

The project was named the most important motivation with an average importance score of 4.55 (s = 0.51), followed by energy cost reduction ($\overline{x}$ = 4.41, s = 0.80), the mitigation of GHG emissions ($\overline{x}$ = 4.27, s = 0.83), and improving the municipality's image ($\overline{x}$ = 3.91, s = 1.15). Being a role model was seen as moderately important ($\overline{x}$ = 3.14, s = 1.04), whereas the least important motivation was a demand by the council with an average importance score of 2.68 (s = 1.04).

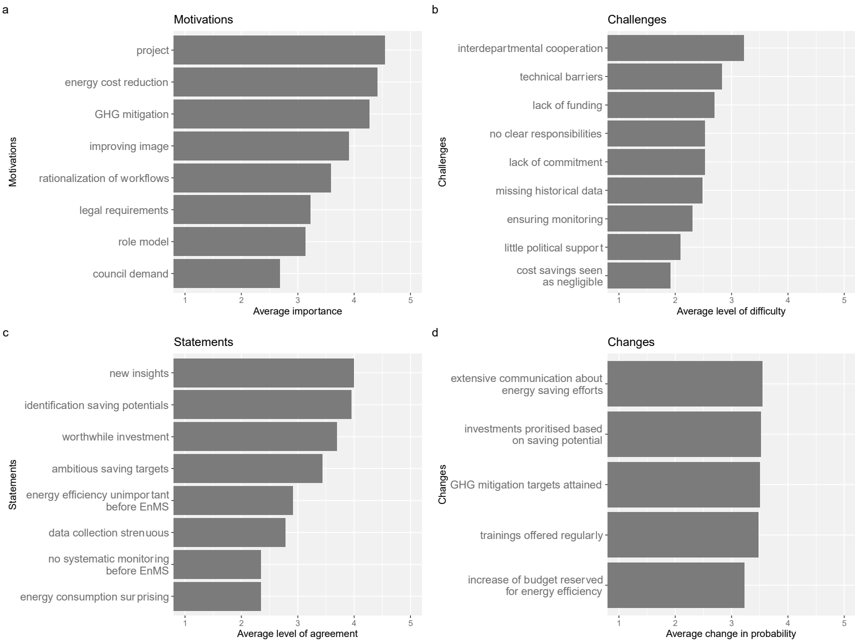

Figure 3. Energy manager assessment of (**a**) motivations for establishing the energy management system (*n* = 22), (**b**) challenges in establishing the EnMS (*n* = 23; *n* = 22 for the item "cost savings seen as negligible"), (**c**) statements regarding the EnMS (*n* = 23), and (**d**) changes due to the EnMS (*n* = 23; *n* = 22 for the items "GHG mitigation targets," "communication," and "increase in budget").

When asked openly about challenges in establishing the EnMS, respondents mentioned several challenges. Numerous energy managers named data issues. These extended both to historical data needed for the energy review as well as the continuous monitoring of energy consumption data. Other challenges that were cited frequently were organizational issues (e.g., getting employees to support the efforts), ensuring the necessary commitment from important decision makers (administrative and political), and lack of resources (especially financial and human resources).

Figure 3b shows that respondents experienced interdepartmental cooperation as the challenge that was hardest to overcome ($\overline{x}$ = 3.22, s = 0.90). Dealing with technical barriers (e.g., too few meters) was seen as second most challenging ($\overline{x}$ = 2.83, s = 1.15). Lack of funding ($\overline{x}$ = 2.70, s = 1.22), no clear assignment of responsibilities ($\overline{x}$ = 2.52, s = 1.16), a lack of commitment ($\overline{x}$ = 2.52, s = 1.20), and missing historical data ($\overline{x}$ = 2.48, s = 1.34) were given a similar level of difficulty by the respondents.

We presented several statements regarding energy management systems to the energy managers and asked to what extent they agreed with these statements (Figure 3c). The statements with the highest level of agreement were that establishing the EnMS led to new insights ($\overline{x}$ = 4.00, s = 0.67), that it allowed the municipality to identify energy-saving potential ($\overline{x}$ = 3.96, s = 0.83), and that the EnMS had already been a worthwhile investment at the time of the survey ($\overline{x}$ = 3.70, s = 1.02). On average, respondents were undecided about whether the EnMS was a motivation to set ambitious energy-saving targets ($\overline{x}$ = 3.43, s = 0.90). Based on the energy managers' impressions, establishing the EnMS was not a change as substantial as we would have expected. Respondents on average were undecided about the statements that energy efficiency was unimportant in investment decisions before the EnMS ($\overline{x}$ = 2.91, s = 1.20), and disagreed that there was no systematic monitoring of energy consumption before the EnMS ($\bar{x}$ = 2.35, s = 1.56) and that the municipality's energy consumption was surprising ($\bar{x}$ = 2.35, s = 1.23).

We also asked energy managers to assess whether the EnMS made certain events more or less likely (Figure 3d). The average assessment of the probability of the events being realized was similar for all events and between "about the same" and "higher." The events were the municipality communicating extensively about its energy conservation efforts ($\bar{x}$ = 3.55, s = 1.01), a prioritization of the municipality's investments based on their energy-saving potential ($\bar{x}$ = 3.52, s = 0.85), the municipality attaining its GHG mitigation targets ($\bar{x}$ = 3.50, s = 1.10), the municipality training its employees on energy conservation behavior regularly ($\bar{x}$ = 3.48, s = 0.99), and the municipality increasing its budget for energy efficiency ($\bar{x}$ = 3.23, s = 0.97).

Answering an open question, energy managers could state what needed to happen for the EnMS to have a marked impact on the municipality's energy consumption and carbon emissions that did not happen at the time of the survey. Several topics stood out among the answers. Some energy managers indicated that more financial and human resources were needed to implement the measures identified during the certification process. A durable commitment by decision makers to the EnMS was also named more than once as a prerequisite. Furthermore, changes in employee behavior were seen as needed. This reiterates the point made in earlier studies that changes in user behavior are even harder in the workplace, as financial incentives are nonexistent [28].

3.4. Results of the Survey among Consultants

In total, all seven consultants supporting the 28 municipalities establishing an ISO 50001 EnMS filled in the questionnaire. When reporting number of observations, we treated each response for an individual municipality as a separate observation. This means that each consultant provided four observations.

Seventy-one percent had achieved certification by the time of the consultant survey. Given that on average energy managers disagreed with the statement that there was no systematic monitoring of energy consumption before the introduction of the EnMS, we asked consultants to rate the municipalities' energy management before the process to establish an EnMS began. The energy management of 36% of the municipalities was rated as either having been good or very good before the study began. Consultants thought that the energy management of 29% of the municipalities was poor before introducing the EnMS (Figure 4a). For 79% of the municipalities, consultants believed that they would not have introduced an energy management system without the project's support. As a reason for this, they named the financial and human resources the project contributed to the process.

When asked which were the most important challenges the municipality had to overcome, several consultants referred to human resources issues, especially finding qualified personnel or getting the personnel sufficiently qualified. Other challenges named more than once involved decision makers and ensuring their commitment as well as data collection problems. We also asked consultants to rate how hard it was to overcome certain challenges on the same scale the energy managers used and compare the consultants' assessment to the energy managers' assessment. One caveat in this interpretation was that energy managers only gave their assessment for 23 municipalities, whereas consultants gave a rating for all 28 municipalities (Figure 4b). Consultants agreed with energy managers that getting interdepartmental cooperation to work was the hardest challenge to overcome ($\bar{x}$ = 3.07, s = 1.22) and that technical barriers were among the three hardest challenges ($\bar{x}$ = 2.64, s = 1.22). In contrast to the energy managers, consultants saw a lack of commitment among the three challenges hardest to overcome ($\bar{x}$ = 2.75, s = 1.24). Still, even these three challenges were, on average, only moderately hard to overcome. Consultants and energy managers also agreed that energy costs being perceived as negligible ($\bar{x}$ = 1.71, s = 0.81) and ensuring continuous monitoring ($\bar{x}$ = 2.04, s = 1.10) were among the three least hardest challenges.

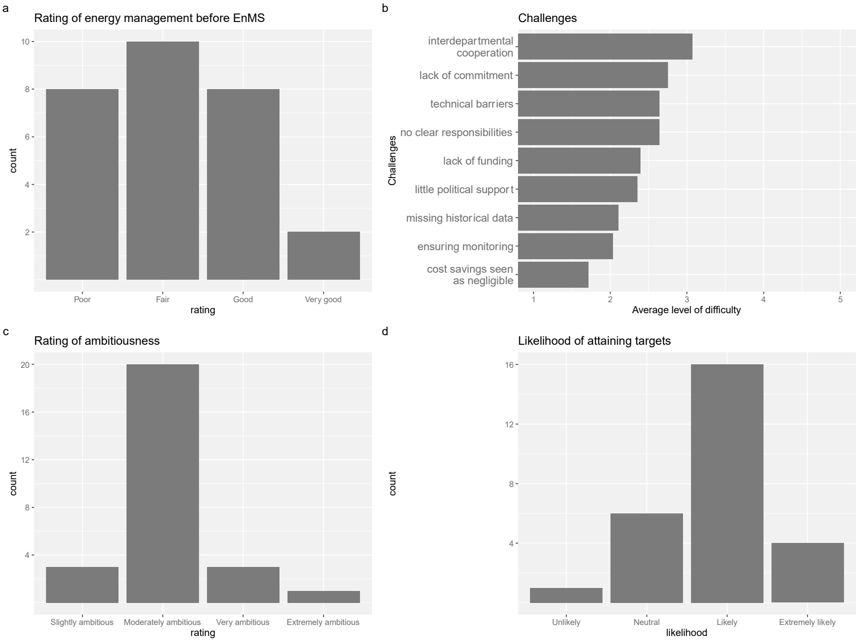

Figure 4. Consultant assessment of (**a**) the energy management before the EnMS (n = 28), (**b**) challenges in establishing the EnMS (n = 28), (**c**) the ambitiousness of targets (n = 27), and (**d**) the likelihood of attaining the targets (n = 27).

When asked what the most important things they learned about municipal energy consumption were, the management consultants reiterated some points that were already discussed:

- Collecting and analyzing data can be a challenging task, especially for small municipalities;
- Energy consumption is often seen in terms of costs. Observed cost increases can be a stronger incentive for action than potential, but notional, cost reductions; and
- Interdepartmental cooperation is a problem that becomes especially pertinent if more than one department is responsible for activities within the scope of the EnMS.

Defining the boundaries and scope of an EnMS is an important task during the process of establishing the system. For municipalities this is not as straightforward as might be the case for companies. Some municipalities decided not to include every building they owned or excluded street lightning or their fleet of vehicles. Therefore, we asked the consultants how satisfied they were with the scope and boundaries of the EnMS they helped to introduce. For 57% of the municipalities, the consultants were very or extremely satisfied with the boundaries and scope. They were only slightly satisfied or not satisfied at all in the case of 29% of the municipalities. If consultants were not satisfied with the scope and boundaries of the EnMS, it was often caused by municipalities excluding some of their buildings. Based on the consultants' assessment, 74% of the municipalities have a moderately ambitious energy target and action plan (Figure 4c). The number of observations was 27 for this and the next two questions because one consultant could not give an assessment for one of the municipalities. Fifteen percent of municipalities have a very or extremely ambitious energy target and action plan. The consultants were optimistic that the municipalities will attain their targets (Figure 4d). For 74% of the municipalities, they rated this as likely or extremely likely. Only in the case of one municipality did consultants consider it unlikely that they would fulfil their targets. Consultants also believed it likely or extremely likely that 78% of the municipalities would commission the recertification audit. This points to the project having a long-term impact and can be interpreted as a sign that once the municipalities receive help in establishing an EnMS they are able to sustain it without external help.

4. Discussion and Conclusions

Regarding the first objective of our study, we found that municipalities are able to establish ISO 50001 certified energy management systems with the help of external assistance. Given that the energy consumption of municipalities is non-negligible and that energy savings of more than 10% were achieved in some of our cases within one year, energy management should become an important component of local energy and climate policy.

Regarding the second objective of our study, we provided data on motivating factors, but also challenges that municipalities face when aiming to establish an EnMS. In both regards, our results for municipalities are not very different from the results earlier studies found for companies [15–18]. As in the case of companies [18,24], external support from consultants was often important and energy-related and environmental impacts were strong motivators [17]. Organizational difficulties (cooperation between a large number of departments), limited resources (financial, human, and technical), and insufficient leadership support were the most important challenges we identified. Regarding the ranking of challenges, municipal employees and consultants largely agreed in their assessment. Although collecting historical data and the continuous monitoring of energy data were named as important challenges in the literature [23], they were not among those hardest to overcome in our study. A large majority of municipalities that had established an EnMS within our study aim to keep operating it and also plan to commission its recertification. This lets us assume that the one-time investment in energy management will have long-term impacts in many cases.

Based on the results of our study, utilizing energy management systems in municipalities seems advisable and can contribute to energy and climate policy. The following points summarize the lessons we learned regarding the process to establish municipal EnMS:

- The impetus given by the study was a crucial motivator for municipalities to establish an energy management system. This support can be institutionalized by setting up an agency that supports municipalities in establishing energy management with money and expertise. A driver for wider application and implementation of EnMS in local authorities would be the introduction of mandatory energy management in national and regional legislation.
- Once an EnMS is up and running, a large majority of the municipalities participating in our study planned to keep it. This means that such an agency's short-term support can have long-term impacts in many cases.
- When helping municipalities to set up an energy management system, it was crucial to involve all departments that managed activities consuming considerable amounts of energy (e.g., every building owned by the municipality, street lighting, the fleet of vehicles, etc.). Achieving functional interdepartmental cooperation was among the hardest challenges in our study, corroborating results from earlier studies for other areas of local energy and climate policy [27].
- A strong commitment by decision-makers, including local politicians, is needed to facilitate interdepartmental cooperation. Support programs for EnMS introduction should incentivize this commitment from administrative heads and local politicians through its terms and conditions.
- Human resources can be a limiting factor, especially for smaller municipalities. Therefore, a program supporting municipalities in establishing EnMS should foresee resources for training. It was also helpful to not task a single person with working on the EnMS, but rather to form an energy team. This confirms results from research on companies using EnMS that also stressed the role of energy managers and training [29].

- Defining the boundaries and scope of the energy management system is a topic that should be addressed early on. Some of the municipalities in our study were very cautious and chose very narrow boundaries and scope.
- Adequate tools that support collecting, analyzing, and presenting data can greatly reduce the administrative burden of the EnMS. Within our study, municipalities had access to an online energy monitoring platform, which 62% of the municipalities used. A program for EnMS introduction should entail access to a tool that supports data collection and analysis.
- To attain energy-saving targets, the energy-use behavior of employees cannot be neglected. The survey among energy managers showed that motivating colleagues to change their behavior was challenging in some cases. Gamifying this by holding an energy-saving competition may be a helpful approach in this case [32].

Our study has several limitations, which point to future research needs. Although we were ultimately successful in establishing ISO certified energy management systems in a majority of the municipalities by the end of our study, supporting municipalities on their way to certification needed more consultant resources and often took longer than anticipated. Due to the comparatively low number of municipalities in our study, the survey results are exploratory in character and do not allow us to explain which municipalities are more likely to successfully establish an energy management system. Furthermore, our study does not permit us to explain differences in energy savings after establishing the energy management system. Since the municipalities only established the energy management systems recently, we cannot evaluate their long-term impacts. A relevant research question is whether the experience and know-how acquired by establishing and running the EnMS carries over to other fields of local climate policies and thereby helps to improve and increase the number of measures (e.g., from the SECAP) implemented. This would imply that municipal EnMS can have impacts even beyond the EnMS's scopes and boundaries. To study this question, future studies should collect data from a larger number of municipalities over a longer timeframe. Future research could also build on studies that apply maturity models to the energy management of industrial companies [4,24] and transfer this approach to municipal energy management. This would also help to answer the requirement of continuous improvement foreseen in the ISO 50001 standard.

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Upgrade from SEAP to SECAP: Experience of 6 European Municipalities

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***Abstract* – Since 2008 many municipalities in the European Union have taken part in the Covenant of Mayors (CoM) initiative and have developed Sustainable Energy Action Plans (SEAP) to contribute to climate change mitigation. To respond to new policy goals for 2030, the CoM has expanded its focus and since 2018 requires municipalities to cover climate adaptation actions. The main aim of this paper is to analyse the first experiences of six municipalities from Spain, Portugal and Latvia in upgrading their existing Sustainable Energy Actions Plans to Sustainable Energy and Climate Action Plans (SECAP). SECAPs were developed through a participatory process involving all relevant local stakeholders, to gain maximum understanding and acceptance. Each municipality implemented climate adaption actions to demonstrate the need for adaptation and the ways it can be accomplished.**

***Keywords* – Adaptation strategies; SECAPs; urban resilience**

1. INTRODUCTION

Since the Rio Earth Summit [1] tackling climate change has been one of the European Union's (EU) policy priorities [2]. The EU has introduced different climate change mitigation policies and programmes and set targets to reduce GHG emissions by 40 % in 2030 [3], and in 2020 the European Commission proposed to increase the target to 55 % by 2030 [4]. Moreover, as climate change effects become more and more visible, EU has also started to focus on adaptation to climate change, to increase the resilience of local communities.

Compared to the period from 1978 to 1997, reported losses from extreme weather events rose by 151 % in 1998–2017 [5]. In a global risk report by the World Economic Forum [6], extreme weather is among Top 5 global risks in terms of likelihood and impact since 2017 and in 2020 for the first time all Top 5 risks in terms of likelihood are environmental risks.

According to the Intergovernmental Panel on Climate Change (IPCC), mitigation aims to reduce sources and enhance sinks of greenhouse gases, while adaptation is defined as 'The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects' [7]. According to these definitions, mitigation can be seen as a long term solution and

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adaptation as a short-term response to the problem [8]. However, in the context of the Paris Agreement and Sustainable development goals, adaptation also should be considered as a sustainable approach for long-term resilience [9], as the climate will continue to change.

With continuously growing urbanization (54 % of the world population in 2015 lived in urban territories [9]), cities are one of the most vulnerable territories to climate hazards, considering the amount of people concentrated there. But while growing cities are well positioned to adapt to climate change by appropriate urban planning and design [10], smaller cities with reducing populations are often hesitant to invest in adaptation measures, as other issues, like social and economic problems, may seem more immediately pressing. Assessment of urban resilience can also be challenging because of insufficient long-term data availability [11]. It is also noted that one of the most vulnerable are people living in energy poverty circumstances [12], as future weather conditions will negatively affect how buildings are performing, as they are built for current or even past climatic realities [13].

Many European municipalities have participated in the Covenant of Mayors (CoM) initiative [14] and used the Sustainable Energy Action Plan (SEAP) as a tool for participating in the global fight against climate change. There is wide research on SEAP effectiveness and potential outcomes showing both success and drawbacks of the SEAP approach [15]–[20]. In 2015 CoM merged with Mayors Adapt creating a Covenant of Mayors for Climate & Energy. The main outcome was the integration of climate adaptation and energy poverty aspects within the SEAPs creating Sustainable Energy and Climate Actions Plans (SECAP). This way mitigation and adaptation can be addressed coherently, using advantages of solutions and measures that give both mitigation and adaptation outcomes.

Nevertheless, while climate change mitigation has been sufficiently researched and evaluated in recent decades [21]–[23], the methodology and approaches how municipalities could address climate adaptation challenges at the local level is vaguely studied. To adapt our cities to climate change is a complex task and requires detailed analysis of the local climate, main impacts and vulnerabilities. To do that, different methods are being proposed in scientific literature, for example, many researchers use geographical information system framework [24], system dynamics tools [11] and even machine-learning methods [25]. Usually these methods require a lot of data input and are too complicated to be used by municipalities. Simple and easy-to-use methods should be developed, to enable adaptation to climate change at the municipal level.

The LIFE Adaptate Project, entitled 'Common methodology for the development of Sustainable Energy and Climate Action Plans in European municipalities', aimed to address the effects of climate change on urban areas. This article addresses the experience gained in six municipalities in Latvia, Spain and Portugal by upgrading their existing SEAPs to SECAPs and implementing demonstration actions to adapt their municipalities to new climate realities. We present methodology developed and tested for the assessment of climate adaptation measures at the local level.

2. METHODOLOGY

The climate adaptation approach elaborated within the Life Adaptate project was based on three main pillars – SECAP development, adaptation of local policies to the needs of climate change, and implementation of adaptation measures. The project tested the approach in six European municipalities – Lorca, Águilas, Cartagena in Spain, Alfandega da Fe and Mertola in Portugal and Smiltene in Latvia. Each municipality developed a SECAP according to the procedures suggested by project partners (Fig. 1) and implemented one pilot project to demonstrate adaptation actions.

As in many cases, mitigation and adaptation actions can be complimentary to each other and therefore SECAP development requires a holistic approach including mitigation, adaptation and energy poverty assessment. Also, the overall process heavily relied on stakeholder participation and feedback, to compensate the lack of spatial data of climate hazards and to motivate them to participate in the implementation of SECAP actions. This participatory process (Fig. 4) requires the selection of three main working groups: The smallest group is composed of the main direct team, in charge of the SECAP redaction, that is, representative of different departments of the local administration. Another intermediate group is formed with all relevant stakeholders, those who have something to contribute to the SECAP development. And finally, all local citizens and visitors, who will have the opportunity to participate in the general surveys.

Before SECAP development, the SECAP working groups were established and the main stakeholders identified.

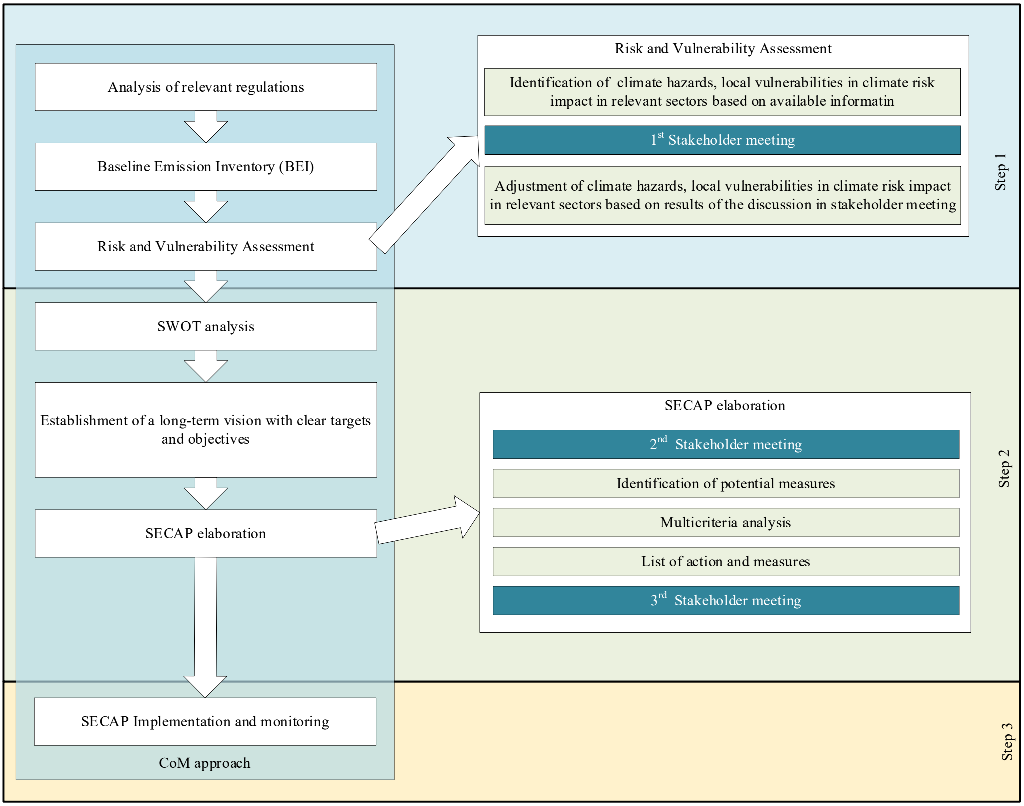

Fig. 1. CoM approach and proposed key steps for preparing a SECAP [26], [27].

SECAP development in Life Adaptate project can be divided in 3 main steps.

Step 1 – identification of local climate change risks and vulnerabilities. When developing the risks and vulnerabilities, the methodological approach of the CoM already identified that smaller local authorities need a simple, qualitative approach, that can be used by non-expert users [27]. Within the project, mainly the CoM approach was used, with an addition of stakeholder involvement. The initial analysis of climate hazards was made using data from the climate change national tools (all gathered at the EU Climate Adapt platform) [28], but the evidence detected by the stakeholders was equally important. The local vulnerabilities were classified according to social, economic, physical and environmental vulnerabilities. The link of every vulnerability with every climate hazard was applied to certain sectors, generating climate impact potential risks. Finally, following the Covenant of Mayors recommendations to assess each risk, three criteria are used: likelihood of occurrence, expected impact level and timeframe.

Stakeholder opinion was gathered by organizing a public stakeholder meeting and inviting representatives from all relevant municipal and private entities and local citizens as well. It was important to explain the need for climate adaptation and the available data of local, regional, or national climate trends (depending what data is available) in order to gain understanding and involvement of participants. Once the context was explained, participants were involved in a 'brainstorming' session, to list all possible climate hazards and vulnerabilities they saw as relevant. Based on the results of the meeting, the initial risks and vulnerability assessment was adjusted.

Step 2 – identification of the adaptation actions. When the main risks and vulnerabilities are identified, another stakeholder meeting was organized to identify the range of possible adaptation actions. First a 'brainstorming' session was held to list all relevant actions. Second, a multicriteria principle was used to evaluate each action and the highest rated actions were included in the SECAP. At this step the municipality can set a limiting criterion in order to include realistic actions that can be implemented.

For the multicriteria analysis, nine criteria were included in the guidelines as a suggestion for the municipalities, but they were allowed to choose how many criteria to use. The nine criteria were as following.

- Effectiveness: Extent to which the proposed solution is able to solve the problem.
- Efficiency: Extent to which the benefits exceed the costs.
- Equity: Extent to which the action adversely affects other areas or citizen groups.
- Flexibility: The action allows for adjustments or incremental implementation.
- Legitimacy: Extent to which the action is politically and socially acceptable.
- Urgency: Timeframe to solve the problem.
- Synergies: Degree of coherence with other objectives or measures.
- Costs: Investment amount.
- Funding: Availability of internal or external funding to implement the measure.

Municipalities were also able to choose if the weights should be assigned to each criterion, or all criteria will be considered equal [26]. Multicriteria analysis were performed by all members of the working group and stakeholders in the meeting.

Step 3 – finalisation of the SECAP. When the list of the most relevant adaptation actions was final, the necessary resources, timing and responsibilities are defined, the 3rd stakeholder meeting was held to present the final SECAP and implementation of the plan can commence. Within the project period all six municipalities implemented at least one demonstrative adaptation action.

This approach allows that small municipalities with limited knowledge and resources to address adaptation issues according to their specific situation and modify the method according to their ambition.

3. RESULTS

In all six municipalities SECAPs have been developed and demonstrating adaption actions have been implemented. Demonstration projects also included the establishment of monitoring systems, but since not all measurements are completed by the time of this publication, the results of adaptation actions are explained only briefly.

3.1. Communication and Stakeholder participation in SECAP development

All municipalities developed a SECAP drafting group consisting of a few of the most relevant municipal employees, to effectively work with the SECAP document. All interested stakeholders from the public and the private sector were included in the SECAP working group and 2 – 3 stakeholder meetings were organised in all municipalities to involve these stakeholders in the process.

During the process, a total of 385 stakeholders were involved in SECAP development in the municipalities (Águilas 61, Alfandega da Fe 44, Cartagena 69, Lorca 45, Mertola 70, Smiltene 96). As the stakeholder meetings were organized as a public event, not just for municipal employees, meetings were attended by representatives from:

- business and industry associations;
- organizations involved in the research and development of mitigation and/or adaptation solutions;
- educational entities;
- finance and insurance sectors;
- landowners and managers;
- non-governmental organizations involved in the promotion of environmental and social objectives;
- institutions that provide technical support to both government and industry (e.g., universities, research institutions, think tanks, and consultants);
- waste and water supply companies;
- civil protection, police, firefighters and civil society representatives;
- agriculture and forestry sectors;
- health sector representatives;
- tourism sector representatives;
- citizens.

As the process was organized in 3 parts, not all workshops were attended by the same stakeholders, giving an opportunity to involve a wider variety of people, but also creating a challenge to involve newcomers in a process that had already started. Some climate change denial was observed, but overall the attitude by participants was more positive and the need for sustainable adaptation was acknowledged. As the meetings were attended by different stakeholders, such as public organisations that are not directly linked to municipalities, the need for adaptation were expressed by them. During the meetings some stakeholders also gave a presentation about the climate change impacts in the sectors they represent. For example, in Latvia, a representative from the joint stock company 'Latvia's State Forests' presented the situation with forest fires during the last decade, and local municipal police representatives presented civil protection principles. This information provided the municipality with valuable information for decision making in the further SECAP process. This way it was shown to the public that the municipality not only acknowledges climate change as an issue, but such meetings also give an opportunity for active citizens to express their needs and expectations.

Each municipality also implemented a demonstration activity during the SECAP development process, to highlight the need for adaptation and to show an example of how to do it. Each municipality defined the action prior SECAP, based on their most visible climate threat and resources available to implement the activity in a considerably short amount of time.

Lorca placed awnings above the most crowded streets and squares, to reduce sun exposure during the summer period. Actions aimed at reducing air temperature by 2 degrees comparing to other similar streets. The first preliminary data show that the air temperature decreased more than 2 degrees. Águilas built an urban forest using treated sewage water from the city sewage treatment plant for irrigation of the territory, reducing summer heat impact, and the risks of water shortages. Cartagena linked existing green territories by green, shadowed paths for bikes and pedestrians to reduce air temperature during the hot season in the area. Mertola installed shades in different public areas to reduce the impact of summer heat, and developed a sustainable tourism plan to improve the sustainability of tourism industry in the area. Alfadega da Fe built an artificial lake to collect the spring waters to use during the dry season in the summer to eliminate wildfires and for farmland irrigation. Alfadega da Fe also installed shade covered with PV panels to provide shade during the summer period and to increase renewable energy production. Both Mertola and Alfandega da Fe developed a project 'creation of multi-purpose forest with native species and at promoting the regeneration of native species'. Smiltene cleaned the lake in the city centre and refurbished the sluices to enable automatic water regulation in the lake in case of heavy rain. All the adaptation actions are serving as an example for how municipalities can adapt to the existing and forthcoming climate reality.

Results from the surveys in municipalities about pilot projects (Lorca 51, Águilas 62, Cartagena 29, Smiltene 36 respondents), show that overall people in six municipalities are aware of the climate change issues, more than 80 % of respondents think that climate change is an important issue and similarly more than 90 % of respondents think that municipalities should engage in climate change mitigation.

As regards each pilot project, the results vary more. In Smiltene and Lorca municipalities most of the respondents, around 90 %, think that the project has improved the local urban environment while in Águilas it is 65 % of respondents and in Lorca only 35 %. About 65 % in Lorca, 70 % in Águilas and 55 % in Smiltene think that these actions reduce the local climate risks, while in Cartagena around 33 % think that risks are reduced.

3.2. Main impacts and adaption measures assessed

Another challenge identified during the process was related to coordination of the SECAP development process within the municipality, as they had to collect different data and fill a risk and vulnerability assessment template internally. This activity required more time than was foreseen in all six municipalities. As a result, more extensive consultancy work was done by project partners in order to fill the gaps. It was indicated that when municipalities work with SECAP development for the first time, they should be provided with closer guidance and knowledge, even about the basic concepts as in some cases the lack of knowledge was a contributor in mismanagement and in lower motivation to deliver on time.

The main impacts identified in the six municipalities are summarised in Table 1. As expected, the main climate hazards depend on the geographic location of the municipality, but the impact can be different for the same risks, depending not only on location, but also on local social, economic and policy factors.

TABLE 1. MAIN IMPACTS OVER THE TERRITORIES

Municipality	Main climate hazard risks	Impacted sectors	Impacts expected
Smiltene	Extreme heat Extreme precipitation Droughts	Buildings Environment & Biodiversity Energy	Demand for building cooling in summer. Energy supply network and infrastructure damage. Increase in pest levels, insect infestation, biodiversity loss, eutrophication.
Mertola	Extreme heat Droughts Forest fire risk due to temperature and drought	Tourism Health Biodiversity	Negative impact on tourism as the temperatures get extremely high. Forest fires increase health risks and increase the pressure on civil protection services.
Alfandega da Fe	Extreme heat Droughts Forest fire risk due to temperature and drought	Tourism Health Biodiversity	The expected worsening of the dryness index of areas susceptible to desertification leads to reductions in biodiversity and changes in ecosystems. Forest fire risks increase health risks. And temperature changes will affect winter and summer tourism characteristics.
Cartagena	Extreme heat Droughts Storms	Land use planning Health Energy	Poor land use planning fosters the heat island effect. Extreme heat negatively affects not just population health but increase the demand for cooling energy as well.
Águilas	Extreme heat Droughts Sea level rise	Tourism Water Energy	Longer periods of drought and heat waves will cause clean water shortages. Demand for energy will increase due to the need for more cooling power, and extreme heat reduces tourism activities during the summer season.
Lorca	Extreme heat Droughts Landslides	Water Health Energy	Extreme heat and droughts will facilitate desertification and biodiversity loss. Heat waves add pressure to health sector and increase the demand for cooling energy.

To address the identified climate risks, adaptation activities were included in the SECAPs. During the stakeholder meetings, a wide range of the potential actions were identified, and multicriteria analysis was used to choose the most useful and realistic measures. Spanish municipalities in multicriteria analysis used all 9 criteria suggested in the guidelines. They also assigned weights to the criteria, based on a survey among local experts. In contrast, the Latvian municipality used a more simplified multicriteria method. They used 5 criteria –

efficiency, urgency, costs, synergies, legitimacy, and did not apply weights. As a result, in the SECAP Águilas included 20 measures, Cartagena 23, Lorca 29, Mertola 95, Alfandega da Fe 65 and Smiltene 20.

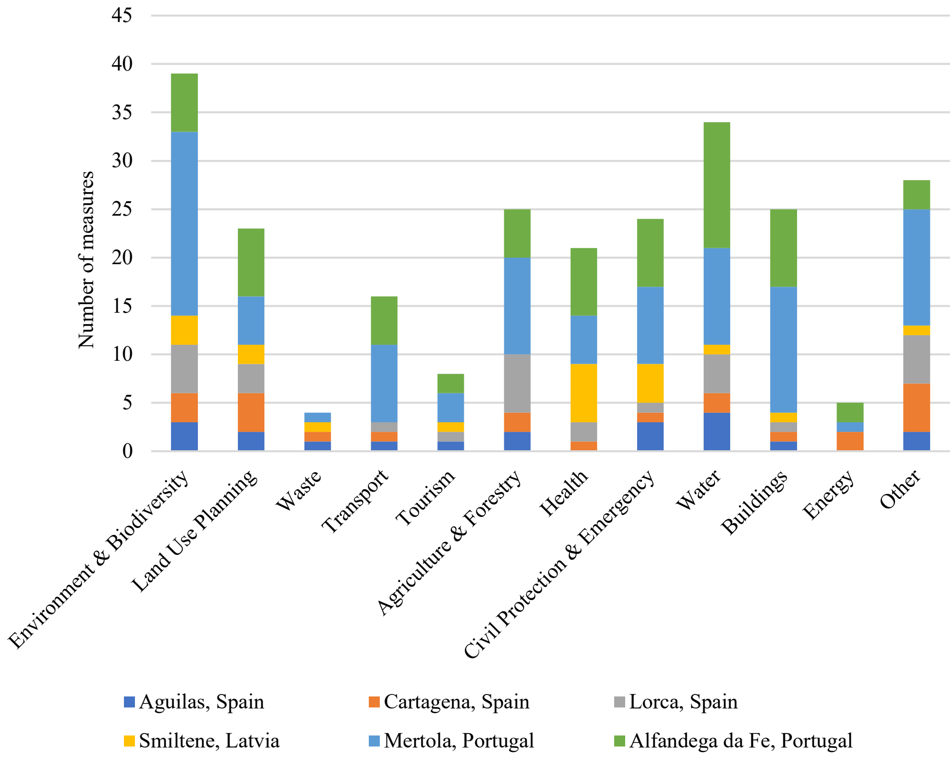

Fig. 2. SECAP measures divided by sectors.

For each municipality, different sectors were identified as more vulnerable, so the focus also differs (see Fig. 2). The biggest number of measures in total are planned in the environmental and biodiversity, water management and buildings sectors. More importantly, all municipalities have included blue or green infrastructure measures, so municipalities have ambitions to significantly improve the local urban environment. Measures in each municipality are specifically adapted to their unique local needs, nevertheless they are similar in terms of their character and goal to increase local resilience to climate change. For example, the environmental and biodiversity sector includes measures like conservation and recovery of areas and habitats of great natural value (Alfandega da Fe, Mertola, Cartagena), measures to increase green territories in urban areas (all municipalities) and others. Measures in the water sector include activities to promote reuse of treated wastewater or rainwater, to improve the water management systems, to reduce drinking water consumption etc., depending on the risks each municipality faces. Under the category ‘other’ mostly soft measures, like educational or awareness campaigns, structural changes, policy improvements, etc. are included.

4. DISCUSSION AND CONCLUSIONS

Adaptation to climate change is a new concept for municipalities and local society and in many cases more complicated than climate change mitigation. During the last decade, different methodological approaches of how to measure, implement and monitor mitigation actions have been developed, and mostly all measures can be communicated to local society via energy and cost-savings or emissions reduced. Regarding adaptation, however, there is a wide variety of types of actions and in some cases, it is very difficult to assess the long-term benefits of those actions at a local level, especially when it comes to the assumptions of improved public health, improved biodiversity and impact to climate change. Adaptation also should be considered as a cross-cutting theme in all municipal planning documents, strategies and policies, to ensure a continuous increase in the resilience of municipalities. This makes adaptation a complicated issue for communicating its necessity to the public, especially in small municipalities where extensive research or communication campaigns are not possible. Therefore, the proposed approach for SECAP development, where stakeholder involvement is used already in the early stages of adaptation strategy development, is considered useful for gaining public acceptance and trust. When stakeholders are involved in the identification of risks and vulnerabilities, it is much easier to justify the need for actions. Notwithstanding, municipalities should pay close attention to how activities are communicated to the public, even small ones with a low budget, as the understanding of smaller measures can lead to an overall understanding of benefits gained by adapting to climate change.

Municipalities also require a lot of guidance and education about climate adaptation issues when they start to work with the topic for the first time. The lack of knowledge and human resources in municipal structures can significantly undermine the SECAP development process and related communication with the public.

To ensure that adaptation plans are made based on reality, not just assumptions made by a few municipal employees, multicriteria analysis were proposed and used. The use of the multicriteria approach helped to structure and focus the decision-making process when specific measures had to be chosen. Municipalities used different levels of complexity of the multicriteria approach, adjusting it to their capabilities and needs.

Nevertheless, further research should be carried out to analyse the implementation process and monitoring of the adaptation strategies in the long-term. More focus should be paid to the multicriteria approach as it could become a widely used tool by municipalities, but the method should be developed as an ‘easy-to-use’ tool, so municipalities with less knowledge would be able to us it just as effectively as others.

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Impact of COVID-19 on Energy Consumption in Public Buildings

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***Abstract* – The COVID-19 pandemic has had a great impact on energy consumption in the world and many researchers have found very different energy consumption patterns. The goal of this study was to analyse the patterns of energy consumption in municipal buildings. Altogether data from 262 buildings from 4 municipalities were used and analysed. Results show very different energy consumption patterns for different types of buildings. In schools and education facilities the link between Covid-19 restrictions and energy consumption deviations are visible, but in administration and office buildings it is not the case. This leads to a conclusion that energy consumption in the buildings is not always linked to the level of occupancy of the building, meaning that there is room for improvements on energy management practices and procedures in the municipalities.**

***Keywords* – COVID-19; energy consumption; energy management system; municipalities; pandemic; sustainability**

1. INTRODUCTION

Two years ago, in 2020, a global pandemic was announced by the World Health Organization [1]. In most world countries, different restrictions were introduced to control the COVID-19 disease [2]. Mainly the restrictions were targeted to significantly limit physical contact. Many services were temporarily restricted, social gatherings banned, which had a big impact on the economy, well-being, employment, environment, health, industry, and other sectors, and changing transport and energy consumption. Many studies show that overall electricity consumption decreased in many countries, but in many cases, this happened due to the decrease in commercial and industrial sector, while energy demand in household sector increased [3]–[8].

A study that included data about 53 countries and regions showed that total electricity consumption decreased by 7.6 % in April 2020. However, the results vary significantly from country to country. It also shows that the stringency of government restrictions is tightly linked to reducing electricity consumption only during the first phase of the pandemic [9].

Studies of electricity consumption in Canada, Ontario, show that after the pandemic started, overall electricity consumption reduced and the electricity demand shifted during the week, compared to pre-pandemic data, and hourly data showed that the morning and evening electricity demand peaks were reducing [10], [11]. Similar results show a study about 4 European countries: Spain, Italy, Belgium and the UK, where weekday energy consumption reduced, and energy consumption profiles were similar to pre-pandemic weekend profiles

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[12]. Another study of the Saudi Arabian case shows an increase in electricity demand in the household sector due to an increased use of air conditioning and lighting during work from home periods [13], [14]. In New York, 17 % reduction in electricity consumption has been reported [15], while in Italy, a reduction in electricity consumption reached up to 37 % [16]. However, energy consumption dropped by 12 % in the Portuguese and Spanish peninsula during April and May 2020 [17]. In China, on average, energy consumption has decreased by 29 %, comparing a pandemic-free scenario with actual data for 2020 [18].

In Latvia, annual gross energy consumption decreased by 6.1 % in 2020, compared to 2019 (Data by Central Statistical Bureau (CSB)). In the transport sector final consumption of energy resources used for passenger transport and freights reduced by 12.8 %, but in the industry sector, consumption of energy resources has increased by 3.3 % [19]. In Latvia multiple plans [20] and policy incentives have been implemented to reduce energy consumption and switch to renewable energy resources to reach climate goals [21], [22], but even though it is expected that the reduction in 2020 and 2021 is partially due to COVID-19 restrictions.

Emergency in Latvia was declared on the 13^{th} of March 2020, strictly limiting operations in most service sectors, culture, education, recreation, and other services during March, April, and May 2020. Schools were closed, and distance learning continued until the end of the respective school year. In the autumn of 2020, the second wave of COVID-19 hit the population, and strict restrictions were implemented again, forcing many services to close the operation, re-initiate distance learning and remote working for many. However, since March 2020, most local culture and other education and recreational activities have been interrupted at different levels for multiple periods and are still interrupted by different restrictions at the beginning of 2022. Such an unprecedented crisis allows to analyse energy consumption behaviours and municipal building management practices within very different circumstances than usual. A study on electricity energy patterns in 289 municipal buildings in Brazil found that even though the occupancy of the municipal buildings was significantly reduced, the base energy consumption was considered surprisingly high in almost all unoccupied buildings [23].

In this article heat and electricity consumption trends in municipal buildings in Latvia are analysed to evaluate how energy consumption has fluctuated during the pandemic period.

2. METHODS AND METHODOLOGY

Monthly heat and electricity consumption data from four different municipalities have been used for the study. All municipalities have introduced energy management system according to ISO 50001:2018 standard in recent years. The main characteristics of the municipalities included in the study are given in Table 1.

Energy data was gathered by the employees of the municipalities, e.g., energy managers or other appointed person in charge of data input. Due to human error some buildings had data gaps or unrealistic data values. Buildings with such errors were excluded from the data set. After the quality assessment data of 262 different type buildings were included in the data set for heat consumption analysis and data of 240 buildings for electricity consumption analysis, see Table 2.

TABLE 1. CHARACTERISTICS OF THE MUNICIPALITIES

	Number of buildings	No. of buildings included in this study with heat data (electricity data)	Total heating area, m^2	ISO 50001
Municipality 1	63	60 (60)	92 276	Certified
Municipality 2	128	95 (73)	262 095	Certified
Municipality 3	28	27 (27)	20 308	Implemented, not certified
Municipality 4	92	79 (80)	134 885	Certified
TOTAL	311	262 (240)	509 564	

TABLE 2. SUMMARY OF THE DATA SET

	No. of buildings for heat consumption analysis	No. of buildings for electricity consumption analysis
Administration and office buildings	47	46
Buildings of the cultural establishment	25	26
Schools and educational institutions	46	45
Kindergartens and pre-schools	53	49
Other	91	74
TOTAL	262	240

To analyse the heat energy consumption trends a data normalization was done to adjust data to the standard heating season using heating degree-days, see Eq. (1) and Eq. (2). Electricity consumption is not considered to be climate affected and was not adjusted. Overall data for four years were collected and used in this study: data from 2018 and 2019 were used as a baseline (not affected yet by COVID-19) and data of 2020 and 2021.

$$K = \frac{L_{\text{st}} \cdot (t_{\text{ind}} \cdot t_{\text{out.reg}})}{L_{\text{act}} \cdot (t_{\text{ind}} \cdot t_{\text{out.act}})}, \tag{1}$$

where

- K Climate correction coefficient;
- L_{st} Standard monthly heating duration, days;
- L_{act} Actual monthly heating duration, days;
- t_{ind} Average indoor temperature during the heating season, °C;
- $t_{\text{out.reg}}$ Standard monthly average outdoor air temperature, °C;
- $t_{\text{out.act}}$ Actual monthly average outdoor air temperature, °C.

$$H_{\text{K}} = K \cdot H_{\text{a}}, \tag{2}$$

where

- H_{k} Climate corrected monthly heat energy consumption, MWh;
- K Climate correction coefficient;
- H_{a} Actual monthly heat energy consumption of the building, MWh.

Deviation of energy consumption was analysed by comparing the baseline energy consumption to energy consumption in 2020 and 2021 when different COVID-19 restrictions were in place. The baseline was calculated as mean energy consumption in 2018 and 2019. The deviation was calculated by Eq. (3), the difference between the energy consumption in the analysed year and baseline was divided by baseline [23]. Deviation indicates if the energy consumption during the COVID-19 in 2020 and 2021 was lower (negative value) or higher (positive) than average energy consumption in 2018 and 2019.

$$D = \sum_{i=1}^{n} \left(\frac{\left[E_y - \left(\frac{E_{2018} + E_{2019}}{2} \right) \right]}{\frac{E_{2018} + E_{2019}}{2}} \right), \tag{3}$$

where

- D Deviation of the energy consumption during pandemic, %;
- E_y Energy consumption in 2020 or 2021, MWh;
- E_{2019} Energy consumption in 2019, MWh;
- E_{2018} Energy consumption in 2018, MWh;
- n Number of buildings.

Throughout the COVID-19 pandemic in Latvia in 2020 and 2021, the use and occupancy of the municipal buildings changed. From March 13 until June 9, 2020 all schools, education facilities, and cultural establishments were closed [24]. During summer 2020, most of the restrictions were removed as the number of infected persons dropped (see Fig. 1). The second wave started in autumn 2020, and from November 9, many of the restrictions were reinstated [25]. For example, an autumn break for pupils was extended, and distance learning resumed for pupils in grades 7 to 12 (or smaller grades depending on the individual situation in the school). Most of the cultural establishments were closed. Extensive testing was introduced in the schools and workplaces, reducing restrictions for persons with negative COVID-19 tests. From December 2020, restrictions in each municipality varied depending on the rate of COVID-19 infected in each municipality. However, most schools, offices, and cultural establishments were still closed, or their occupancy was significantly reduced. Restrictions remained in place until the end of the spring semester of 2021. As vaccination started in the end of 2020 [26], by summer of 2021, the restrictions were significantly reduced for vaccinated people [27], [28], but even when the third COVID-19 wave hit in the autumn 2021, a lock-down was introduced for one month from October 21 until November 15 [29]. Since then, most of the restrictions have been withdrawn for vaccinated or tested people, therefore, schools, offices, and culture establishments could open [30]. Kindergartens and pre-schools have been open throughout the COVID-19 in 2020 and 2021, however, parents were encouraged to keep the children at home.

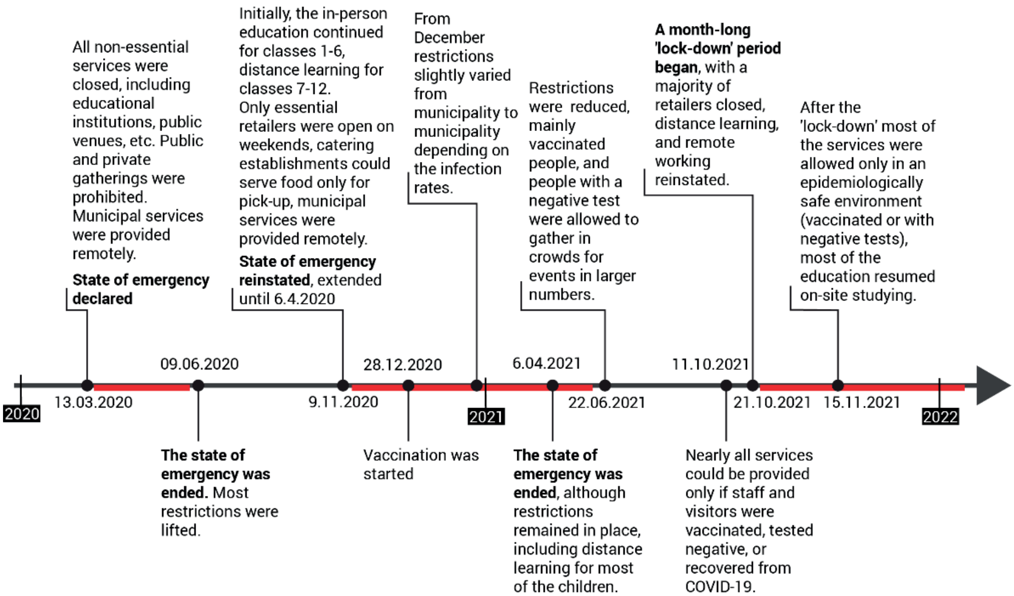

Fig. 1. Summary of most relevant COVID-19 restrictions during 2020 and 2021 in Latvia [24]–[30].

3. Results

The energy consumption trends in the municipal buildings show different patterns. The results presented in Fig. 2 show that electricity and heat energy consumption has decreased in most buildings. However, there are also many buildings where energy consumption has remained the same or increased during pandemic years. On average, electricity consumption decreased by 12.1 %, while heat energy decreased by 3.6 % in 2020. The average deviation for electricity is much lower than the average deviation for heat consumption, meaning that electricity consumption was affected more by COVID-19 restrictions (see Table 3). It is also observed that there is a significant amount of municipal buildings where energy consumption has increased by more than 20 %; this would require a further analysis on the causes of such increase.

TABLE 3. SUMMARY OF STATISTICS FOR DEVIATIONS IN 2020 AND 2021 COMPARED TO BASELINE (MEAN CONSUMPTION VALUES FOR 2018+2019), %

	Electricity consumption deviation in 2020	Electricity consumption deviation in 2021	Heat energy consumption deviation in 2020	Heat energy consumption deviation in 2021
Average	–12.1	–13.4	–3.6	1.04
Median	–14.2	–13.9	–2.9	–2.6
Minimum	–82.4	–88.1	–95.1	–74.5
Maximum	122.4	268.3	112.2	142.8
Lower quartile	–24.4	–33.3	–13.8	–13.5
Upper quartile	–0.07	1.54	5.5	9.1
Standard deviation	25.0	34.8	24.6	27.7

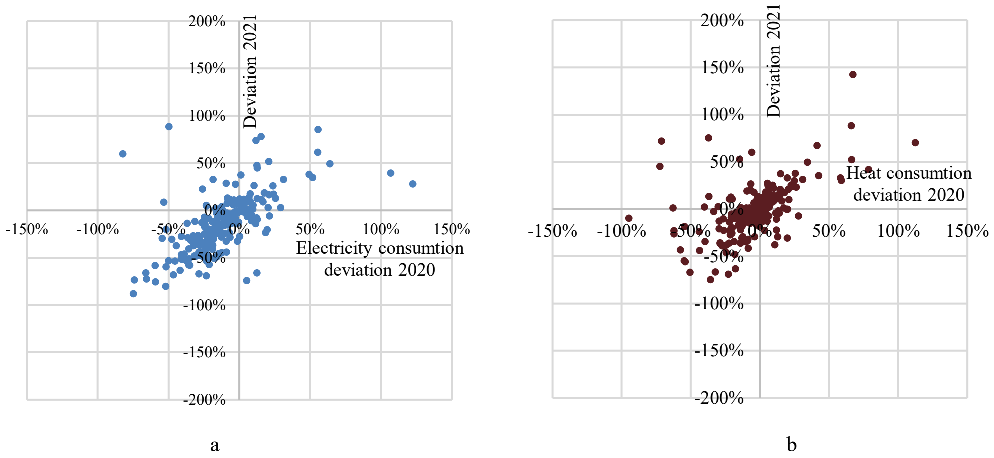

Fig. 2. a) Deviations in heat and b) electricity consumption data in municipal buildings in 2020 and 2021, compared to baseline (mean consumption of 2018 and 2019), %.

3.1. Trends in Heat Energy Consumption

Total heat energy consumption (climate corrected) in 2020 and 2021 decreased in two of the municipalities: in municipality 1 by 13 % in 2020 and 12 % in 2021, and in municipality 3 by 14 % in 2020 and 4 % in 2021. In the meantime, in municipality 2, total heat energy consumption in 2020 increased by 1 % compared to baseline (see Fig. 3). The highest increase of heat energy consumption was observed in municipality 4, i.e., 4 % in 2020 and 6 % in 2021 compared to baseline.

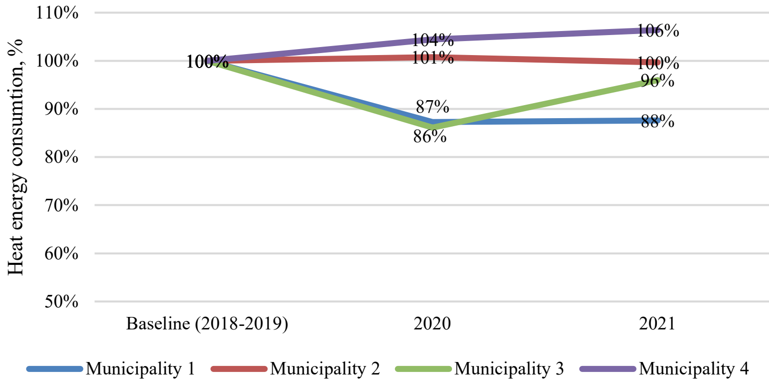

Fig. 3. Heating energy consumption deviations in four municipalities, compared to baseline (2018–2019), %.

Total heat energy consumption in all municipalities increased in January and February in 2020, but in March and April, it decreased by 5 % and 13 % against the baseline. Similarly, in October 2020, heat consumption reduction is 15 %, but in November and December, less than 1 %. During 2021 reductions in heat consumption are low. Only in January, heat consumption has decreased by 6 % compared to baseline, but the reduction was less than 2 % in other months.

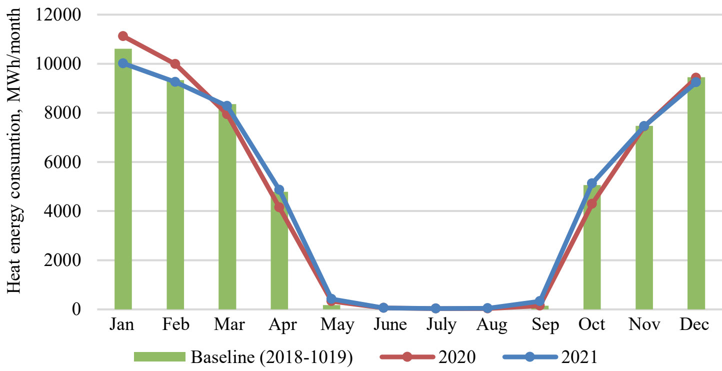

Fig. 4. Total heat energy consumption, compared to baseline (2018–2019).

3.2. Trends in Electricity Consumption

A significant drop in electricity consumption was first observed during the first wave of COVID-19 – on average a 27 % reduction in 240 buildings in April and a 23 % reduction in May compared to baseline. During the summer 2020 when all the restrictions were removed, electricity consumption in all municipalities even increased in June. During the second wave (since October) electricity consumption continued to reduce however at lower rate – 7 % in October, 10 % in November and reached on average 17 % in the winter and spring of 2021 (January – May).

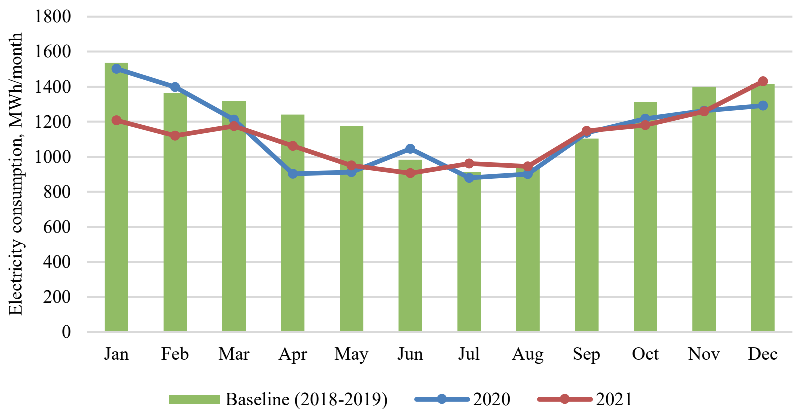

Fig. 5. Electricity consumption in all buildings, MWh/month.

A more detailed analysis was performed to analyse energy consumption trends in four types of buildings – schools and educational institutions, kindergartens and pre-school institutions, administration and office buildings, and buildings of the cultural establishment.

3.3. Monthly Heat Energy Consumption Patterns in the Public Buildings

1. *Schools and educational institutions*. Total heat consumption in schools and educational institutions (46 buildings) decreased by 5.5 % in 2021 and 5.3 % in 2020 compared to the baseline (see Fig. 6). The highest reduction in heat consumption was

observed in April and October 2020, 23 % and 28 %, respectively. The reduction in April is likely due to COVID-19 impact, as in April 2020 all schools were closed. In 2021 highest reduction was detected in January (14 %) and March (8 %).

2. *Kindergartens and pre-schools.* In kindergartens and other similar institutions (53 buildings), the reduction of heat energy consumption was higher in 2020, when 33 % reduction was reached in April, 17 % in October, and 11 % and 9 % in November and December compared to baseline. In 2021, heat energy consumption decreased by 12 % in January, but in other months when heating is used, energy consumption reduction was below 6 %. In total, heat energy consumption in 2020 was 9 % lower, while in 2021 – 2 % against the baseline. The reduction in 2020 might be connected to COVID-19, as many parents chose to keep children at home. Often in the case of one COVID-19 positive person in the group, the whole group of children were declared as contact-persons and were in quarantine. Therefore, many kindergartens worked with reduced occupancy most of the COVID-19 pandemic.

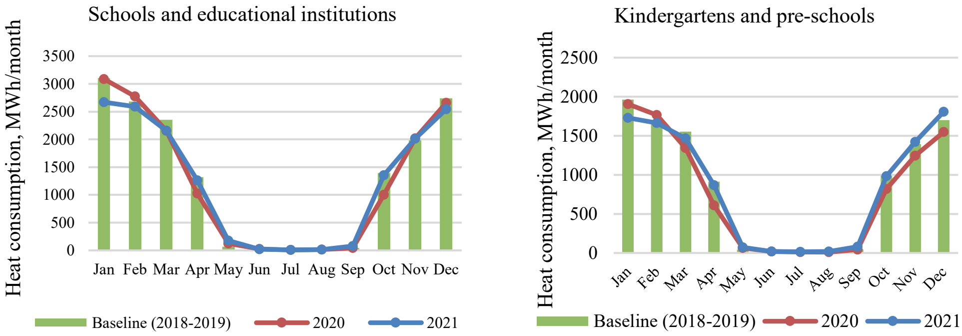

Fig. 6. Heating energy consumption corrected for the regulatory heating season, MWh/month.

3. *Administration and office buildings.* Total heat consumption in administration and office buildings (47 buildings) increased by 8 % in 2021 and 3 % in 2020, compared to baseline. Only in March and October 2020, heating energy consumption decreased by 2 % and 4 %, respectively. Otherwise heat consumption increased on average between 1 % and 22 %. COVID-19 rarely influenced heat consumption in administrative buildings as public officers went to the offices in-person.
4. *Buildings of the cultural establishment.* Total heat consumption in buildings of cultural establishments (25 buildings) increased by 4 % in 2021 and 3 % in 2020 compared to baseline. Monthly heat energy consumption also has increased on average by 2 % in 2020 and 6 % in 2021 compared to baseline. Comparing the COVID-19 restrictions, it would be expected that energy consumption would decrease at least in the same amount as in schools, as the schools and cultural establishments both were closed.

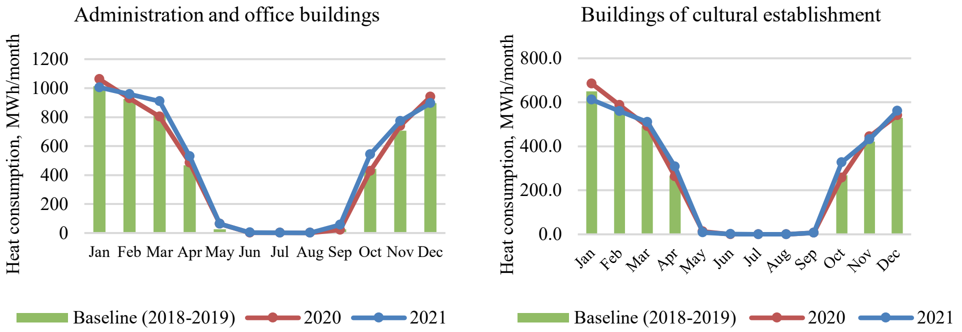

Fig. 7. Heating energy consumption corrected for the regulatory heating season administration and office buildings and in buildings of cultural establishment, MWh/month.

3.4. Monthly Electricity Consumption Patterns in the Public Buildings

1. *Schools and educational institutions*. In total, electricity consumption reduction of 19 % and 29 % was achieved in 2020 and 2021 in schools and other educational facilities in all four municipalities. The highest reduction was in April and May 2020, when first COVID-19 wave hit and schools were closed, reaching 59 % and 62 % compared to baseline (see Fig. 5). Data of 2021 show that significant reduction occurred in all months when national COVID-19 restrictions were in place. During the spring semester of 2021 (Jan–May) monthly average reduction was 47 %, but in the autumn semester (Sep–Dec) 11 %, which also is likely to be linked to COVID-19 restrictions, resulting in significantly reduced occupancy in schools.
2. *Kindergartens and pre-schools.* Monthly electricity consumption data in kindergartens and pre-schools show a high reduction during the first Covid-19 wave when electricity consumption reduced by 19 % in March, 46 % in April, and 28 % in May compared to baseline (see Fig. 5). The second period of significant reductions was observed in October and November 2021, when electricity consumption decreased by 21 % in October and 20 % in November. In 2020 and 2021, the total electricity consumption reduced in average by 4 % compared to baseline.

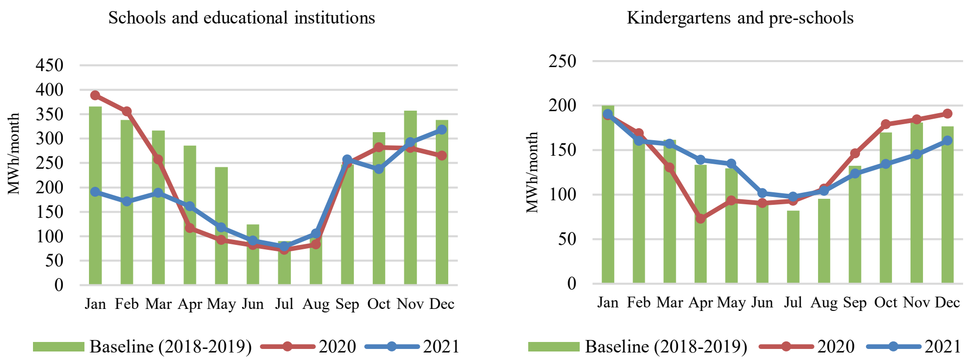

Fig. 8. Electricity consumption in schools and educational institutions and in kindergartens and pre-schools, MWh/month.

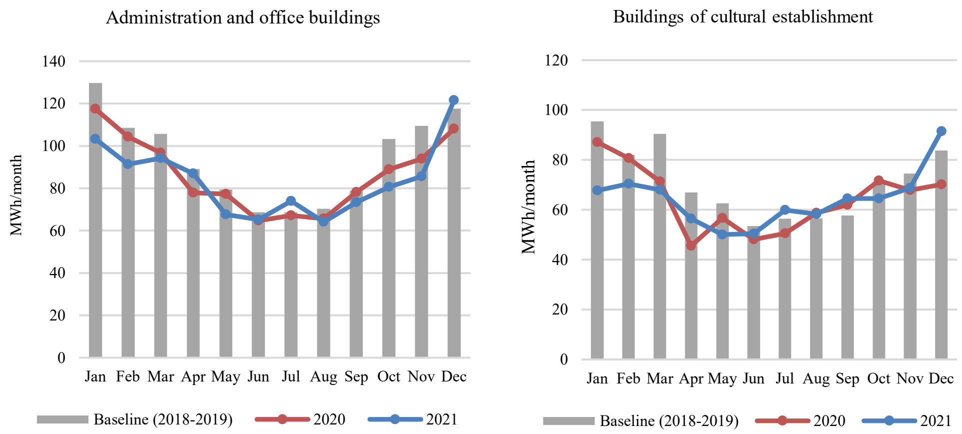

Fig. 9. Electricity consumption in administration and office buildings and in in buildings of cultural establishment, MWh/month.

3. *Administration and office buildings*. Much less fluctuating trends can be observed in administration and office buildings where part of the people continued to go to work during COVID-19 pandemic (see Fig. 7). During the first COVID-19 wave, the deviations are much lower compared to schools. However, in April 2020, electricity consumption reduced by 13 % compared to baseline, and in October and November 2020, the reduction was 14 %, but in December, it was 8 %. In 2021 the highest decrease can be observed in October and November –22 %, while in December, electricity consumption increased by 3% compared to the baseline. Total electricity consumption in administration and office buildings decreased by 8 % in 2020 and 11 % in 2021 compared to baseline.
4. *Buildings of the cultural establishment*. In buildings of the cultural establishment (see Fig. 7), electricity decreased by 21 % in March, 32 % in April, 9 % in May, and 10 % in June 2020 compared to baseline. During the first half of 2020 (Jan-Jun), the average monthly reduction was 14 %, and in 2021 it was 18 %. During autumn 2020, energy reduction was 9 % in November, and 16 % in December, but in 2021 electricity consumption reduced by 9 % in October, 8 % in November, but increased by 9 % in December. In total, electricity consumption in 2021 and 2020 decreased by 9.4 % compared to baseline.

4. Discussion

Within the last ten years, sustainable energy management has been promoted for municipalities intensively to improve energy management practices in municipal buildings and reduce unnecessary energy consumption related to user behaviour. After March 2020, when COVID-19 brought significant disturbances to the operation of many municipal buildings, it is possible to analyse the energy consumption patterns and see if there is evidence of sustainable energy management. This study shows that there have been significant reductions in heat and electricity energy consumption, but still, there is evidence of many challenges in energy management.

Data on total heat energy consumption show that heat energy consumption in average decreased only in two of the four municipalities. In contrast, others have experienced slight increase. In the meantime, total electricity consumption decreased in all four municipalities, which leads to the conclusion that electricity consumption is more strongly linked to building occupancy than heat energy consumption. It is, however, logical that deviations in heat energy consumption should be smaller than electricity, as it is not recommended to reduce the indoor temperature in the buildings too significantly even if they are not used as usual. However, an increase in energy consumption might mean that less attention has been paid to energy management and temperature control in buildings during the pandemic. In contrast, partially reducing electricity consumption might happen unintentionally (lights are not turned in, office equipment is not used).

When specific types of buildings are analysed in more detail, the heat and electricity consumption patterns vary significantly. In schools, kindergartens, and other similar buildings, there is a reduction in heat energy, and in the first year of pandemic, even 25 % reductions and higher are reached. During 2021 reductions are mostly under 10 %. Meanwhile, in office buildings, heat consumption in both 2020 and 2021 increased even though during the first COVID-19 wave, remote working was mandatory as well. It can be assumed that some of the administration work was not possible to organize remotely, and despite that occupancy of buildings reduced significantly, heat energy consumption was not affected. Similar patterns can be seen in data from buildings of cultural establishments where heat energy consumption has also increased during pandemic years. Almost no decrease in heat energy has occurred in these buildings, indicating that occupancy is not a factor that impacts the energy patterns. No cultural events, gatherings, or rehearsals were allowed during the first pandemic months and strictly limited afterward, meaning that these types of buildings were mainly empty.

Electricity consumption trends reflect the impact of pandemics more visibly than heat consumption trends. The first COVID-19 wave is well visible in schools, reaching the peak 59 % electricity consumption reduction in April 2020, when all the schools (1st to 12th grade) were forced to introduce distance learning. During the next school year (2020/2021), electricity consumption is much lower than usual, but not as low as in the first wave. After the first wave, restrictions changed often. Depending on the COVID-19 incidence rates in each municipality, some schools partially opened, but even though the reduced occupancy is reflected in electricity consumption trends. Other researchers have found similar results as well, for example, Gaspar *et al.* analysed an electricity consumption in 83 academic buildings and found that due to COVID-19 restrictions the electricity consumption did decrease, but the decrease during different restriction period were not proportional to buildings occupancy [31]. In kindergartens, the impact of the first COVID-19 wave on energy consumption is well visible. However, afterward, the reductions were not strongly linked to pandemic restrictions as the kindergartens were not closed, and only a few restrictions were applied.

Similarly, to heat energy trends in office buildings and buildings of the cultural establishment, electricity trends do not seem strongly linked to the buildings' occupancy. Geraldi *et al.* has come to similar conclusions, that most of the municipal buildings have high vital loads or stand-by loads, meaning the buildings has significant impact on environment despite how much it is used [23].

5. CONCLUSION

The impact of COVID-19 restrictions on energy consumption in municipal buildings is visible, as, in educational facilities the electricity and heat energy consumption mainly did decrease. While in buildings of cultural establishments and administrations, energy consumption did not decrease as it would be expected, and in some cases, it even increased. The reasons behind the lacking electricity consumption reduction should be researched more closely to see if the result is linked to poor management and lack of control of electricity use behaviour or other factors. This study also suggests that there might be a great potential for energy saving if the standby loads could be reduced in the buildings.

Overall it is clear that occupancy of the buildings does not always determine the energy consumption patterns due to specifics of the building use case or mismanagement. Therefore, much more focus should be paid to sustainable energy management practices. As all the municipalities included in this research have implemented energy management systems, the system's efficiency during such disturbances as COVID-19 caused should be evaluated.

This research is limited to buildings of 4 average-sized Latvian municipalities. Therefore, it should not be assumed that the same trend could be generalized to all municipalities. However, this is an example of how monthly data analysis can indicate problems in building energy management practices.

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Anda Jēkabsone ir dzimusi 1991. gadā Dobelē. Absolvējusi Latvijas Lauksaimniecības universitāti, iegūstot profesionālo bakalaura grādu vides saimniecībā un vides inženierzinātnē un vides inženiera kvalifikāciju (2015). Studijas turpināja Rīgas Tehniskās universitātes Inženierekonomikas un vadības fakultātē, kur ieguva sociālo zinātņu maģistra grādu vadībzinātnē (2017). Profesionālajā darbībā kopš 2017. gada specializējas enerģētikas plānošanas un vides konsultāciju jomā. Patlaban ir SIA "Ekodoma" projektu vadītāja, konsultē uzņēmumus par vides atļauju un emisiju gaisā jautājumiem, kā arī strādā dažādos Eiropas Savienības finansētos projektos.