KLIIMA-NEUTRAALNE AASTAKS 2035

TAL TECH

HOONETE MÕJU JA SUUNDUMUSED EESTI ENERGIAKASUTUSES

JAREK KURNITSKI

26.01.2024

EESTI ELAMUFOND

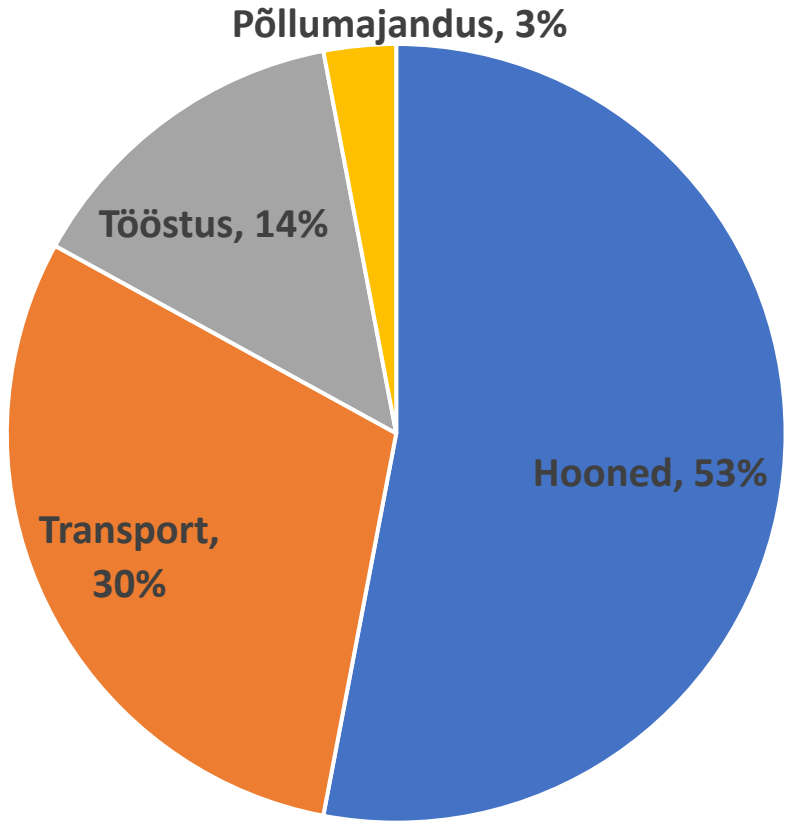
- 22,4 mln m^2 väikeelamuid ja 31 mln m^2 korterelamuid, millest 22,9 mln m^2 <2000 a
- 71% elanikest elab korterelamutes
- **ca 50% elanikest elab renoveerimist vajavates korterites, ehitatud 1950–90:**
  - Majades puudub soojustus ja ventilatsioon – ei ole lihtsaid lahendusi renoveerimiseks
  - Mida varem täisrenoveerimine seda parem – kõige suurem energiasäästupotentsiaal

TAL TECH | TALLINNA TEHNIKAÜL

ENERGIATÕHUSUSE TIPPKESKUS

- Energiatõhususe tippkeskus ENER esindab 53% energia lõpptarbimisest Eestis
- Arvestades, et 75% hoonefondist vajab 30 a perspektiivis renoveerimist, on hinnatud, et **üle 50% roheleppe investeeringutest tuleb teha hoonetesse** – suurim ühiskondlik ja majanduslik väljakutse
- ENER panustab väljakutse lahendamisse leidmaks reaalselt teostatavaid rohepöörde lahendusi ja maksimeerides kaasnevaid kasusid ning elukvaliteedi paranemist

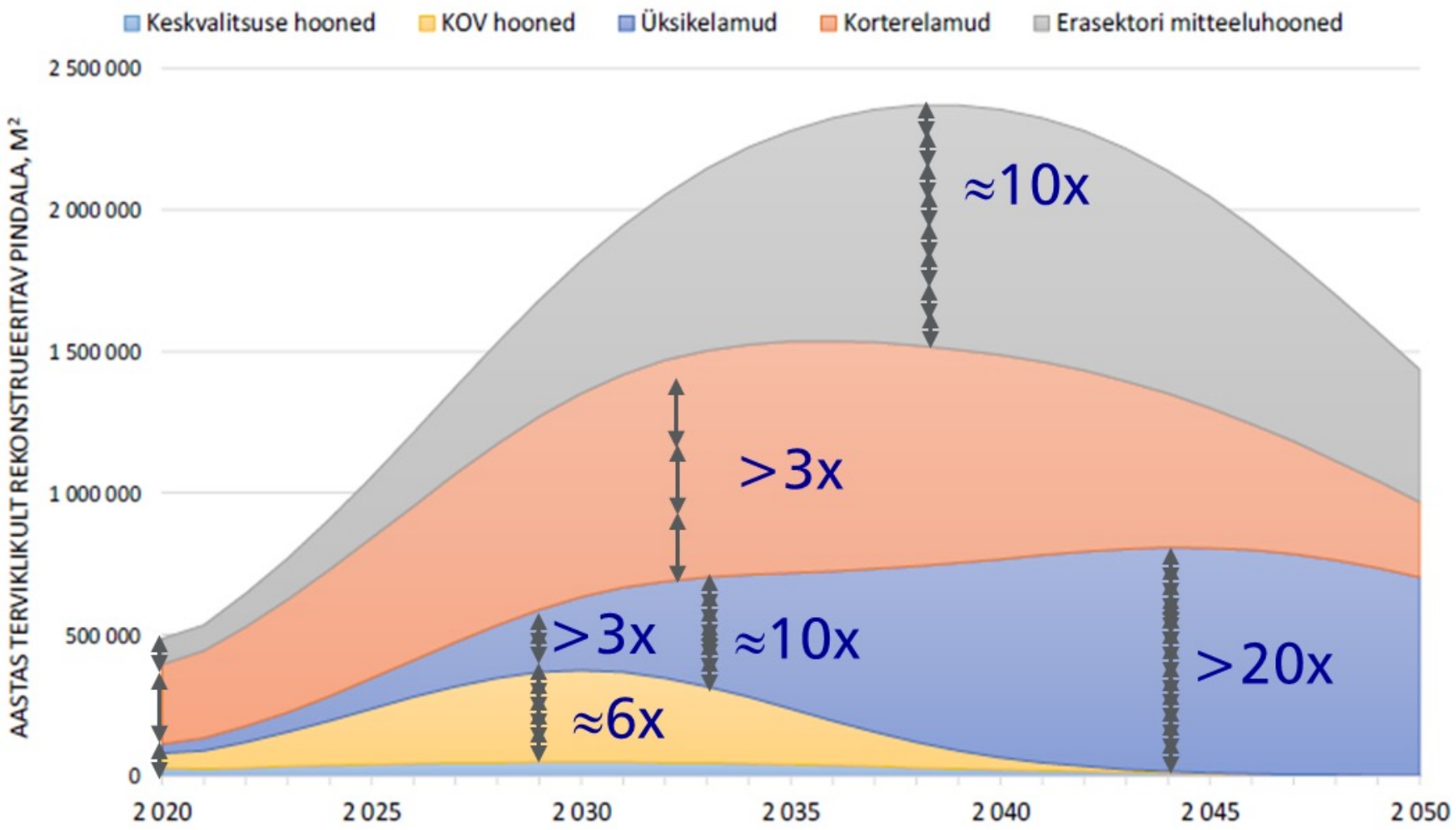
Energia lõpptarbimine 2021, 32,2 TWh



TAL TECH | TALLINNA TEHNIKAÜLIKOOL

- Energia lõpptarbimine 32-33 TWh/a viimase 10 a jooksul
- Hoonete osakaal on tõusnud üle 50%
- Transport samuti tõusutrendis, aga tööstus vähenenud

REKONSTRUEERIMISE PIKAAJALINE STRATEEGIA



Joonis 1. Kumulatiivne aastane rekonstrueerimise vajadus.

ENERGIA- JA RESSURSITÕHUSUS

REGIONAALNE TASAKAAL

ELUKESKKONNA KVALITEET

TEHNOLOOGIA ARENDUS

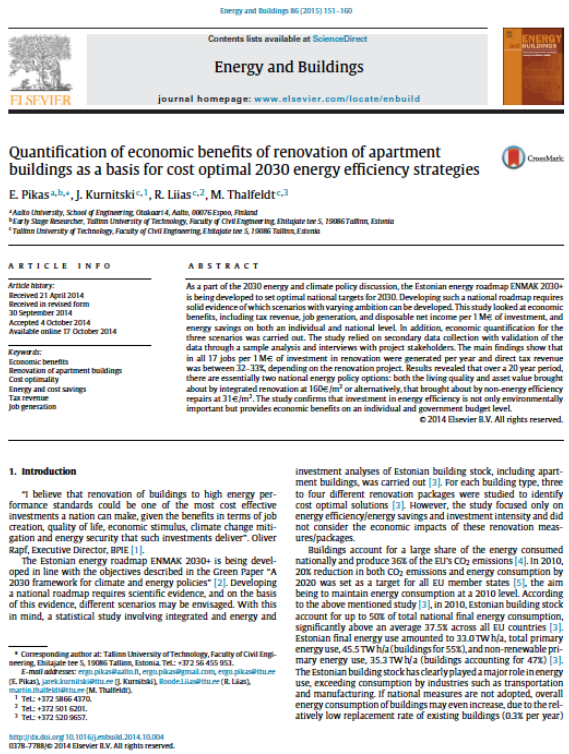
KLIIMA-KOHANEMINE

KULU-OPTIMAALSUS

KredEx-i KORTERELAMUTE RENOVEERIMISTOETUS

Rohepöörde mootor:

- 3 000 korterelamut renoveeritud 2010-
- 14 000 ootab oma järge



Energy and Buildings 86 (2015) 151–160

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Quantification of economic benefits of renovation of apartment buildings as a basis for cost optimal 2030 energy efficiency strategies

E. Pikas[a,b,*], J. Kurnitski[c,1], R. Liias[c,2], M. Thalfeldt[c,3]

[a] Aalto University, School of Engineering, Otakaari 4, Aalto, 00076 Espoo, Finland
[b] Early Stage Researcher, Tallinn University of Technology, Faculty of Civil Engineer ing, Ehitajate tee 5, 19086 Tallinn, Estonia
[c] Tallinn University of Technology, Faculty of Civil Engineering, Ehitajate tee 5, 19086 Tallinn, Estonia

ARTICLE INFO

Article history:
Received 21 April 2014
Received in revised form
30 September 2014
Accepted 4 October 2014
Available online 17 October 2014

Keywords:
Economic benefits
Renovation of apartment buildings
Cost optimality
Energy and cost savings
Tax revenue
Job generation

ABSTRACT

As a part of the 2030 energy and climate policy discussion, the Estonian energy roadmap ENMAK 2030+ is being developed to set optimal national targets for 2030. Developing such a national roadmap requires solid evidence of which scenarios with varying ambition can be developed. This study looked at economic benefits, including tax revenue, job generation, and disposable net income per 1 M€ of investment, and energy savings on both an individual and national level. In addition, economic quantification for the three scenarios was carried out. The study relied on secondary data collection with validation of the data through a sample analysis and interviews with project stakeholders. The main findings show that in all 17 jobs per 1 M€ of investment in renovation were generated per year and direct tax revenue was between 32–33%, depending on the renovation project. Results revealed that over a 20 year period, there are essentially two national energy policy options: both the living quality and asset value brought about by integrated renovation at 160€/m² or alternatively, that brought about by non-energy efficiency repairs at 31€/m². The study confirms that investment in energy efficiency is not only environmentally important but provides economic benefits on an individual and government budget level.

1. Introduction

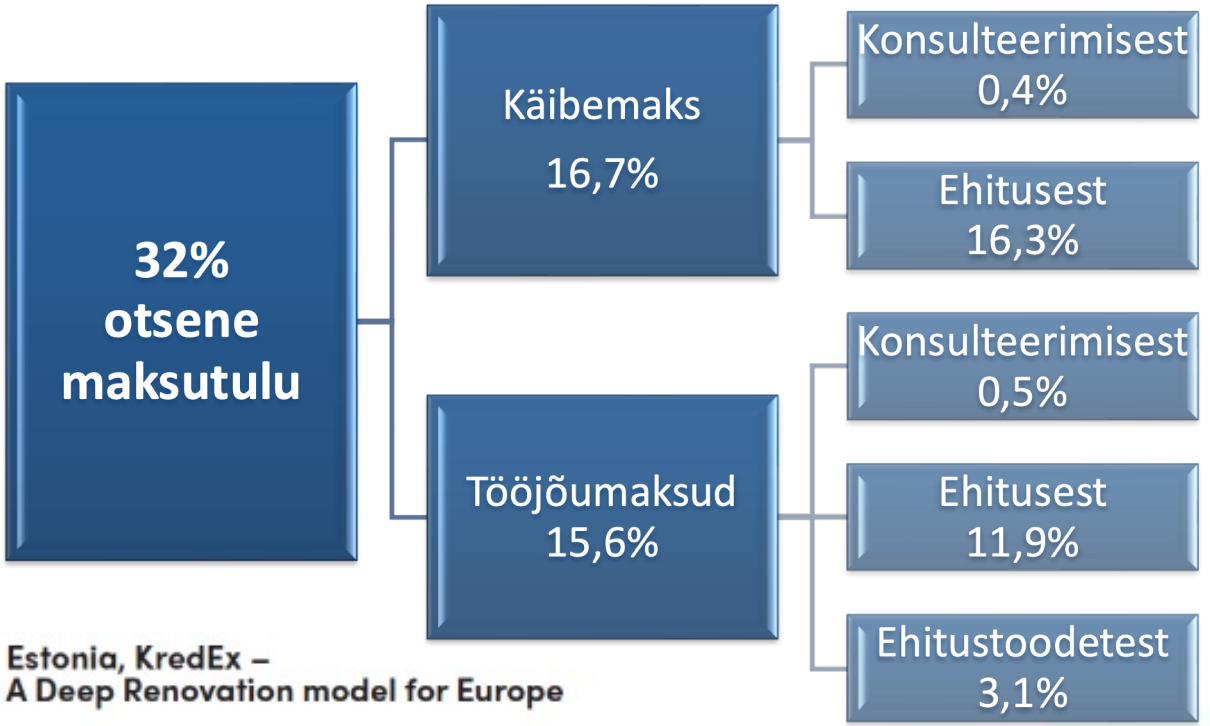
"I believe that renovation of buildings to high energy performance standards could be one of the most cost effective investments a nation can make, given the benefits in terms of job creation, quality of life, economic stimulus, climate change mitigation and energy security that such investments deliver". Oliver Rapf, Executive Director, BPIE [1].

The Estonian energy roadmap ENMAK 2030+ is being developed in line with the objectives described in the Green Paper "A 2030 framework for climate and energy policies" [2]. Developing a national roadmap requires scientific evidence, and on the basis of this evidence, different scenarios may be envisaged. With this in mind, a statistical study involving integrated and energy and investment analyses of Estonian building stock, including apartment buildings, was carried out [3]. For each building type, three to four different renovation packages were studied to identify cost optimal solutions [3]. However, the study focused only on energy efficiency/energy savings and investment intensity and did not consider the economic impacts of these renovation measures/packages.

Buildings account for a large share of the energy consumed nationally and produce 36% of the EU's CO_2 emissions [4]. In 2010, 20% reduction in both CO_2 emissions and energy consumption by 2020 was set as a target for all EU member states [5], the aim being to maintain energy consumption at a 2010 level. According to the above mentioned study [3], in 2010, Estonian building stock account for up to 50% of total national final energy consumption, significantly above an average 37.5% across all EU countries [3]. Estonian final energy use amounted to 33.0 TW h/a, total primary energy use, 45.5 TW h/a (buildings for 55%), and non-renewable primary energy use, 35.3 TW h/a (buildings accounting for 47%) [3]. The Estonian building stock has clearly played a major role in energy use, exceeding consumption by industries such as transportation and manufacturing. If national measures are not adopted, overall energy consumption of buildings may even increase, due to the relatively low replacement rate of existing buildings (0.3% per year)

* Corresponding author at: Tallinn University of Technology, Faculty of Civil Engineering, Ehitajate tee 5, 19086 Tallinn, Estonia. Tel.: +372 56 455 953.
E-mail addresses: ergo.pikas@aalto.fi, ergo.pikas@gmail.com, ergo.pikas@ttu.ee (E. Pikas), jarek.kurnitski@ttu.ee (J. Kurnitski), Roode.Liias@ttu.ee (R. Liias), martin.thalfeldt@ttu.ee (M. Thalfeldt).
[1] Tel.: +372 5866 4370.
[2] Tel.: +372 501 6201.
[3] Tel.: +372 520 9657.

http://dx.doi.org/10.1016/j.enbuild.2014.10.004
0378-7788/



Estonia, KredEx – A Deep Renovation model for Europe

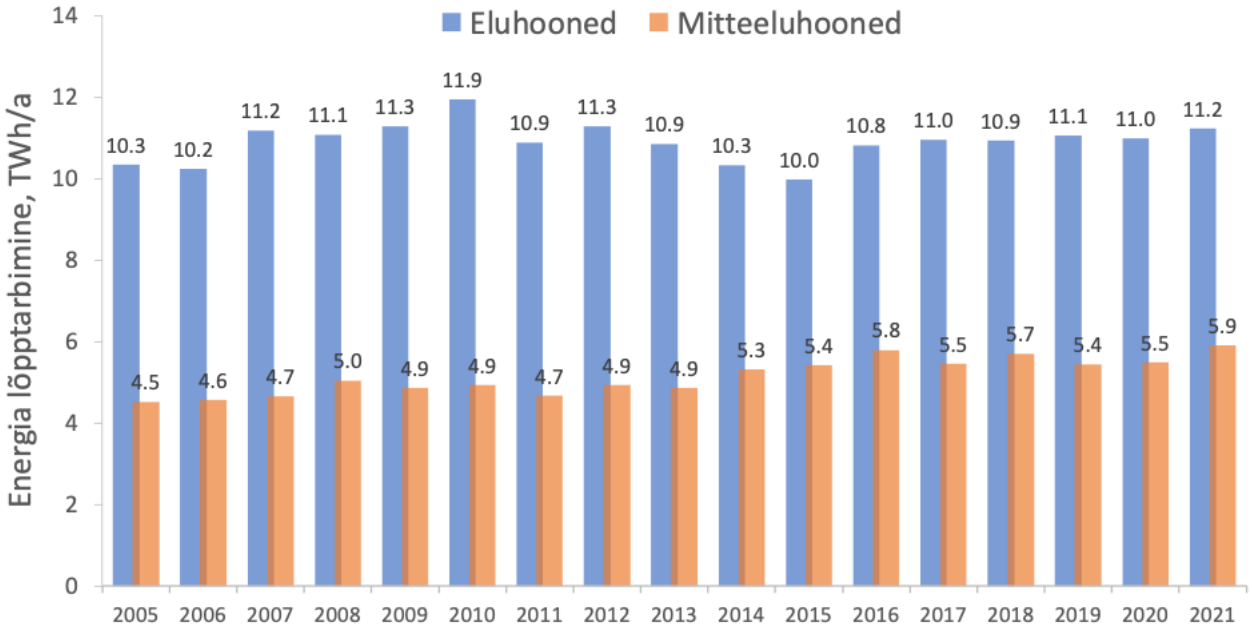
Estonia has achieved great results in deep renovation, thanks to the KredEx renovation grant system. Backed by the EU since its 2010 kick-off, KredEX features strict technical requirements, focusing on high-level energy efficiency and indoor climate conditions.

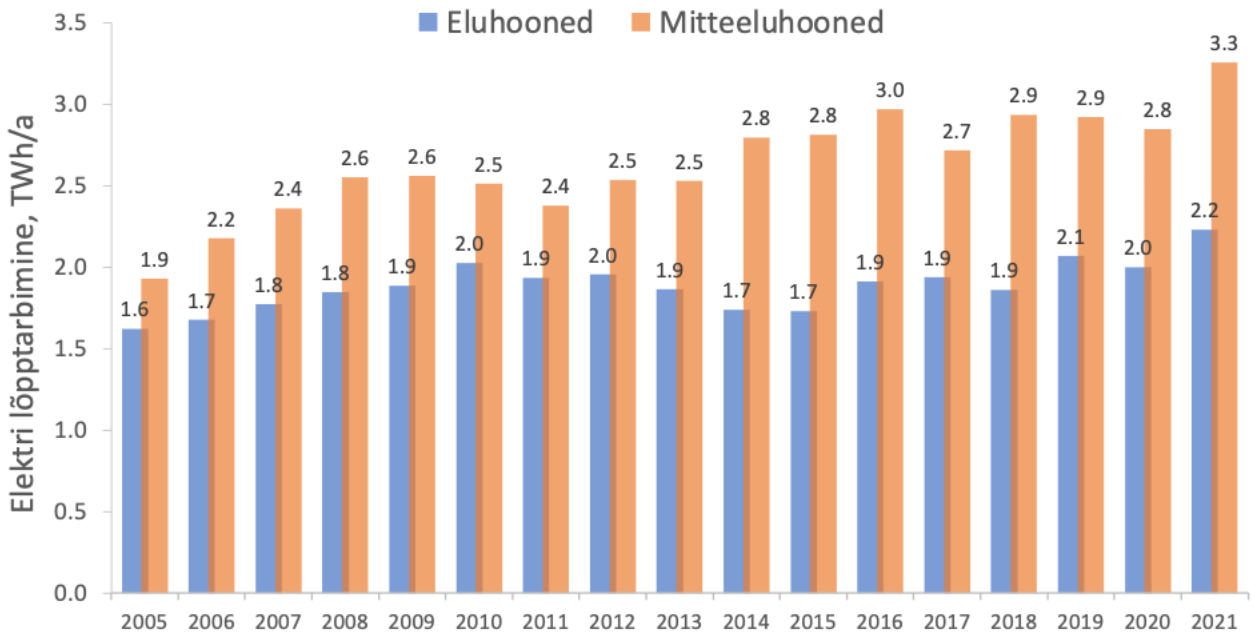
Igiliikur?

- Soojuse kokkuhoid 50-70%
- Elektris väike tõus või vähenemine sõltuvalt päikesepaneelidest

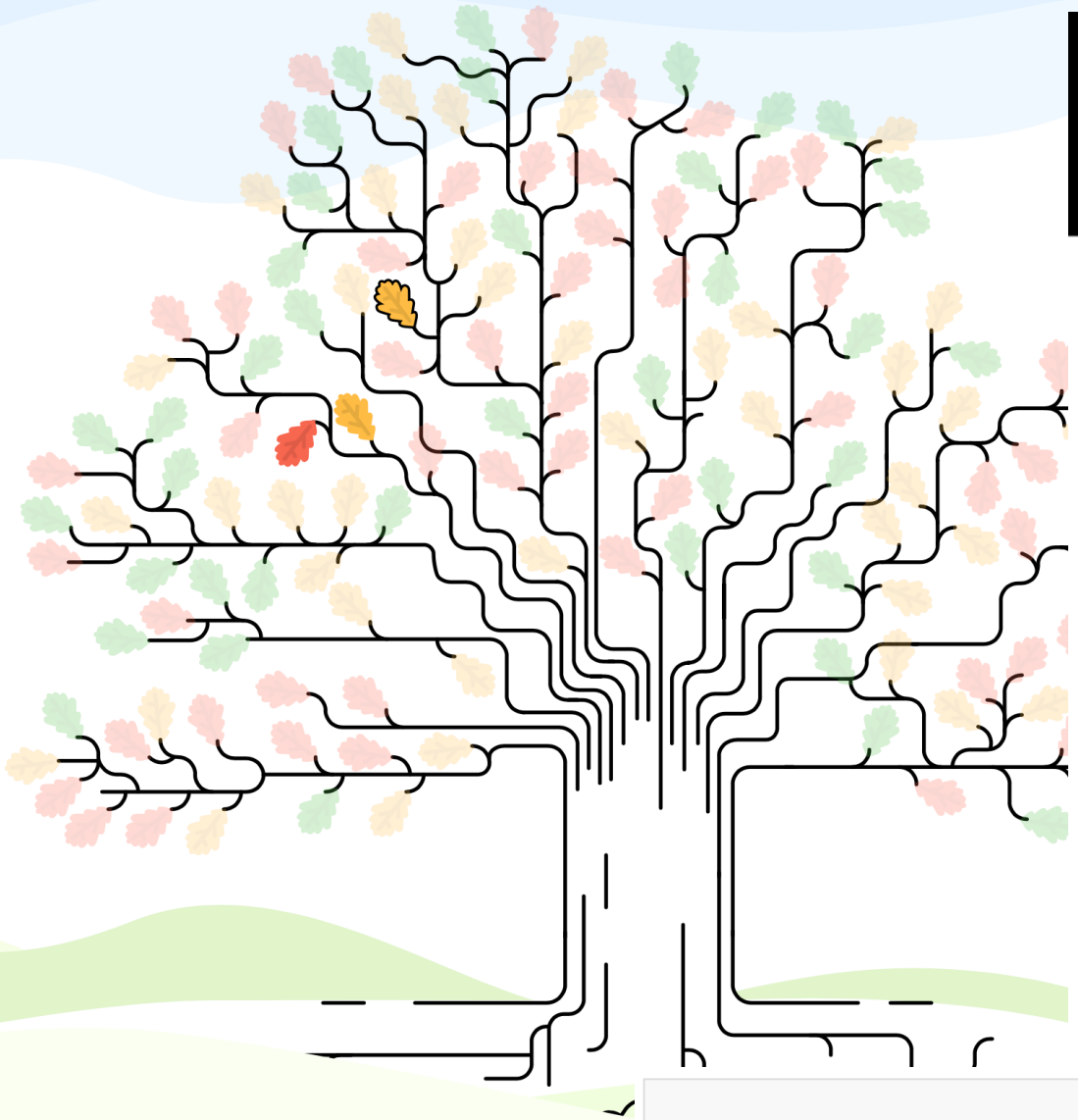
ENERGIA LÕPPTARBIMISE SUUNDUMUSED HOONETES

- Eluhooned stabiilsed
- Mitte-eluhoonetes tõusev trend, +30%/15a
- Elektri tarbimises tõusev trend
- 2021 a Covidi mõju – tavapärasest suurem energiatarbimine hoonetes





Tõetamm



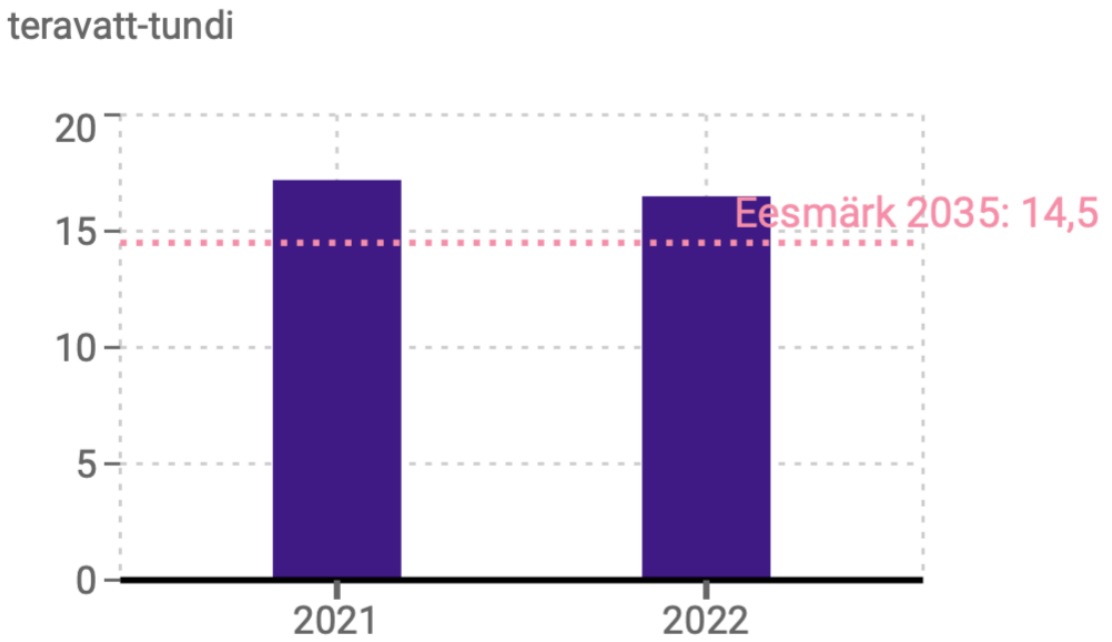
Eesmärk on täidetud

Liigutakse oodatava tulemuse poole

Ei liiguta oodatava tulemuse poole

Eesti 2035

2022: 16,5 teravatt-tundi

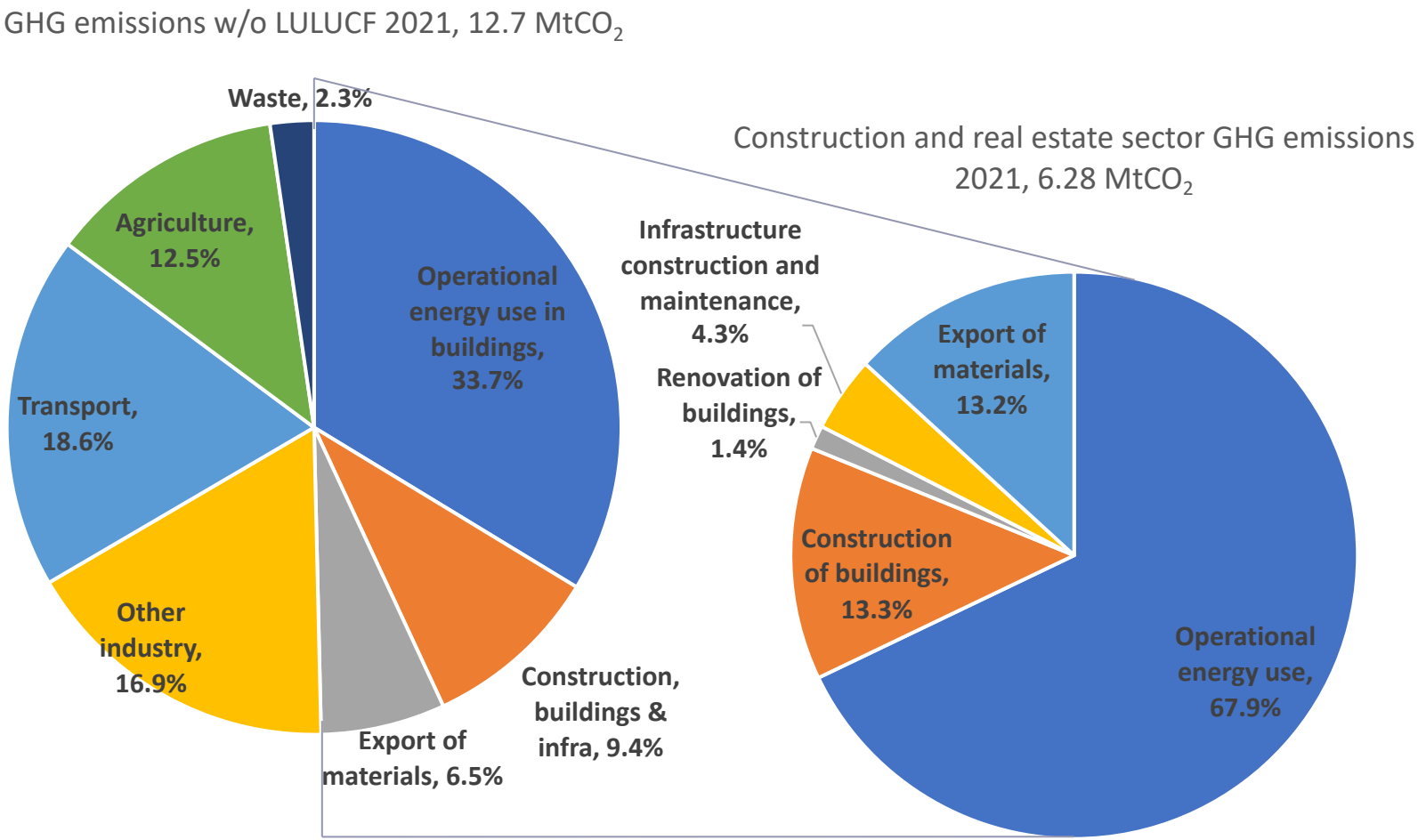


Allikas: Statistikaamet

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
10.5 Elamute ja mitteelamute energiatarve, TWh	15,7	15,7	15,4	16,6	16,4	16,6	16,4	16,4	17,2	16,5	..

GHG EMISSIONS IN ESTONIA

- Estonian GHG emissions in 2021 12.7 million tCO_2 without LULUCF
- 83% of emissions from energy
- GHG emissions from buildings operational energy use, construction and construction related manufacturing industry account for **49.6% of total GHG emissions without LULUCF**
- From real estate and construction sector emissions, **68% are from buildings operational energy use**



www.rohetiiger.ee
Ehituse teekaart 2040

ENMAK 2030 – 10 A VANA PROGNOOS

Table 6
Assumptions for the building stock energy use scenarios 2011–2030.

	Scenario 1	Scenario 2	Scenario 3
Integrated renovation variants	Min	Cost optimal	Cost optimal
Renovation rate of apartment buildings, %/a	0.75	1.5	2.5
Renovation rate of detached houses, %/a	0.5	1.0	2.0
Renovation rate of non-residential buildings, %/a	0.5	0.75	1.0
Building stock loss (demolition), %/a	0.3	0.3	0.3
New construction rate in residential buildings, %/a	1.0	1.0	1.0
New construction rate in non-residential buildings, %/a	1.5	1.5	1.5
Application of nZEB requirements in new buildings, a	2026	2021	2016

To assess achievable energy savings within 20 years, three scenarios were calculated with varied renovation rates for the period of 2011 to 2030. Building stock size and new construction volumes of 2010 were used as reference level. The assumptions used in scenarios are shown in Table 6. Scenario 1 operates with first integrated renovation variants described in Tables 3–5 (second points from the left in Fig. 6) and two other scenarios with cost effective renovation variants (marked in Fig. 6). Renovation rates are selected so that Scenario 1 refers to situation where renovation is not supported by incentives. In two other scenarios, direct renovation funding grants of 25% and 35% of renovation cost, corresponding to Estonian KredEx support scheme, are available for residential buildings. Selected renovation rates are justified by experience from 520 apartment buildings, where integrated renovation has been completed with KredEx grants and similar renovation variants. Because of the budgeting of grants, the renovation rates were fixed, i.e. calculated from the size of 2010 building stock and the same values were used for all years. For demolition, also 0.3% of 2010 stock was used for all years.

New construction rates are the same in all scenarios and they are calculated from construction volume of 2010 (in total 661,900 m^2). The new volume of each year was calculated from previous year

Prognoos vs. tegelik

11,2 vs. 11,7

4,81 vs. 4,82

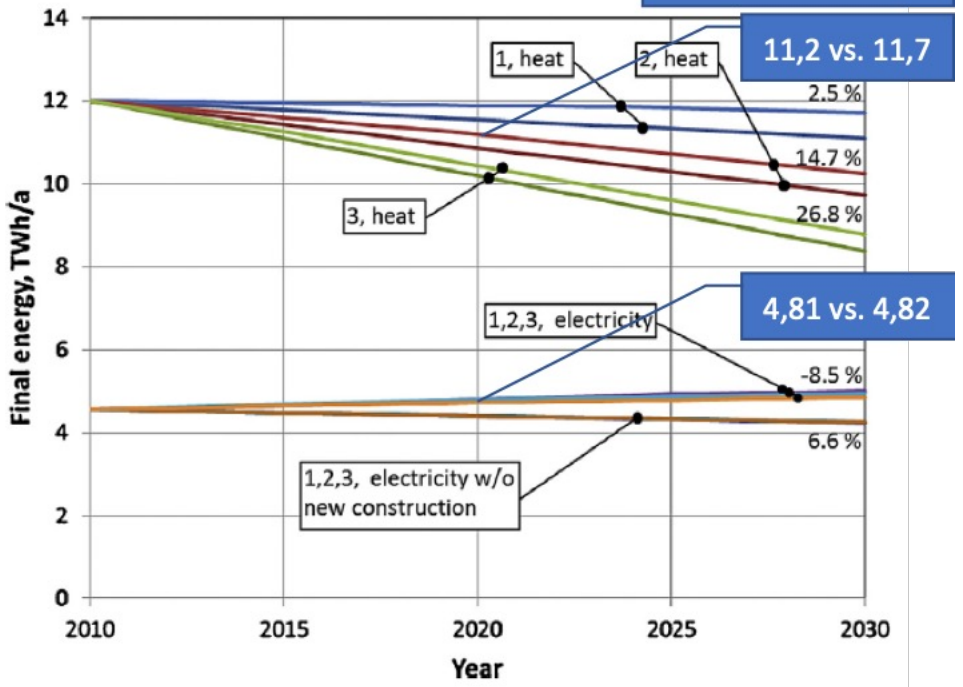
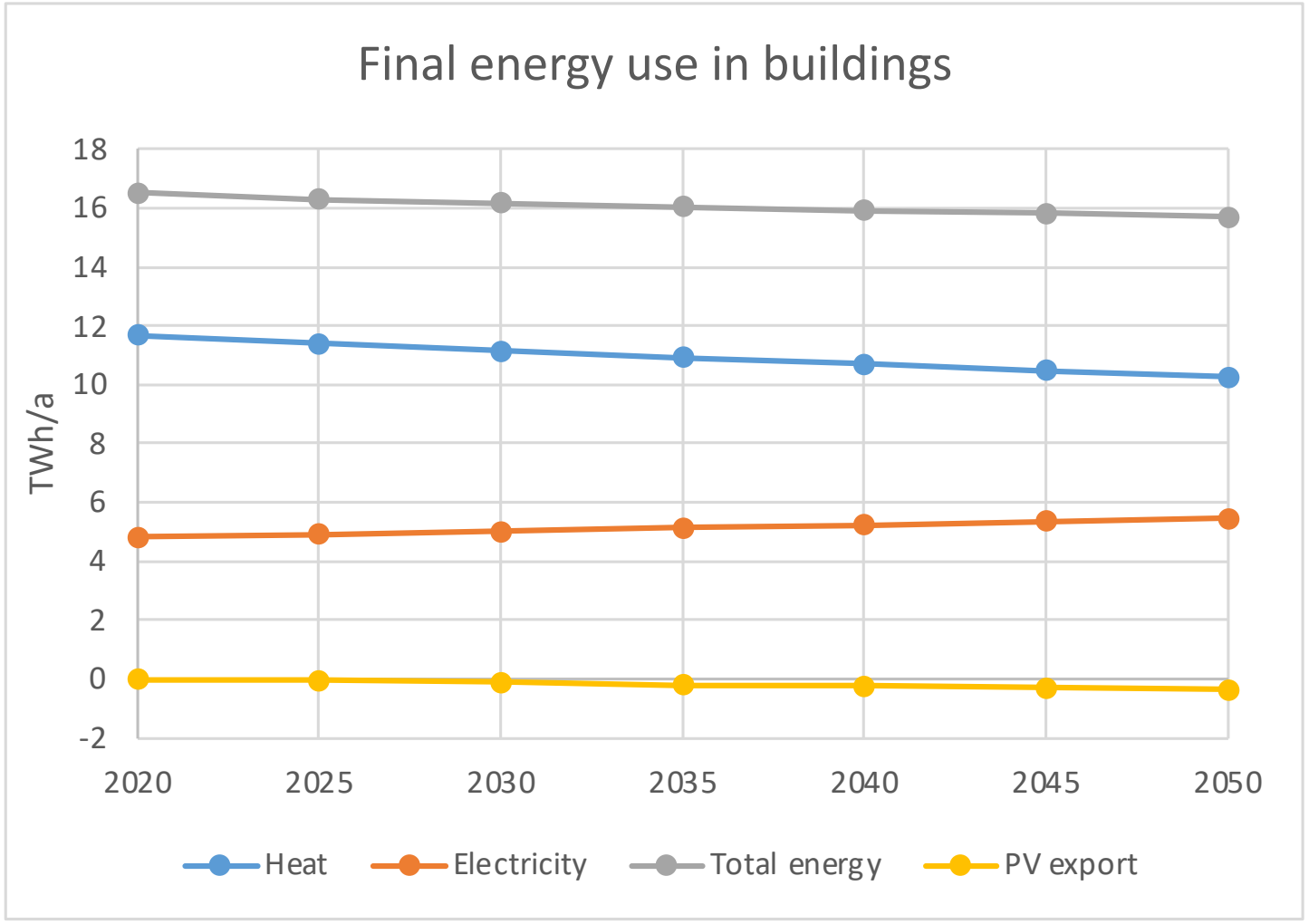


Fig. 9. Final energy development in three scenarios. Heating energy and electricity are shown in each scenario with and without new construction. The upper curves include new construction, for which reductions in % by 2030 are shown. In the case of electricity use without new construction the differences between scenarios were

ELAMUMAJANDUSE JA TEENINDUSSEKTORI TRENDID – BAASJOON

- Uus prognoos (RenoWave 2024)
- Baasjoon ilma meetmeta, st ei täida eesmärke, praegused trendid jätkuvad
- Soojus (kaugküte, kütused) langustrendis – sõltub renoveerimise mahtudest
- Elekteril tõusutrend, osaliselt hoonetes toodetud elekter tasakaalustab
- Elamutes ja mitteeluhoonetes erinevad trendid



TAL TECH | TALLINNA TEHNIKAÜLIKOOL

HOONEFONDI PÕHIPARAMEETRID

- Hoonefondi (energiat kasutatakse sisekliima tagamiseks va tööstushooned) netopind, m^2

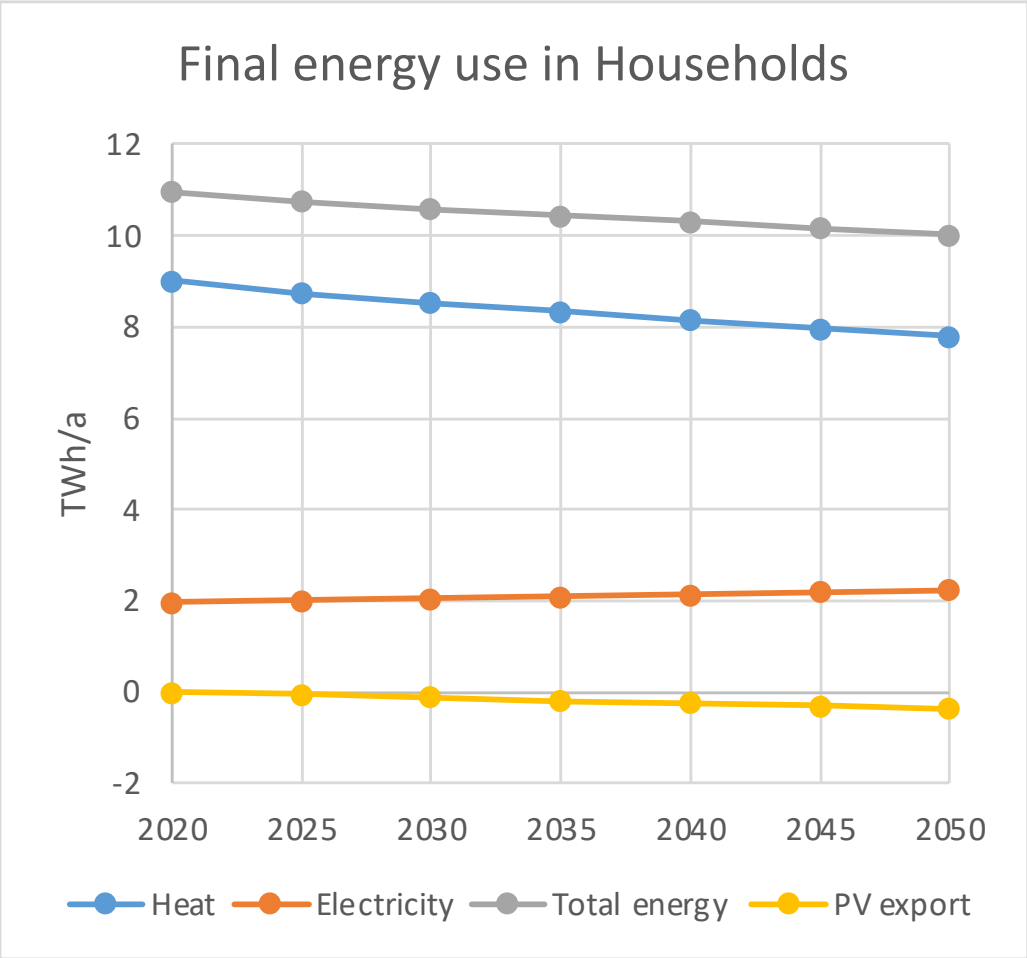
	Üksikelamud	Korterelamud	Büroohooned	Ärihooned	Haridus	Muu	Kokku
<2000	**18 800 000**	**22 900 000**	**4 200 000**	**4 000 000**	**3 700 000**	**4 800 000**	**58 400 000**
>2000	3 600 000	8 100 000	1 600 000	2 600 000	550 000	1 200 000	17 650 000
Kokku	22 400 000	31 000 000	5 800 000	6 600 000	4 250 000	6 000 000	76 050 000

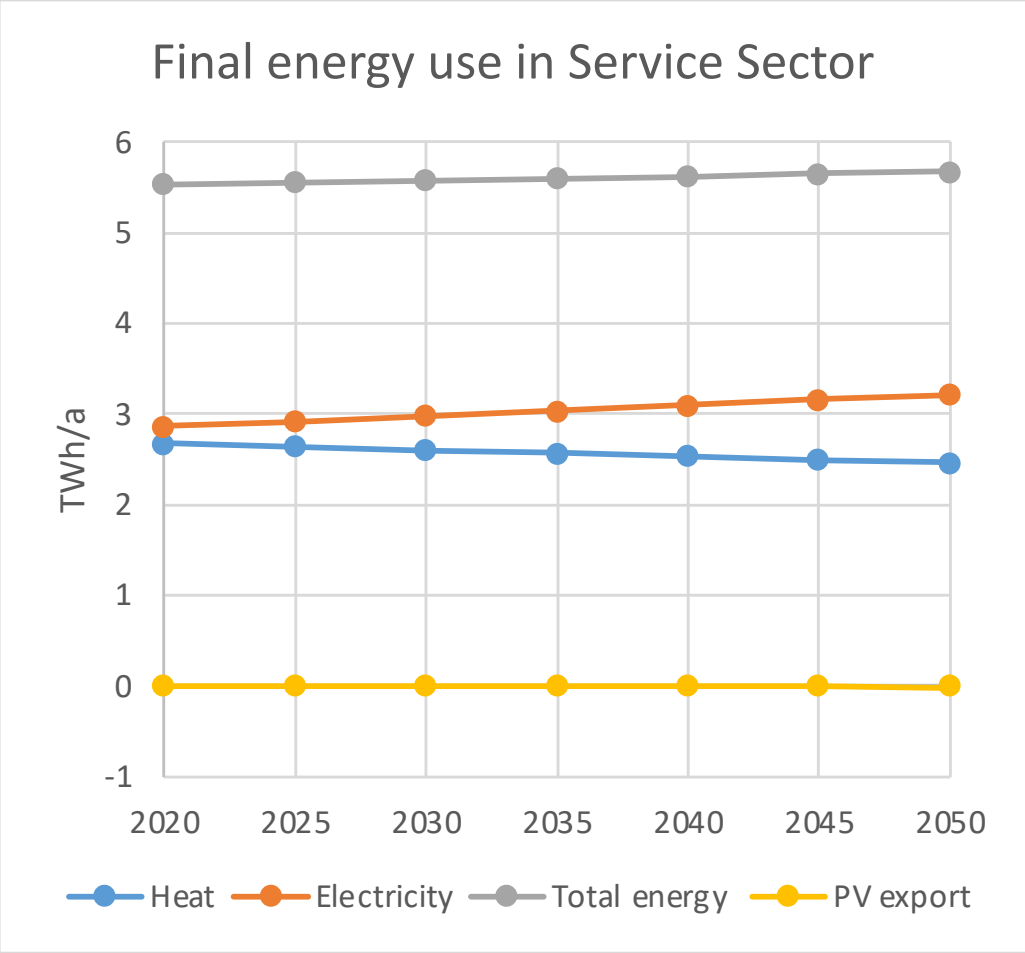
- <2000 a ehitatud hooned on nõrga energiatõhususega ja vajavad renoveerimist

- Energiakasutust mõjutab väljalangevuse, uusehituse ja energiakaalutud C-klassi renoveerimise määr

Aastane muutus	Üksik-elamud	Korter-elamud	Büroo-hooned	Ärihooned	Haridus	Muu	Kokku
Väljalangevus, m^2/%	95 000	110 000	20 000	20 000	10 000	20 000	**275 000**
	0.42%	0.35%	0.34%	0.30%	0.24%	0.33%	**0.36%**
Uusehitus, m^2/%	245 000	310 000	75 000	65 000	35 000	50 000	**780 000**
	1.09%	1.00%	1.29%	0.98%	0.82%	0.83%	**1.03%**
Renoveeri-mine, m^2/%	85 000	280 000	47 500	62 500	42 250	20 000	**692 250**
	0.38%	0.90%	0.82%	0.95%	0.99%	0.33%	**0.71%**

ELAMUMAJANDUSE JA TEENINDUSSEKTORI BAASJOON





- Elamutes ja mitteeluhoonetes erinevad trendid
- Renoveerimine tagasihoidlik, aga hoonefondi energiatõhusus paraneb tänu liginullenergiahoonetele, mis tasapisi asendavad kasutusest välja langevat hoonefondi

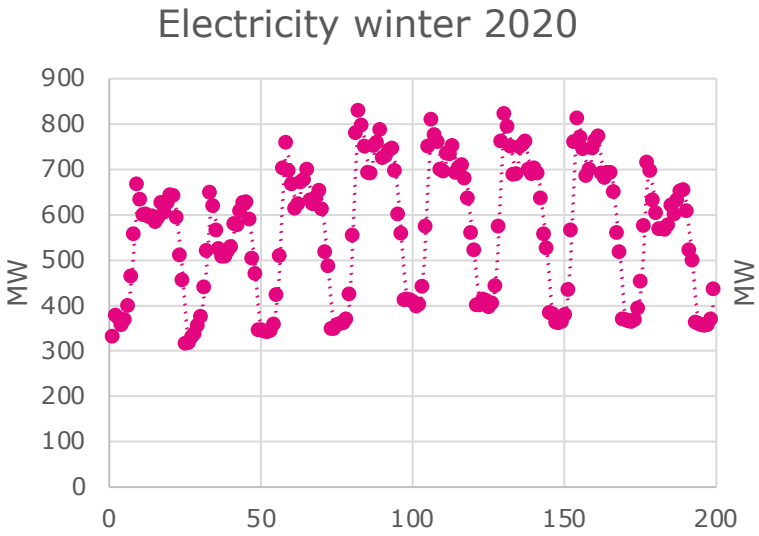
BAASJOONE SOOJUS JA KÜTUSED

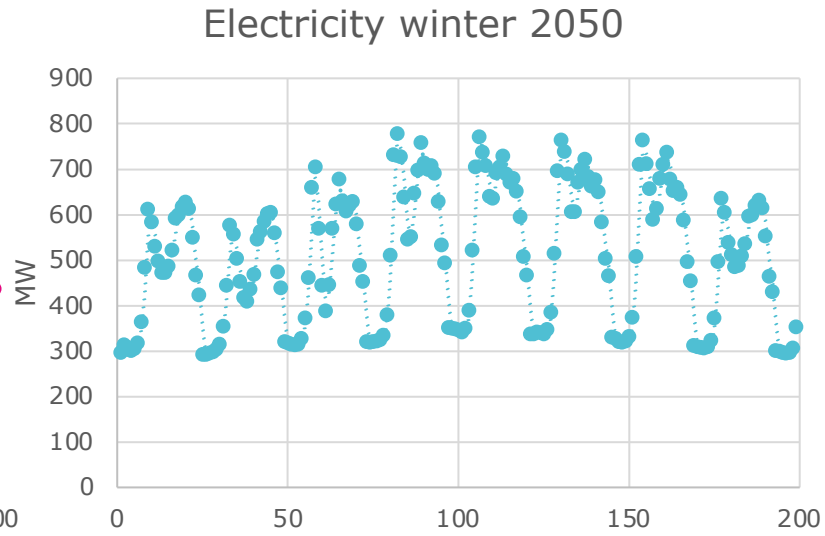
- Kaugküte stabiilne
- Puuküte väheneb ja soojusallikate jaotus muutub renoveerimise käigus
- Baasjoon ei sisalda meetmeid fossiilkütuste vähenendamiseks

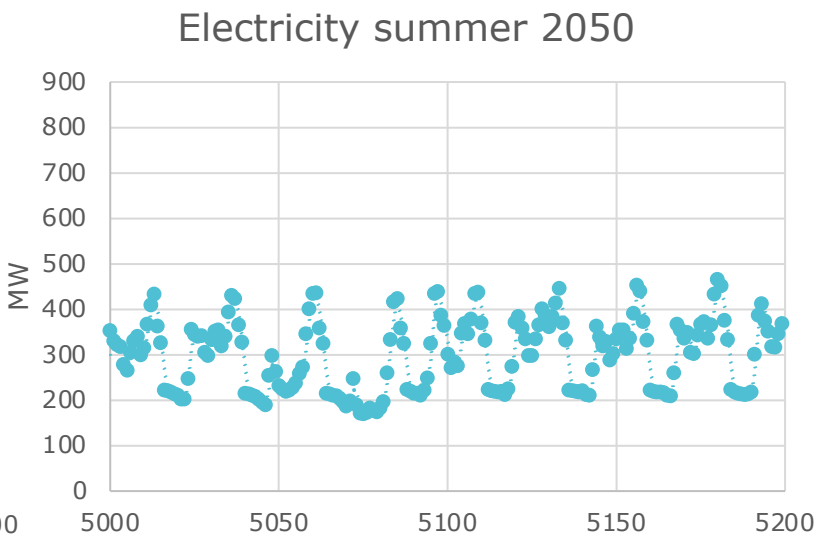
Heating energy by source GWh/a						
	Wood	Gas	Biogas	District heating	Oil	Coal
2010-20219 EH0240	4588	1302	27	5057	370	55
2020	4666	1351	21	5203	389	53
2025	4465	1305	24	5172	366	50
2030	4285	1263	27	5164	345	47
2035	4118	1224	30	5169	324	45
2040	3952	1185	32	5175	303	42
2045	3785	1145	35	5181	282	40
2050	3618	1106	37	5186	261	38

HOONETE OSAKAAL ELEKTRI TARBIMISES JA TIPUKOORMUSES – 2050 REKS EELDUSTEGA

- Hoonetes tarbitakse täna ca 60% elektrienergiast
- Hoonefondi tipukoormus ca 80% kogu tarbimise tipukoormusest
- 2050 tarbimine/tipukoormus suureneb (soojuspumbad, uusehitus jne) või väheneb (tõhususe parandamine) sõltuvalt meetmetest
- REKS strateegia – kulutõhusad meetmed – hoonefondi täisrekonstrueerimine:
  - kütuste tarbimine väheneb 60%
  - soojuse tarbimine väheneb 30%
  - elektritarbimine ei muutu





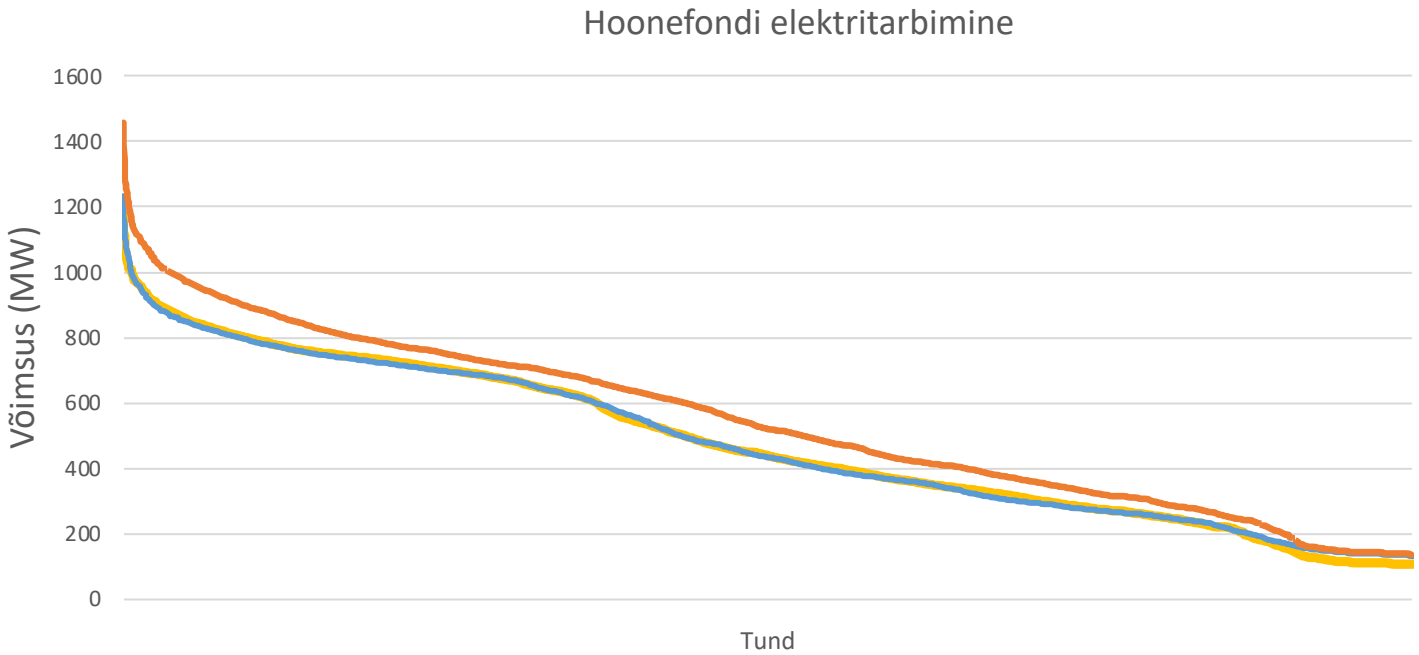


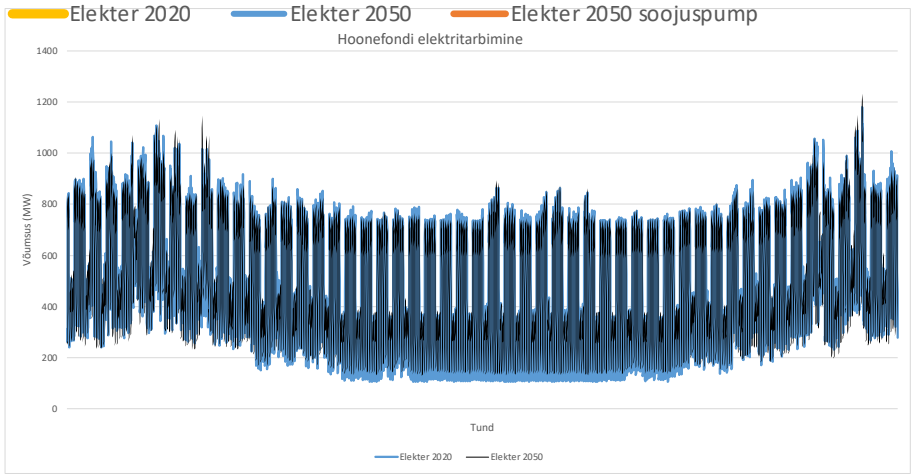
TAL TECH | TALLINNA TEHNIKAÜLIKOOL

HOONETE OSAKAAL ELEKTRI TIPUKOORMUSES

- Hoonefondi tipukoormus 1180 MW ca 80% kogu tarbimise tipukoormusest
- Tipukoormus 1230 MW 2050 REKS strateegia elluviimisel
- Mitteeluhoonete elektri vähenemine kompenseerib eluhoonete elektri suurenemise
- Võimalik ka 1460 MW 2050 kui strateegiat ei rakendata

- (Einstein 2022)





ENERGIATÕHUSUSE DIREKTIIV EED

- **New EED target**
  - **From current 0.8% new savings each year to 1.49% in average over 2024-2030**
  - Gradually to 1.9% new savings each year at the end of 2030
- EC calculation for Estonia
  - Previous target was 33 TWh FEC (with baseline ~36 TWh), and is now 11% lower at 30 TWh
- How?
  - Strengthening existing EE policies
  - Designing & implementing new EE policies
- Additional Estonia 2035 target for FEC in residential and non-residential buildings:
  - 16.5 TWh 2019
  - 14.5 TWh 2035

Changes to the 2030. targets:

Final Energy Consumption:
33 TWh -> 30 TWh -10,9%

Primary Energy Consumption:
53 TWh -> 45,7 TWh -13,5%

Cumulative energy savings:
14,767 TWh -> 21,279 TWh +44%

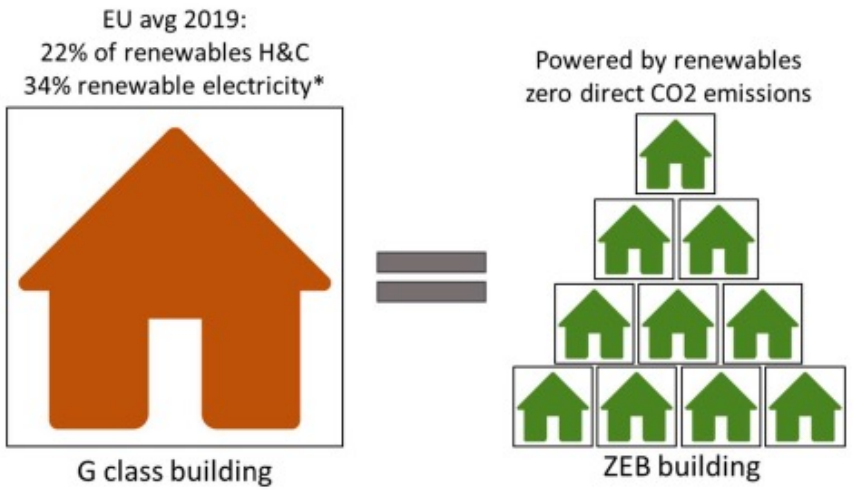
TAL TECH | TALLINNA TEHNIKAÜLIKOOL

HOONETE ENERGIATÕHUSUSE DIREKTIIV 2002-2010-2018-2024

- Heitevabad uued hooned 2028/2030
- Miinimum energitõhususe standardid (MEPS) – kergem renoveerimine
- Täisrenoveerimine + oluline rekonstrueerimine
- Energiamärgiste harmoniseerimine

- Uus visioon muuta EL hoonefond nullheitega hooneteks 2050
- Põhiline instrument riiklikud renoveerimiskavad (31.12.2025), mis on järgmine samm rekonstrueerimise pikaajalistest strateegiatest

Main changes compared to 2018 EPBD



TAL TECH | TALLINNA TEHNIKAÜLIKOOL

KODUDE ENERGIATÕHUSUSE PARANDAMINE

MEPS ja progressiivse renoveerimise trajektoorid (Art 9):

- Eluhoonete renoveerimise trajektoori koostamine 2030, 2040 ja 2050
- Trajektoor peab väljendama eluhoonefondi keskmise primaarenergiatarbe vähenemist (kWh/m^2 a) + iga-aastaseid renoveerimise mahte
- Eluhoonefondi 2020 a primaarenergiatarve peab vähenema:
  - **vähemalt 16% võrra aastaks 2030**
  - **vähemalt 20-22% võrra aastaks 2035**
  - 2040 ja iga järgmise 5 a jooksul nii nagu riiklikus renoveerimiskavas ette nähtud
- Vähemalt 55% säästust peab tulema kõige nõrgema energiatõhususega hoonetest (worst-performing buildings, 43%, E, F ja G energiaklass)
- Kohustused on riiklikul tasemel, **puuduvad nõuded üksikule hoonele/hooneomanikule** (va juba olemasolev olulise rekonstrueerimise nõue – C energiaklass)

TAL TECH | TALLINNA TEHNIKAÜLIKOOL

MITTEELUHOONETE ENERGIATÕHUSUSE PARANDAMINE

- Tuleb määrata viimase 16% ja 26% energiatõhususe piirväärtused (ligikaudu energiamärgise G ja F klass)
- MEPS nõuded igale üksikule hoonele peavad tagama, et kõik mitteeluhooned saavutavad:
  - **16% piirväärtuse aastaks 2030 (=energiamärgise F klass)**
  - **26% piirväärtuse aastaks 2035 (=energiamärgise E klass)**
  - Edasised eesmärgid vastavalt riiklikule renoveerimiskavale (D klass)
- Vastasel juhul ei saa eeldatavasti hooneid rentida või müüa
- On võimalik kehtestada erandid (muinsuskaitse jne), millele nõuded ei rakendu
- Kohustus hoone omanikul, kõik eeldused teostada turupõhiselt

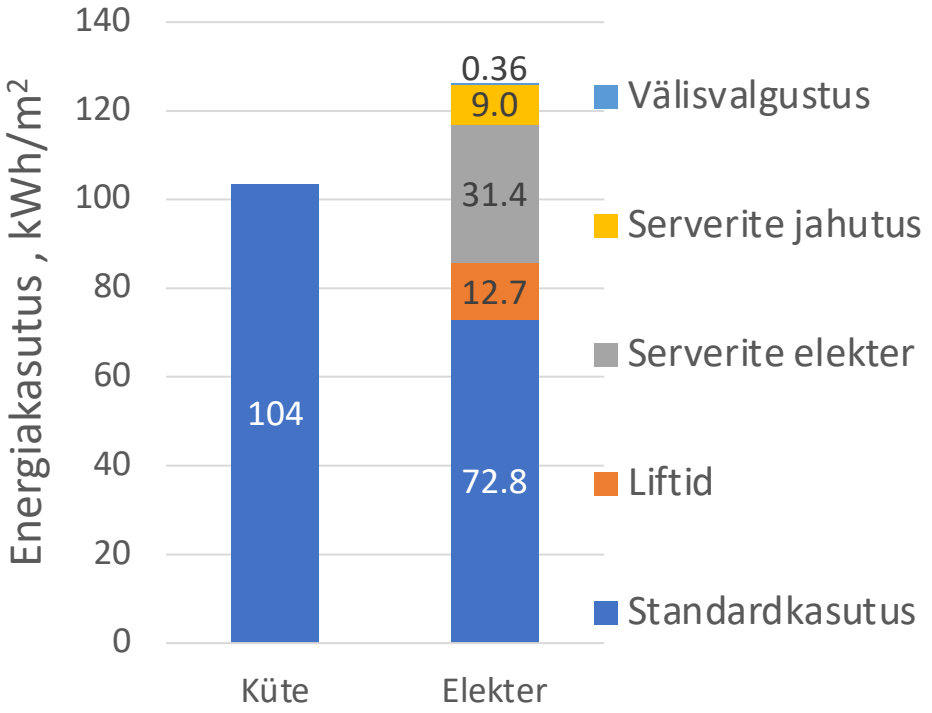
TAL TECH | TALLINNA TEHNIKAÜLIKOOL

ENERGIATÕHUSUSE PARANDAMISE NÄIDE

Ärimaja 16 990 m², 2008:

- Mõõdetud energiakasutus, gaasiküte

- Peaarvestite järgi KEK=357, G klass
- Paigaldades alamarvestid KEK=250, E klass



ETA või KEK, kWh/(m²a)	Klass
ETA või KEK ≤ 100	A
101 ≤ETA või KEK ≤ 130	B
131 ≤ETA või KEK ≤ 160	C
161 ≤ETA või KEK ≤ 210	D
211 ≤ETA või KEK ≤ 260	E
261 ≤ETA või KEK ≤ 320	F
321 ≤ETA või KEK ≤ 400	G
ETA või KEK ≥ 401	H

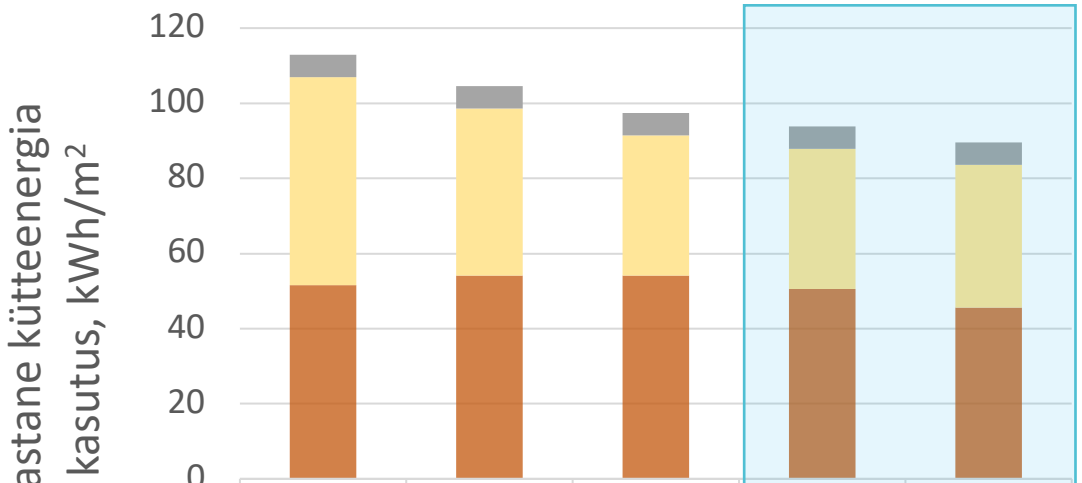
TAL TECH | TALLINNA TEHNIKAÜLIKOOL

Kuivjõgi et al. 2021

https://doi.org/10.1051/e3sconf/202124605002

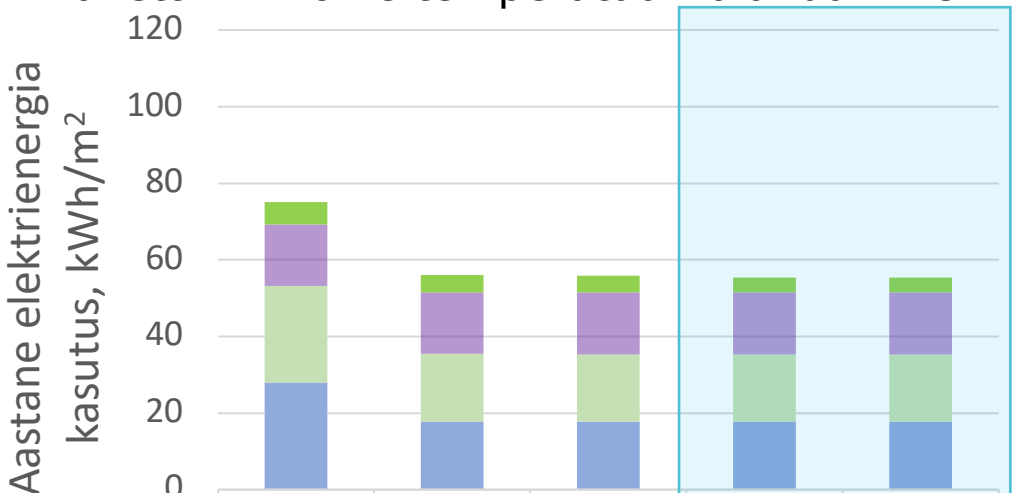
ENERGIATÕHUSUSE PAKETID

- Pakett 1: valgustus, vent. SFP ja soojustagastus, jahutusfunktsioon soojustagastusele
- Pakett 2: + söökla vent. nõudluspõhiseks
- Pakett 3: + akende vahetus
- Pakett 4: + öine temperatuuri alandamine



	Baas-mudel	Pakett 1	Pakett 2	Pakett 3	Pakett 4
Tarbevesi	6.0	6.0	6.0	6.0	6.0
Vent. Küte	55.4	44.5	37.2	37.2	38.1
Ruumi küte	51.6	54.1	54.1	50.6	45.5
ETA, kWh/m²	200	179	171	166	163
ETA(+PV) kWh/m²	x	173	165	160	156

Pakettide kütteenergia võrdlus



	Baas-mudel	Pakett 1	Pakett 2	Pakett 3	Pakett 4
Jahutuse elekter	5.8	4.5	4.5	3.9	3.9
Seadmed	16.1	16.1	16.1	16.1	16.1
Ventilaatorid ja pumbad	25.2	17.7	17.7	17.7	17.7
Valgustus	28.0	17.7	17.7	17.7	17.7
ETA, kWh/m²	200	179	171	166	163
ETA(+PV) kWh/m²	x	173	165	160	156

Pakettide elektrienergia võrdlus

TAL TECH | TALLINNA TEHNIKAÜLIKOOL

→ Hästi tasuvad paketid 1 ja 2 jõuavad D klassi (teostatud, 37 €/m²)

KOKKUVÕTE/PROBLEEMIPÜSTITUS TIPPKESKUSELE

- Kuidas mõistlikult täita riiklikku energiasäästukohustust (EED) ja renoveerimise eesmärke (EPBD) – EED 1,5%/a 2024-30 ja EPBD -16% 2030
- Korterelamute täisrenoveerimine kui keskne ja kulutõhus meede mõlema eesmärgi täitmiseks – 14 000 korterelamu renoveerimine 2050 aastaks
- Senise korterelamute renoveerimise tehnilise edu täiendamine laiapõhjalisuse ja taskukohasusega kõikidele ühiskonnagruppidele
- Väikeelamute renoveerimise toetamise vajadused – oskusteave, sihtgrupid
- Mitteeluhoonete MEPSi tehniline raamistik
- Uute hoonete lahendused – nullheitega hooned, kuluoptimaalsus
- Andmepõhine juhtimine ja monitooring reaalse säästu saavutamiseks ja toimivuse tagamiseks
- Elektrifitseerimine, soojuspumbad, taastuvenergia ja salvestus
- Hooned energiasüsteemi osana – energiapaindlikkus ja tipukoormused

TAL TECH | TALLINNA TEHNIKAÜLIKOOL

ENERGIATÕHUSUSE TIPPKESKUS ENER 2024-2030

Nullenergia hooned
Jarek Kurnitski

Avaliku sektori innovatsioon
Veiko Lember

Renoveerimise tehnoloogiad
Targo Kalamees

Eluase ja rahvastikumuutused
Hannaliis Jaadla

Tark ja säästlik elektrifseerimine
Dmitri Vinnikov

Eluaseme-uuringud
Tiit Tammaru

Andmeteadus juhtimis-süsteemidele
Juri Belikov

Andmepõhine juhtimine ja AI
Eduard Petlenkov

TAL TECH | TALLINNA TEHNIKAÜLIKOOL

ENERGIATÕHUSUSE TIPPKESKUS ENER 2024-2030

Progression of the Renovation Wave

Drivers

Climate change and the need to reduce GHG emissions

Motivation

Buildings & construction ecosystem accounts for 53% of final energy and 50% of energy related GHG emissions in Estonia

Need for radical improvements towards highly performing zero-emission building stock

CoE Activities

Developing new concepts and technologies (WP 1,2)

Developing new data infrastructure and data driven solutions (WP3)

Improving governance systems and understanding the behaviour of relevant actor groups (WP4)

Outcomes

Energy use of the building stock reduced by 60% and GHG emissions by 90%

Implications

- Social
- Regional
- Economic
- Technological
- Behavioural