



PASSIVE HOUSE
ASSOCIATION OF
ESTONIA

sense

4 aastat elu passiivmajas

ja

Miks ning kuidas rajati Põlva Riigigümnaasium pilootprojektina liginullenergiahoonena?

Kuldar Leis

23.11.2016



Hoone Põlvas, Kuldar Leis



Arhitektid

**Martha E. Reinberg
Georg W. Reinberg**

Kõnetav pind

280 m²

Projekteerimine

2010-2011

Ehitamise aeg


2011-2013

Ehituse juhtimine

Sense OÜ

Kasutuse algus

veebr 2013


 Passive House Institute

Passive House Institute
Dr. Wolfgang Feist
Rheinstr. 44/46
D-64283 Darmstadt

Certificate

The Passive House Institute awards the seal "Certified Passive House – Pilot Project" to the following building

SFH Kuldar Leis in Estonia Metsa 5a, EE 63305 Põlva, ESTONIA

 Certified Passive House
Passive House Institute

Client: **Kuldar Leis**
Metsa 5a, EE 63305 Põlva, ESTONIA

Architect: **Architekturbüro Reinberg**
Lindengasse 39/10, A 1070 Wien, AUSTRIA

Building **S&P climadesign GmbH**
Services: Mitterweg 1, A-4684 Ohlsdorf, AUSTRIA

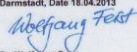
This building was designed to meet Passive House criteria as defined by the Passive House Institute. With appropriate on-site implementation, this building will have the following characteristics:

- Excellent thermal insulation and optimised connection details with respect to building physics. The heating demand or heating load will be limited to **15 kWh per m² of living area and year or a heating load of 10 W/m², respectively**
- When outdoor temperatures are high, thermal comfort can be ensured with passive solutions or with minimal energy demand for cooling and dehumidification according to the location-specific Passive House requirements.
- A highly airtight building envelope, which eliminates draughts and reduces the heating energy demand: The air change rate through the envelope at a 50 Pascal pressure difference, as verified in accordance with ISO 9972, is less than **0.6 air changes per hour with respect to the building's volume**
- A controlled ventilation system with high quality filters, highly efficient heat recovery and low electricity consumption, ensuring excellent indoor air quality with low energy consumption
- A total primary energy demand for heating, domestic hot water, ventilation and all other electric appliances during normal use of less than **120 kWh per m² of living area and year**

This certificate is to be used only in combination with the associated certification documents, which describe the exact characteristics of the building.

Passive Houses offer high comfort throughout the year and can be heated or cooled with little effort, for example, by heating/cooling the supply air. Even in times of cold outdoor temperatures the building envelope of a Passive House is evenly warm on the inside and the internal surface temperatures hardly differ from indoor air temperatures. Due to the highly airtight envelope, draughts are eliminated during normal use. The ventilation system constantly provides fresh air of excellent quality. Energy costs for ensuring excellent thermal comfort in a Passive House are very low. Thanks to this, Passive Houses offer security against energy scarcity and future rises in energy prices. Moreover, the climate impact of Passive Houses is low as they reduce energy use, thereby resulting in the emission of comparatively low levels of carbon dioxide (CO₂) and air pollutants.

Issued:
Darmstadt, Date 18.04.2013


Dr. Wolfgang Feist

Certificate-ID: 5978_PHI_PH-Pilot_20130418_JSt

Miks selline maja?

- 1. Energiatarve väike
- **2. Hea sisekliima:**
 - Savi, puit, õlid, vahad
 - Seinaküte
 - Korralik ventilatsioon
 - Stabiilne õhuniiskus aastaringselt
- 3. Kohalikud loodussõbralikud materjalid**

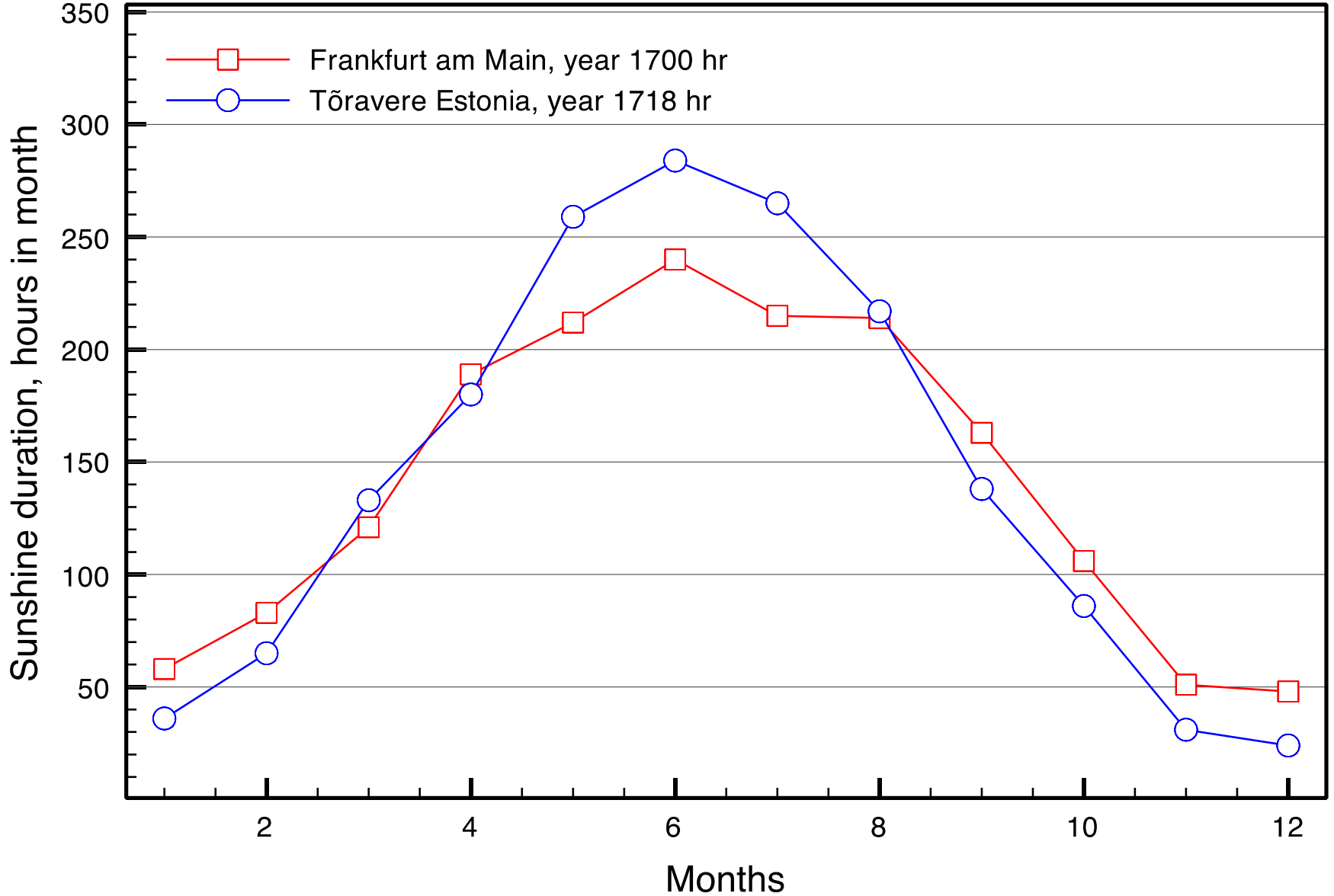
Aastast 2019 peavad Euroopa Liidus kõik ehitatavad **uued avalikud** hooned olema **liginullenergiahooned**

Aastast 2021 ka erahooned

See on jõhkram kui passiivmaja



Sunshine duration

















Hoone Põlvas, Kuldar Leis

sense



RISTKIHTPUIT (CLT)









Passive House Conference Frankfurt 2013 G. Reinberg ja W. Feist



Ruumide kütte netoenergiavajadus

Specific Demands with Reference to the Treated Floor Area

Treated Floor Area: m²

Applied:

Monthly method

PH Certificate:

Fulfilled?

Specific Space Heating Demand:

14,61 kWh/(m²a)

15 kWh/(m²a)

Yes

Heating Load:

13 W/m²

10 W/m²

Yes

Pressurization Test Result:

0,36 h⁻¹

0,6 h⁻¹

Yes

Specific Primary Energy Demand

(DHW, Heating, Cooling, Auxiliary and Household Electricity):

119 kWh/(m²a)

120 kWh/(m²a)

Specific Primary Energy Demand
(DHW, Heating and Auxiliary Electricity):

55 kWh/(m²a)

Specific Primary Energy Reduction
through Solar Electricity:

kWh/(m²a)

Frequency of Overheating:

0 %

over °C

Specific Useful Cooling Energy Demand:

kWh/(m²a)

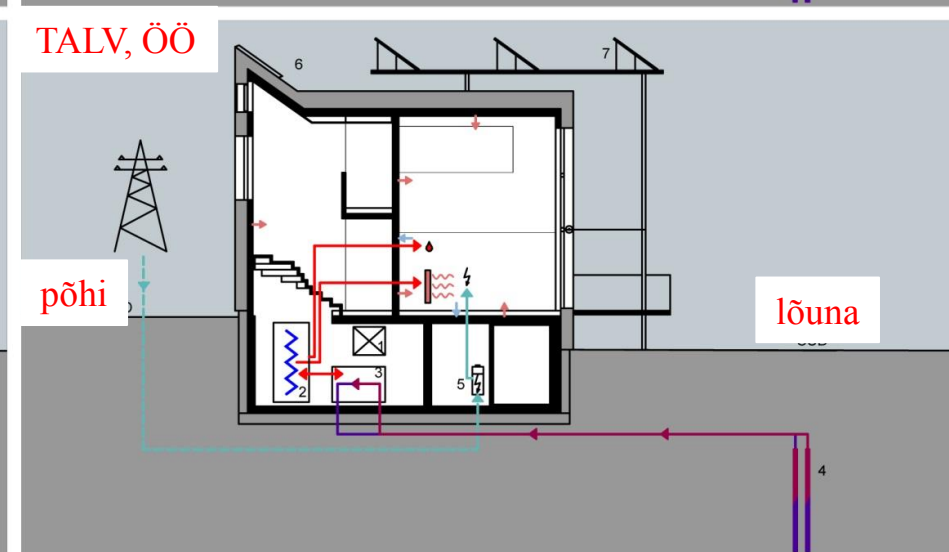
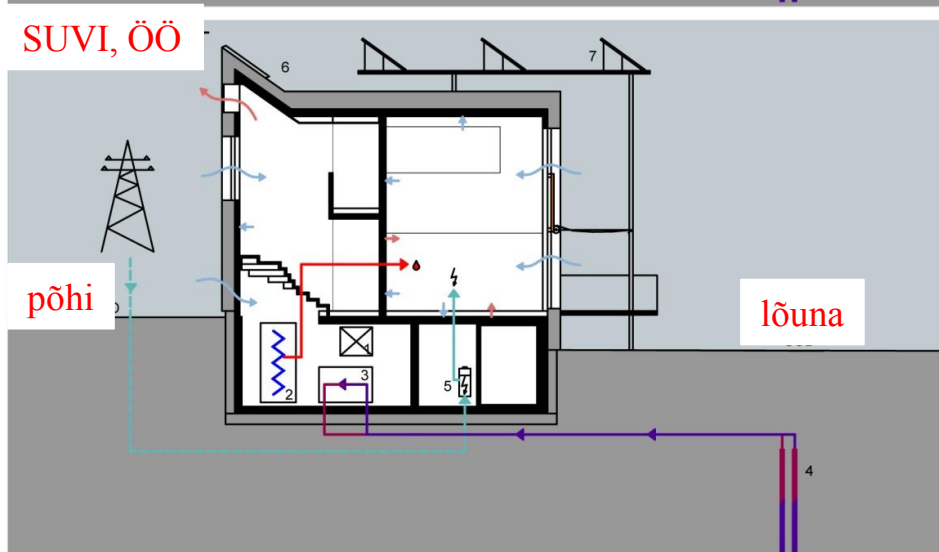
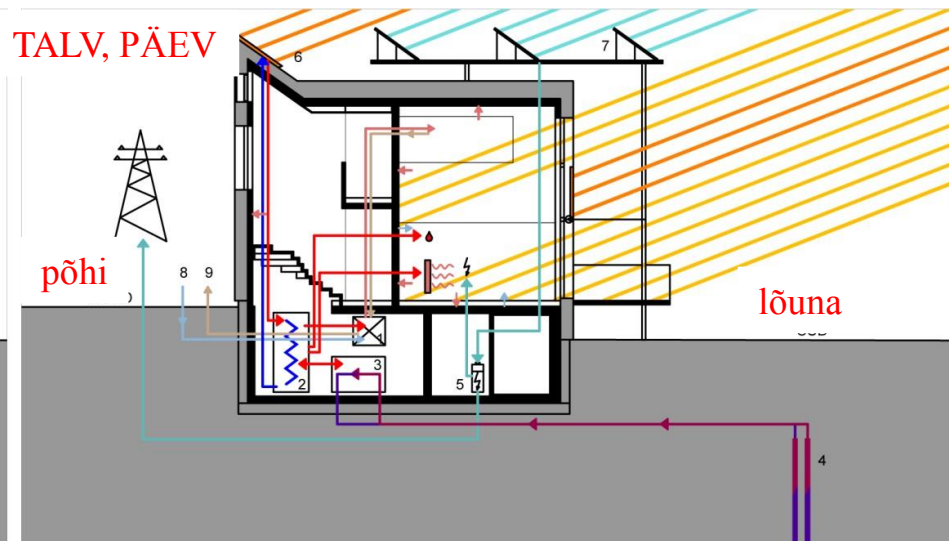
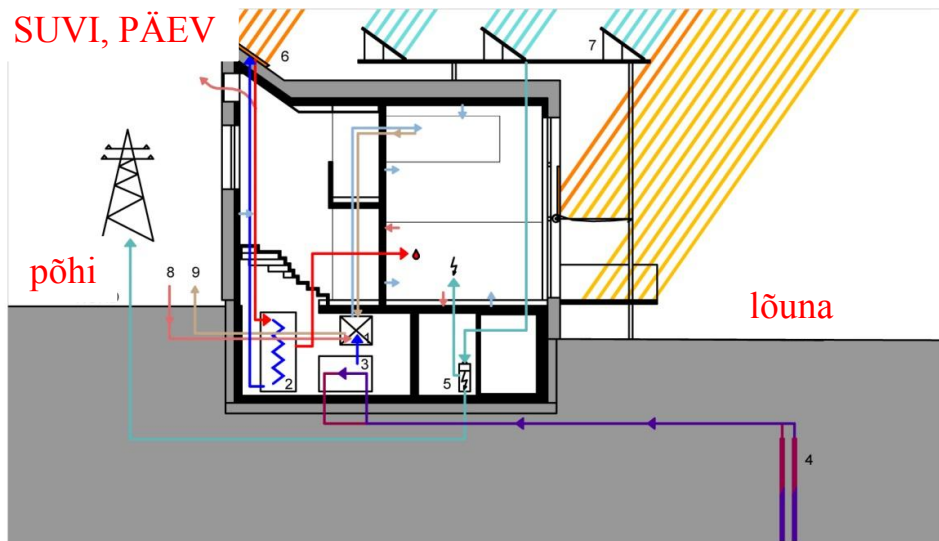
15 kWh/(m²a)

Cooling Load:

1 W/m²

4100 kWh/a ehk **14,6 kWh/(m²a)**

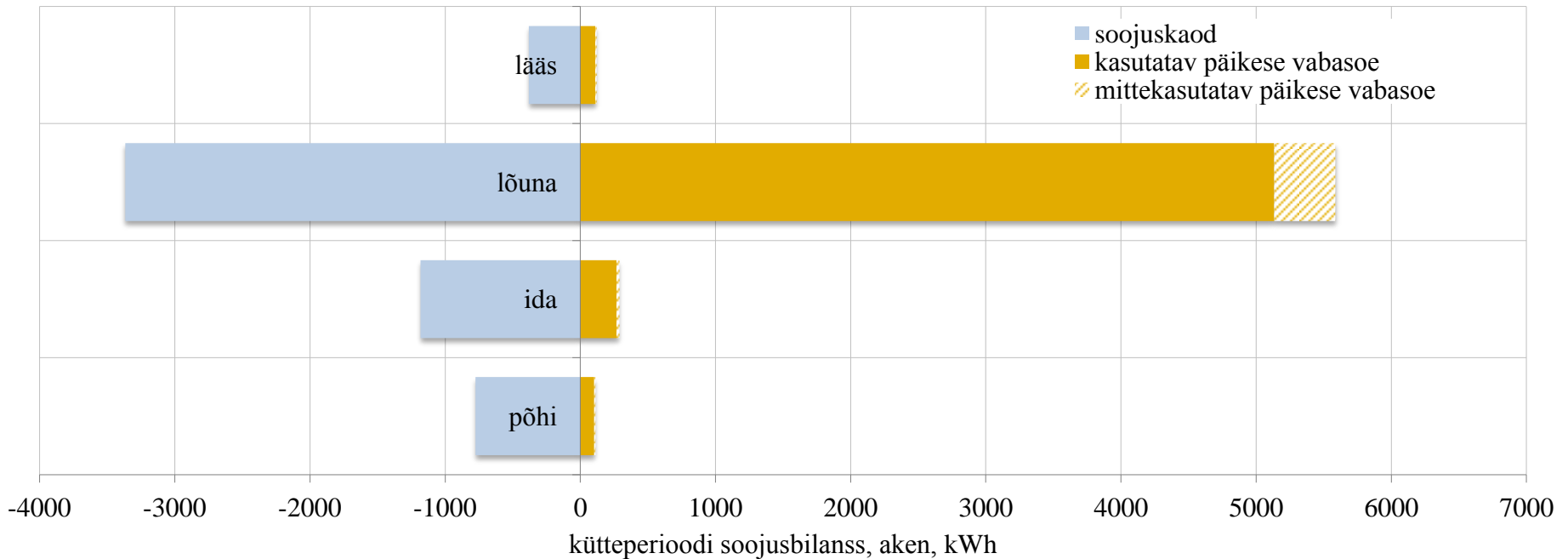
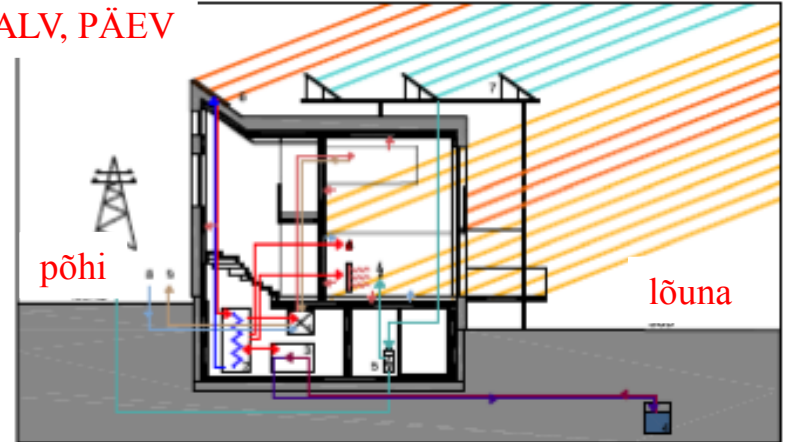
Energiakontseptsioon



Energiakontseptsioon

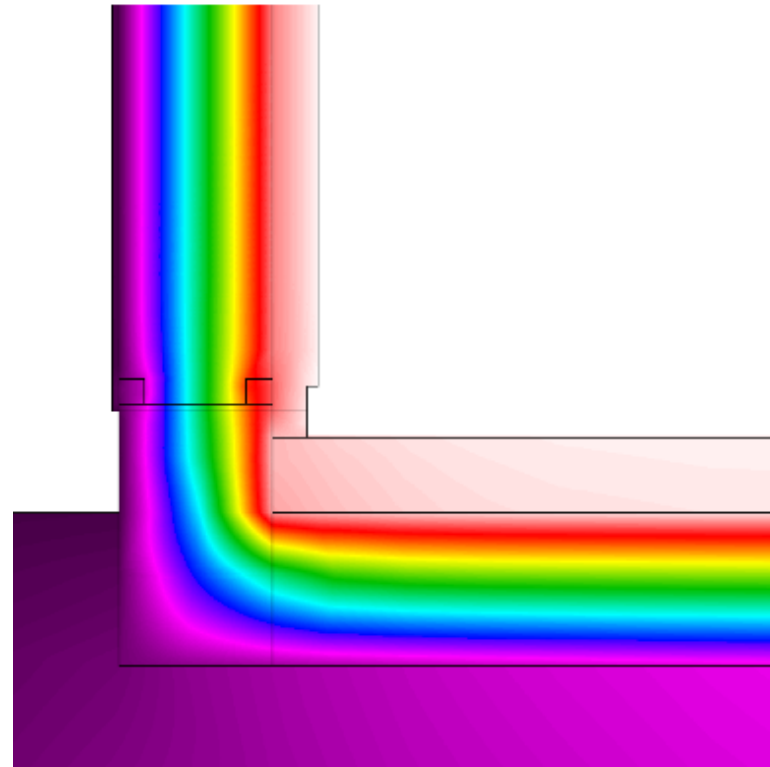
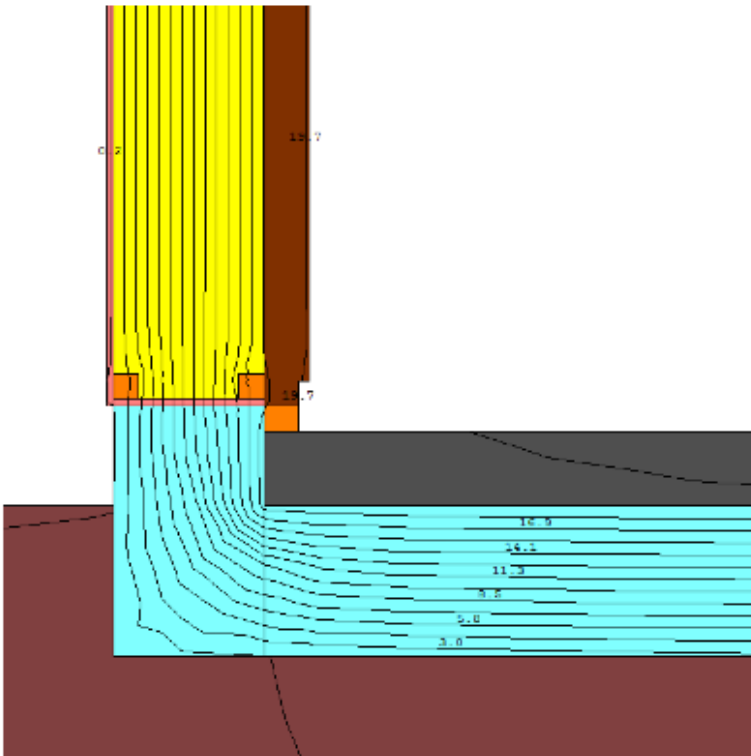


TALV, PÄEV

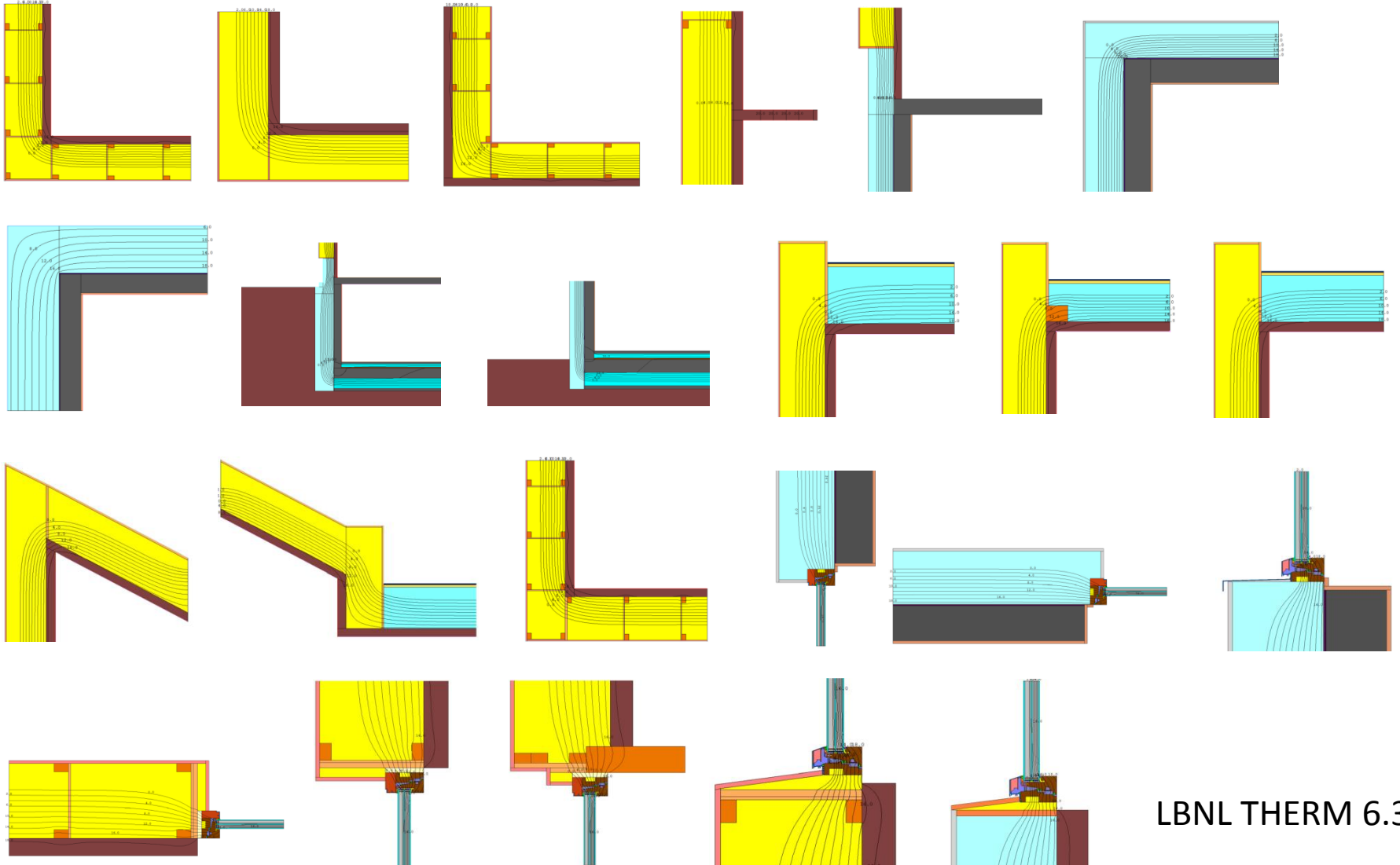


Seinakonstruktsioon

$$U = \mathbf{0,105} \text{ W/(m}^2\text{K)} \quad \Psi \mathbf{-0,014} \text{ W/(mK)} \quad \text{THERM 7.1}$$

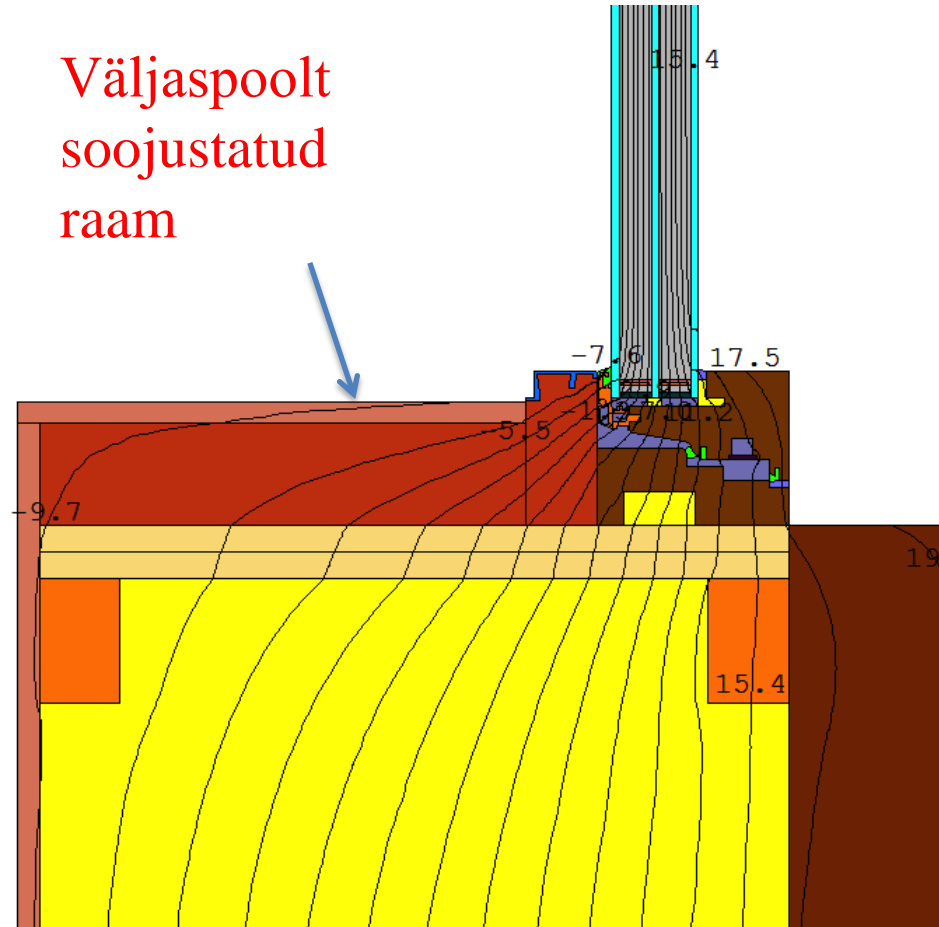


Thermal bridge free design (overall reduction by 1,9 kWh/(m²yr))



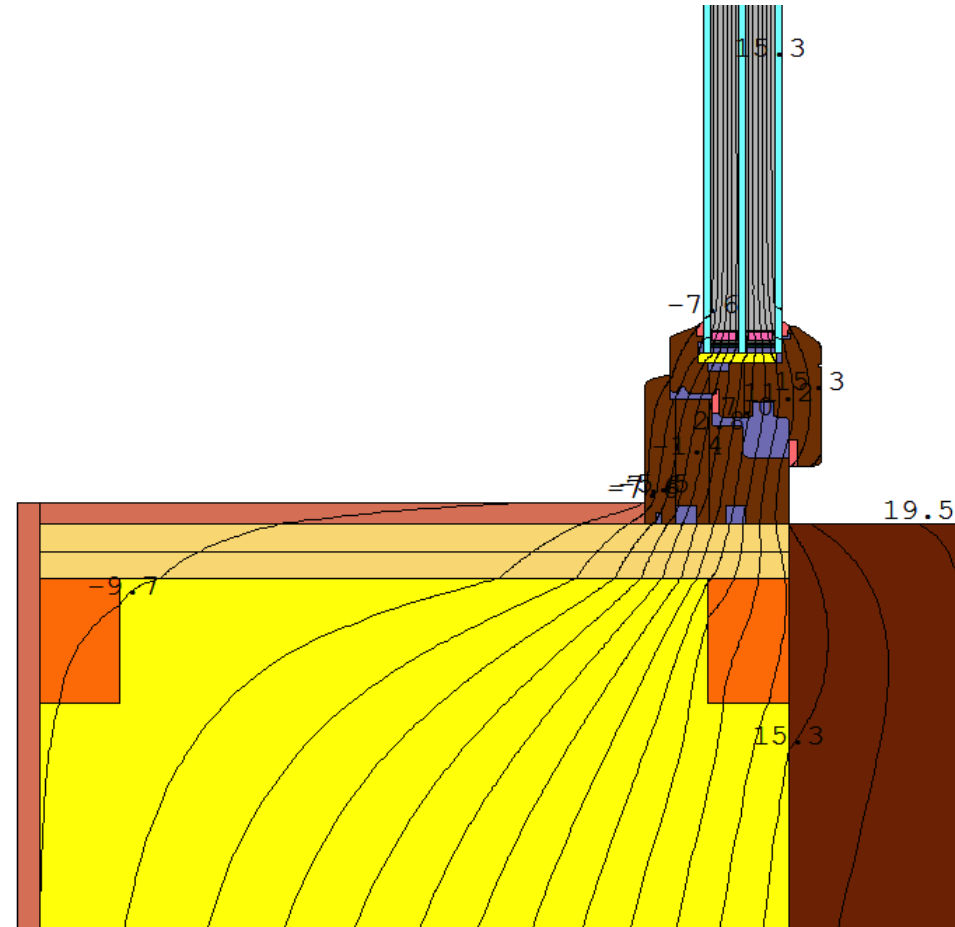
Aken

Väljaspoolt
soojustatud
raam



$$\Psi = 0,014 \text{ W}/(\text{mK})$$

SmartWin



$$\Psi = 0,050 \text{ W}/(\text{mK})$$

Võrdlus: mittesoojustatud

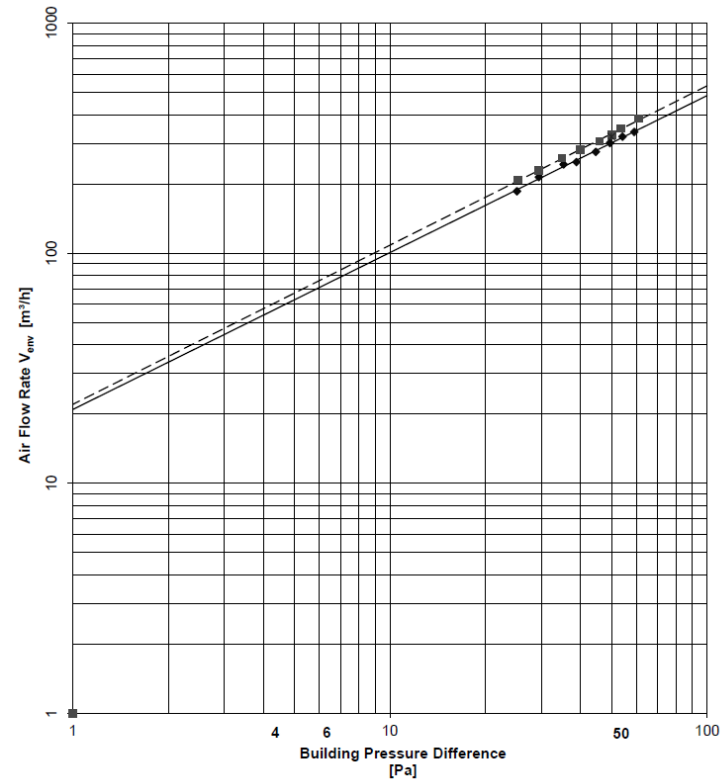


Ventilatsiooniseade
Paul Novus 300, soojatagastus 93%

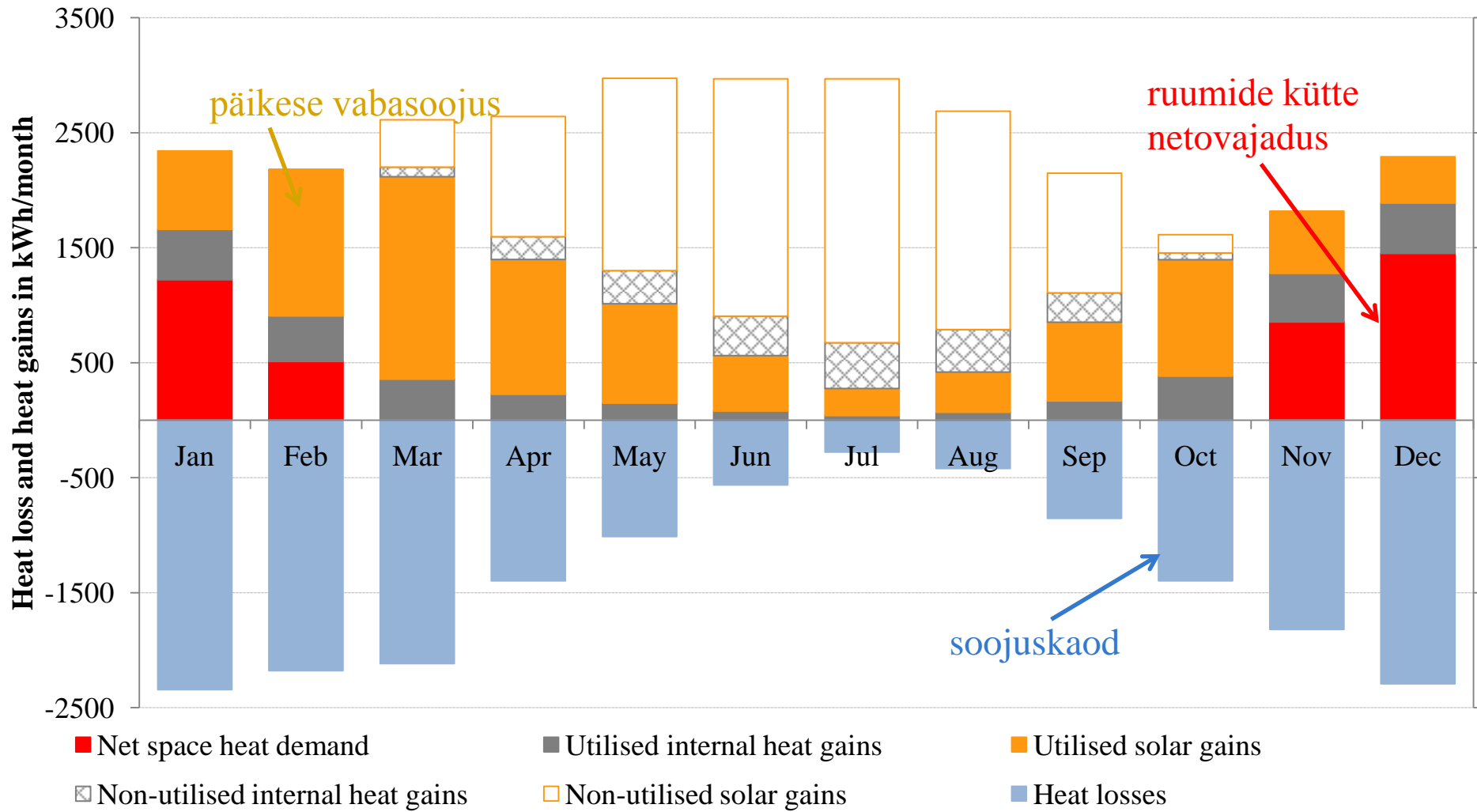
Välisõhu eelsoojendus
Paul Sole Defroster SD-550, 226 m
pikkune ring 40 mm toru

Ōhupidavus

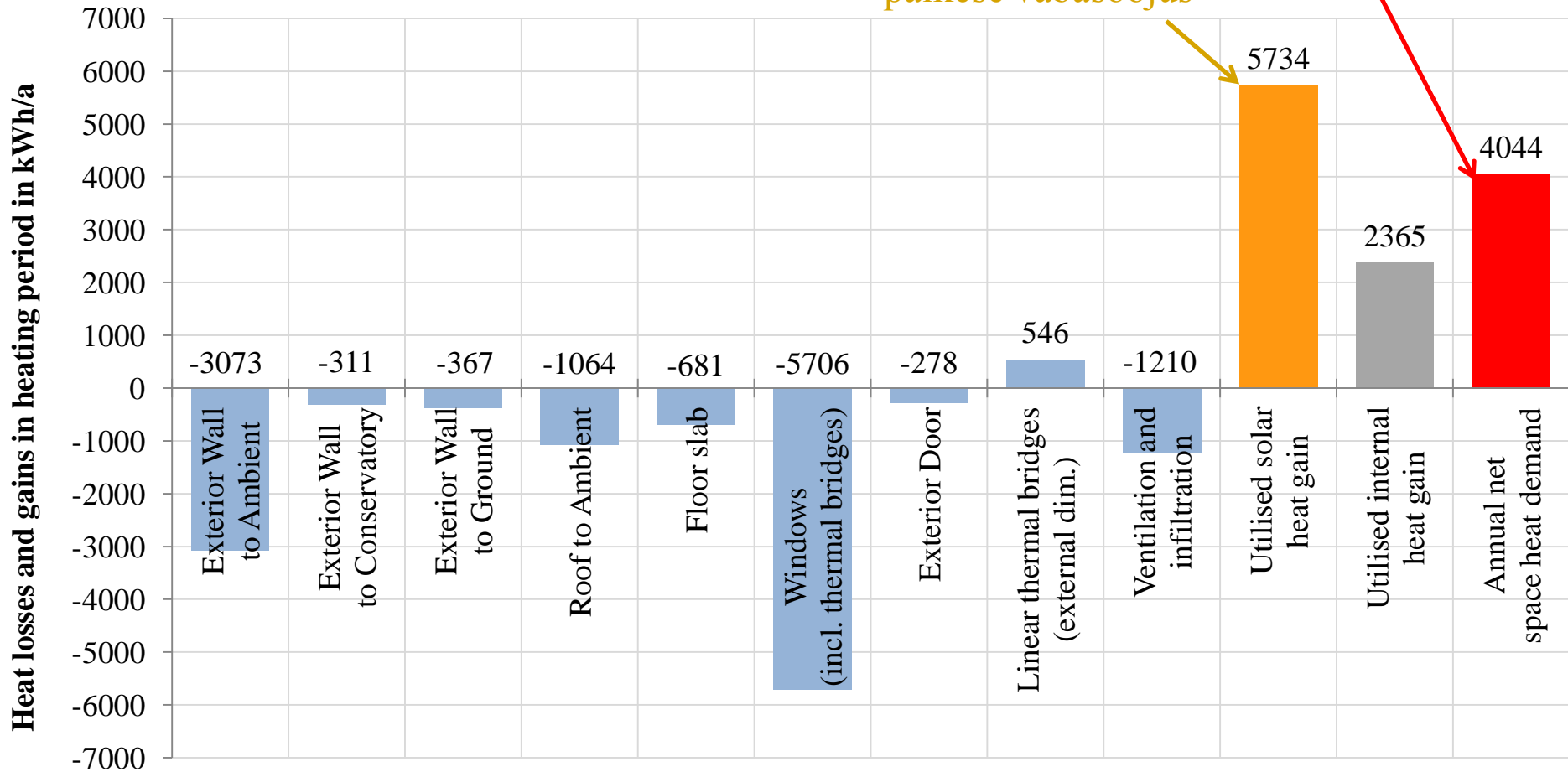
$$n_{50} = 0,36 \text{ h}^{-1}$$



Hoone soojusbilanss kWh/kuu



Hoone soojusbilanss kWh/kuu



12 m² katusega integreeritud kollektoreid sooja vee valmistamiseks



Sonnenkraft SK IMK



Maasoojuspump

Viessmann Vitocal 300
G BWC

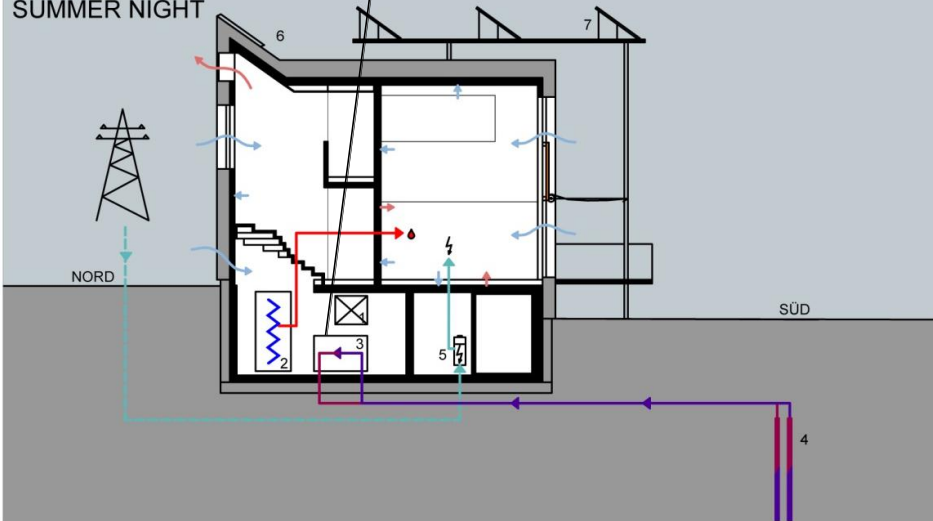
5,9 kW

COP = 4,5

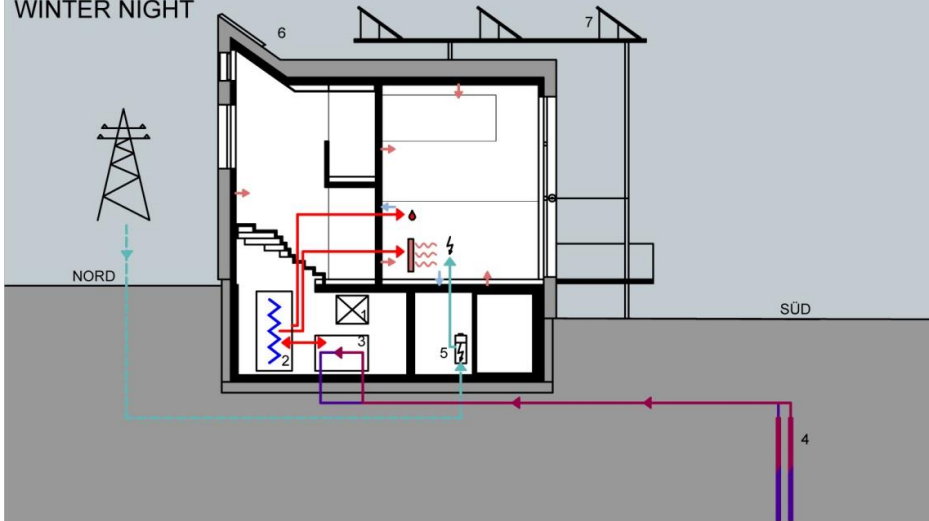
2 x 80 m vertikaalsed
puuraugud



SUMMER NIGHT



WINTER NIGHT

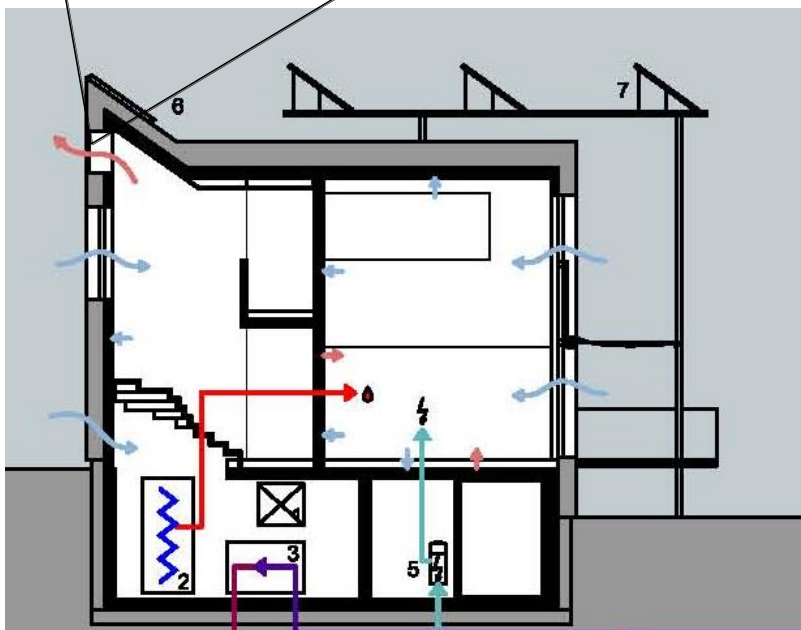


Seinaküte



2 x 1000 L

39/33°C pealevoolu/tagasivoolu temperatuur



Suvi:
jahutus öise vaba-
tuulutusega

90 m² PV paneele, SolarWorld Sunmodule Plus SW 196 Vario poly

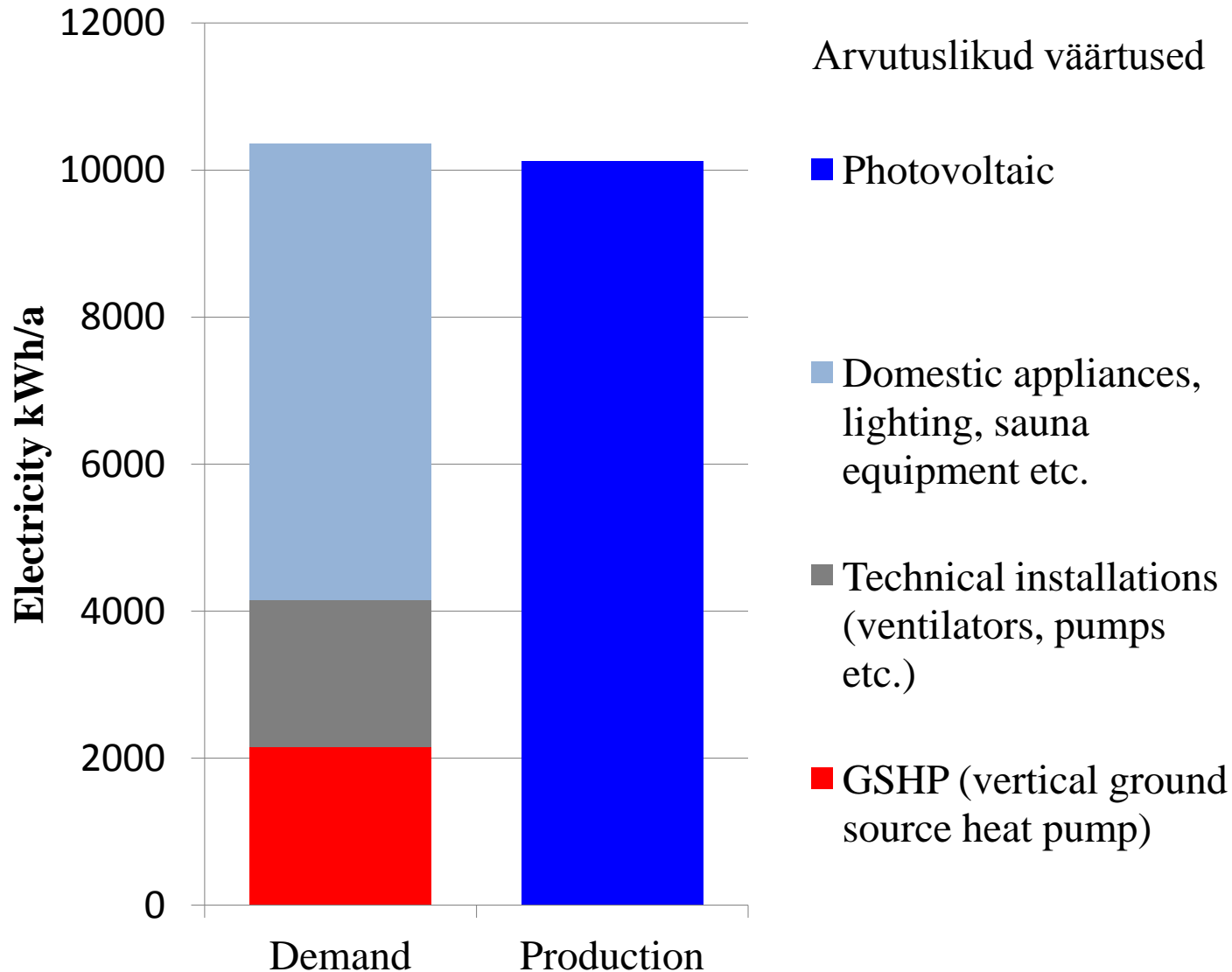


Arvutuslik süsteemi tootlus 10120 kWh/a

Tavamaja liginullenergiahoonena



Elektrienergia vajadus ja tootmine, kWh/a



Elektrienergia vajadus kõik kokku

- soojuspump
- majapidamine
- abienergia

10 360 kWh/a

PV tootlus

90 m² SolarWorld Sunmodule Plus SW 196 Vario poly
arvutuslik

10 120 kWh/a

Neto vajadus ≈ 0

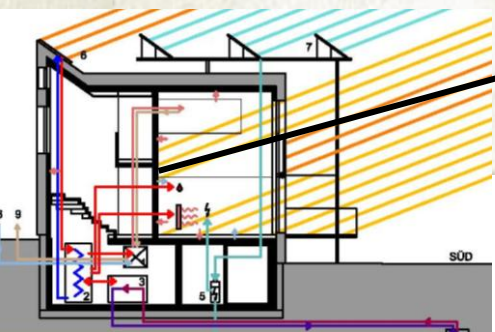
Seire

SA Archimedes projekt TÜ/TTÜ

"Hoonete keskkonnamõju vähendamine läbi energiatõhususe parandamise"

- siseõhu temperatuur ja niiskus -- 6 ruumi
- CO₂ kontsentratsioon -- kaks ruumi
- massiivse seina temperatuur 4 punktis 3 sügavusel -- 12 sensorit
- ventilatsiooniseadme temperatuurid ja õhuniiskus -- 5 punkti
- temperatuur ja õhuniiskus välispiirde konstruktsioonis -- 5 punkti
- soojusvoog välisseinas -- 1 punkt
- akende ja usete asendi andurid -- 4 punkti (õine tuulutus ja CO₂)
- välisõhu temperatuur ja õhuniiskus -- 1 punkt
- summaarne kiirgus -- 1 punkt (katus)

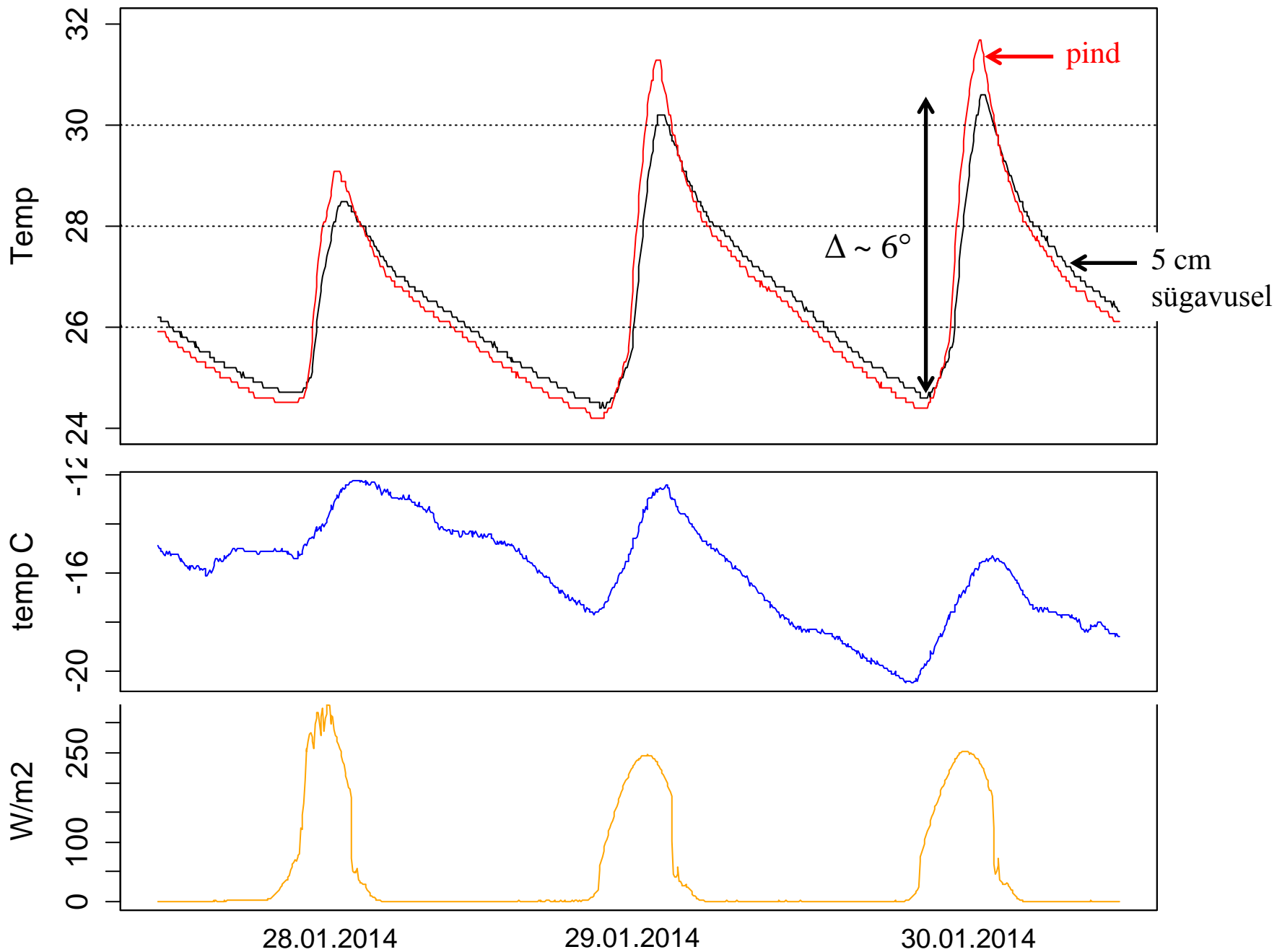




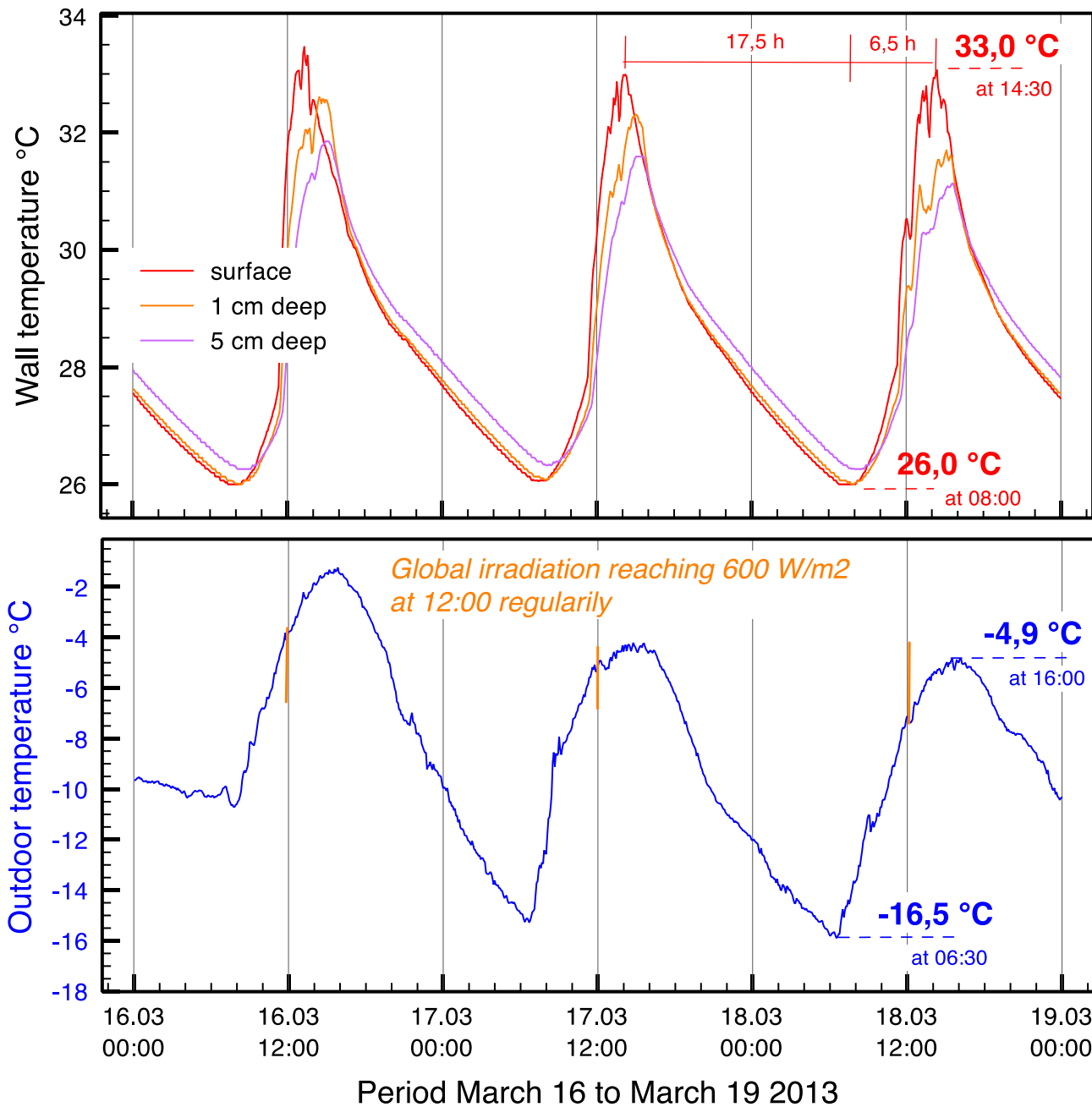


Massiivse siseina temperatuurikäik

28.01.2014 - 30.01.2014



Massive wall exposed to direct solar beam, temperature course in 3-days period



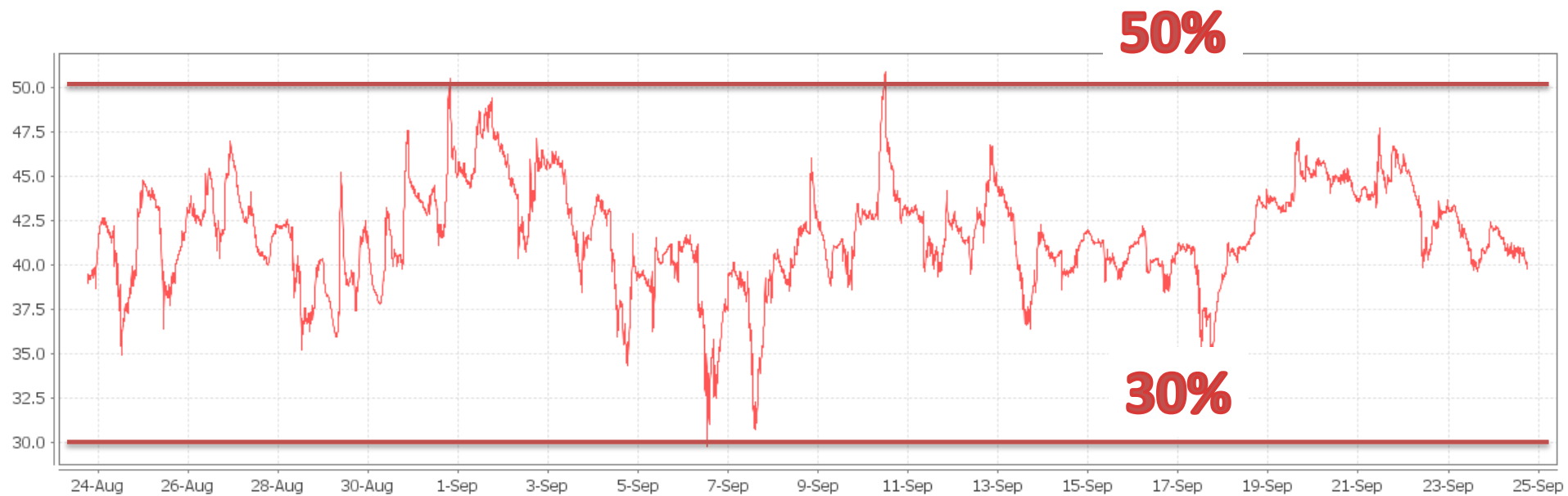
First results:

Process of warming up the massive wall

Regular temperature increase 7 K in 6,5 hr

No additional heating in whole March

Magamistoa suhteline õhuniiskus %



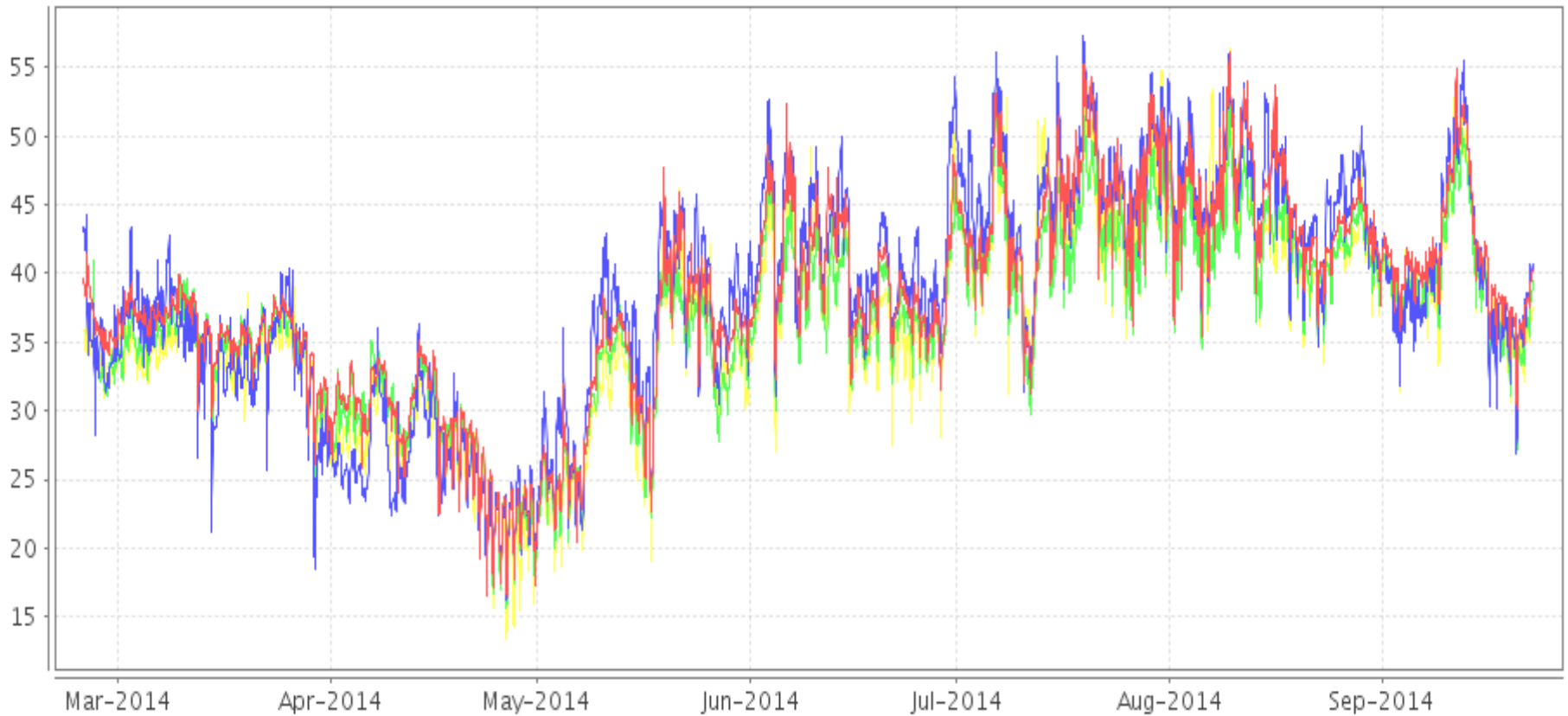
1 month period: Aug 24 to Sept 24 2013

Magamistoa suhteline õhuniiskus %



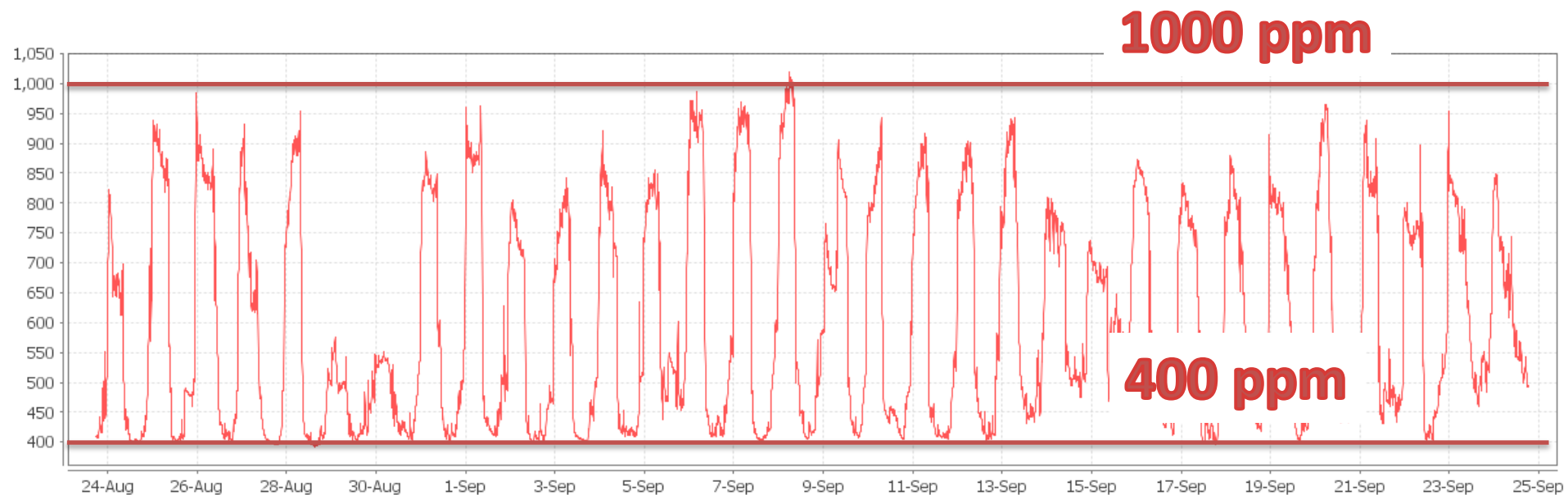
1 month period: Aug 24 to Sept 24 2014

Ruumide õhuniiskus märts – sept 2014



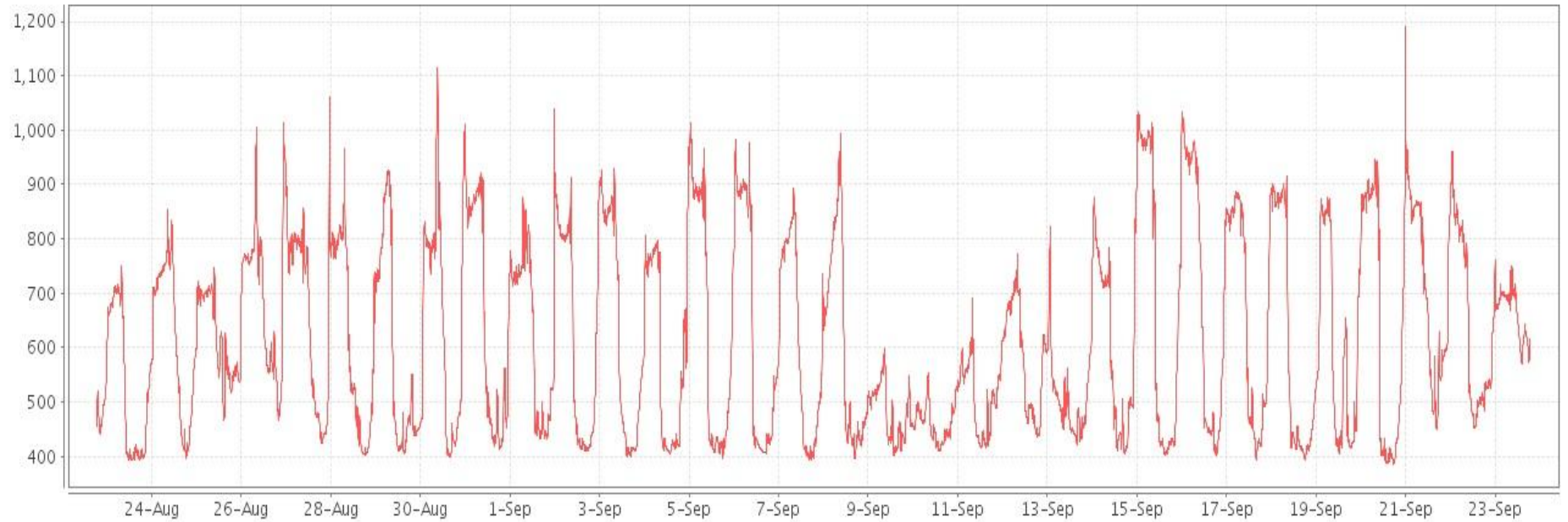
— Maja1 - 001 RH - ruum 1 (kabinet) — Maja1 - 002 RH - ruum 4 (lõunapoolne magamistuba) — Maja1 - 018 RH - ruum 2 (põhjapoolne magamistuba)
— Maja1 - 019 RH - 1. korruse magamistuba

Magamistoa õhu CO₂



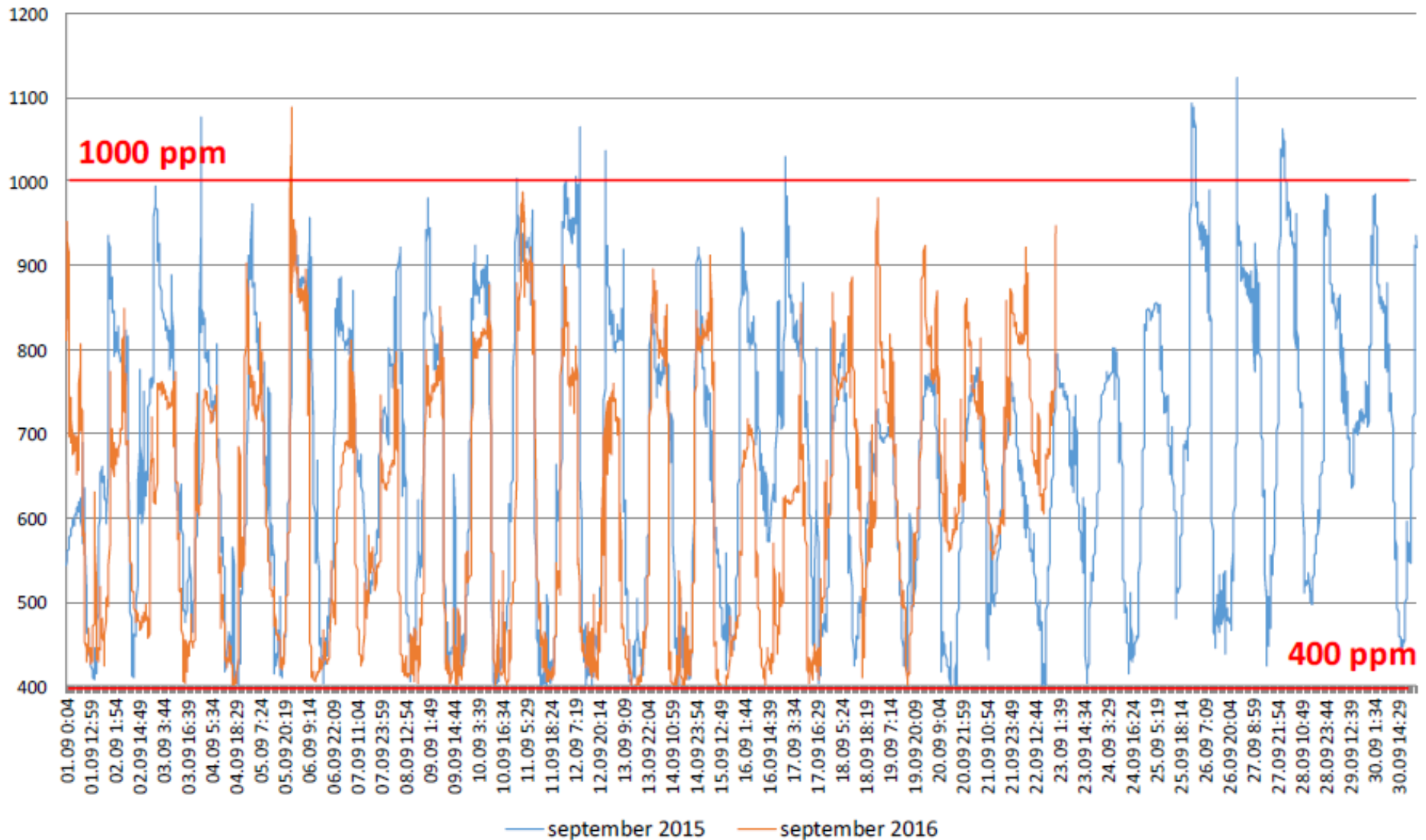
1 month period: Aug 24 to Sept 24 2013

Magamistoa õhu CO₂

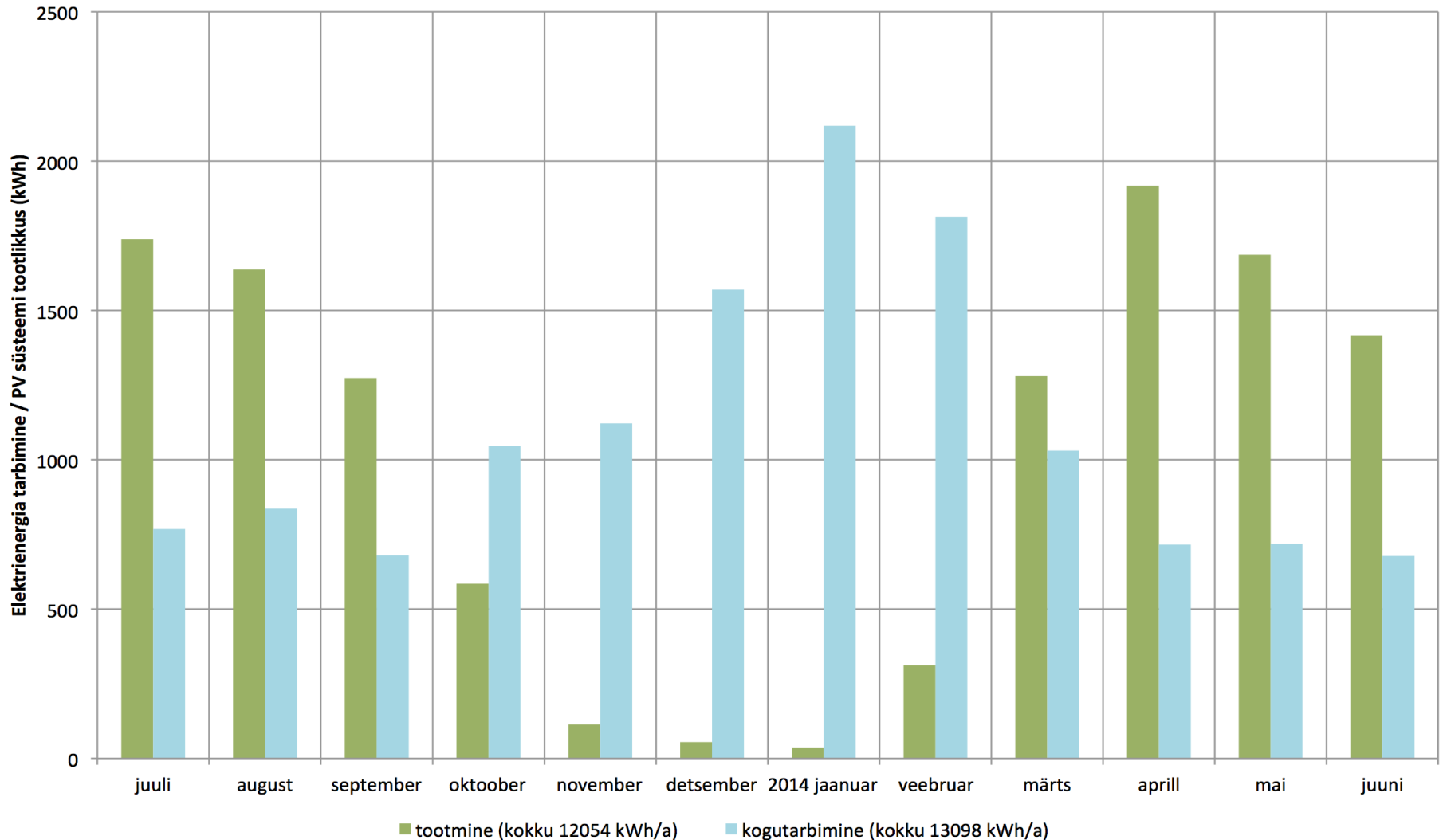


1 month period: Aug 24 to Sept 23 2014

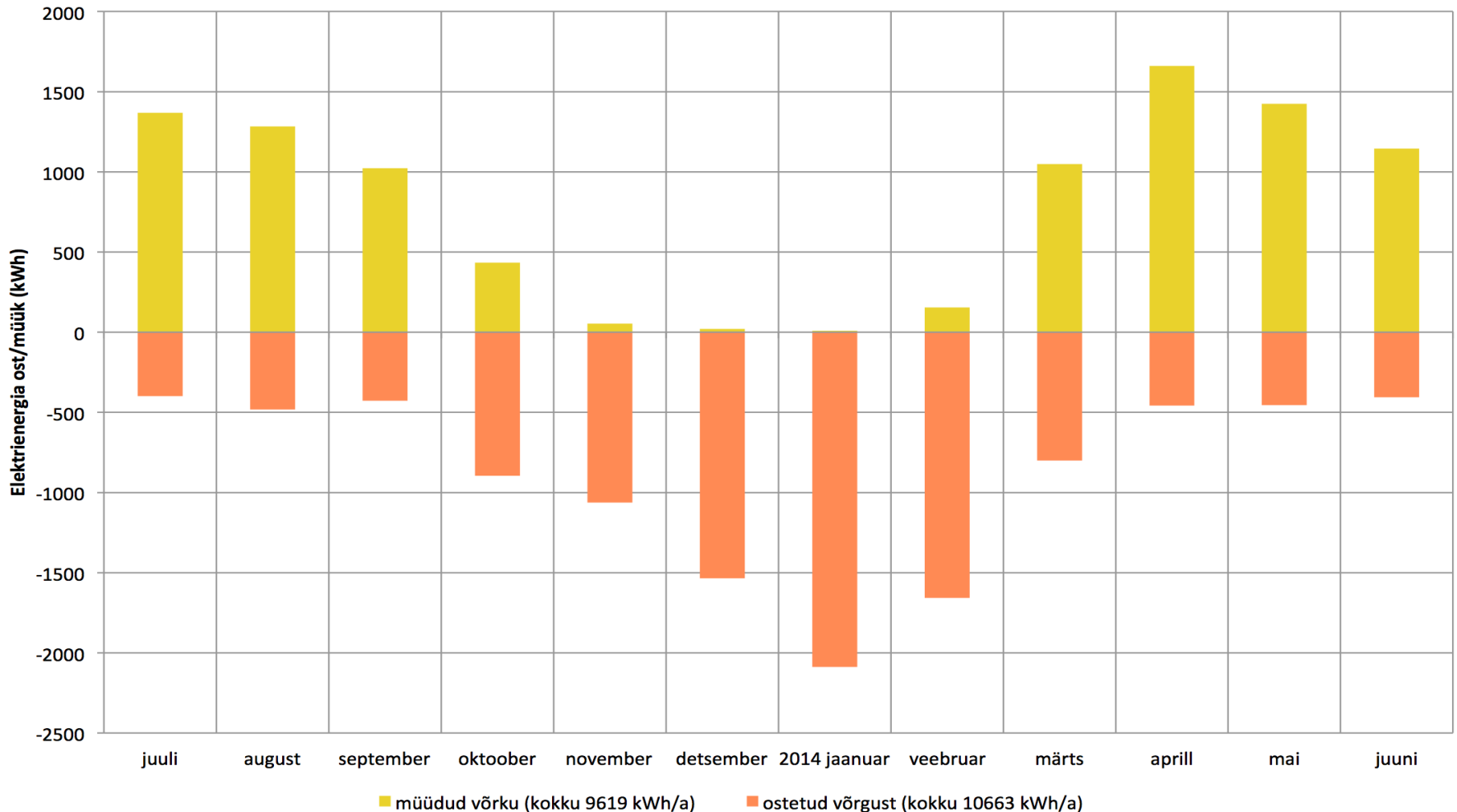
Magamistoa ðhu CO2 (ppm) september '15/'16



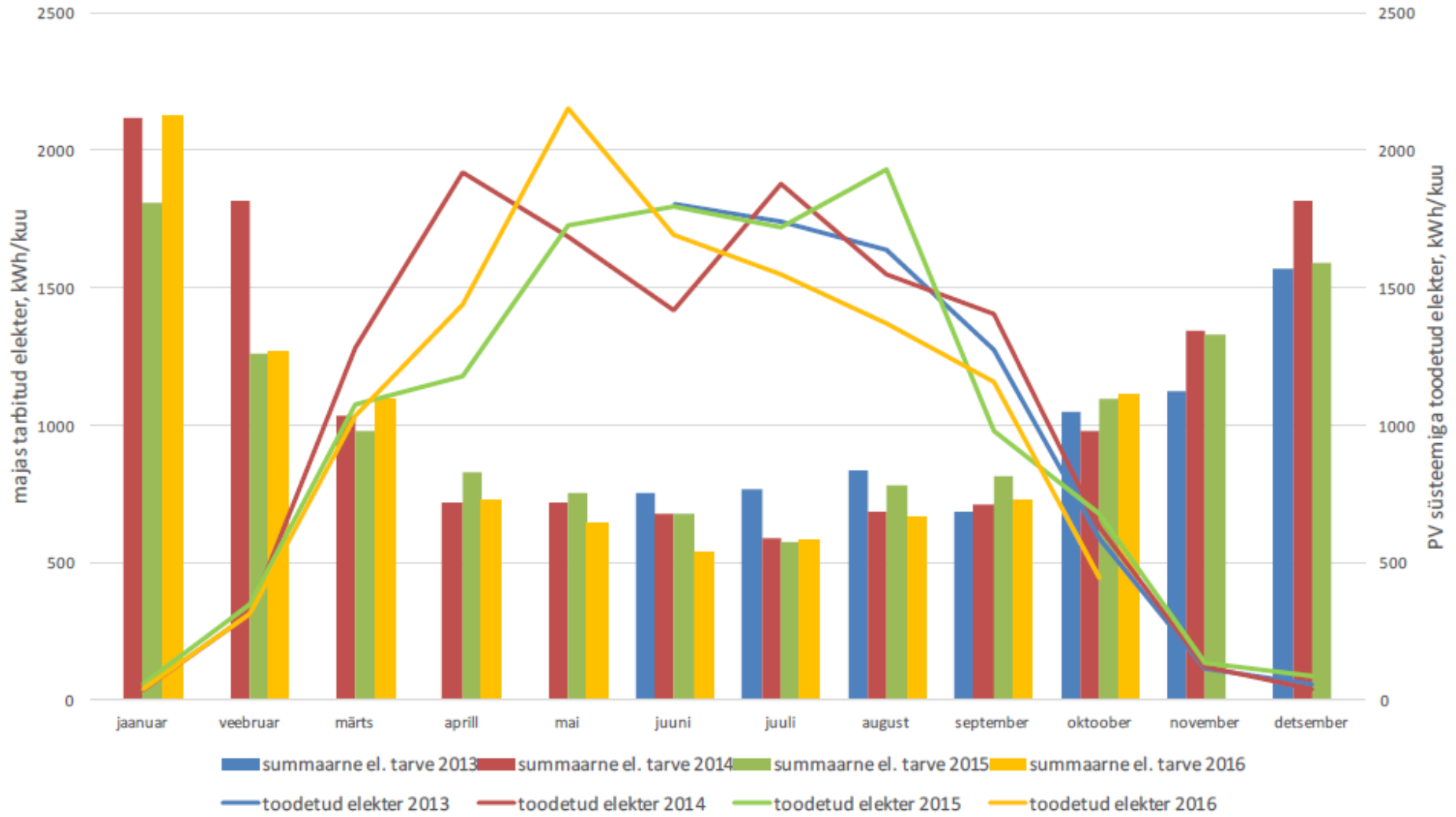
Toodetud (12054 kWh) ja tarbitud (13098 kWh) elektrienergia juuli 2013 – juuni 2014



Müüdnud võrku (9619 kWh) ja ostetud võrgust (10663 kWh) elektrienergia juuli 13 – juuni 14



Metsa 5a hoone summaarne energitarve (küte + soe vesi + elekter) ja -tootmine (TÜ seireandmed)





Tulemused



Metsa 5a, Põlva

Ostetud energia, aasta
Elekter 10663 kWh

Müüdud energia, aasta
Elekter 9619 kWh

Neto ost 1044 kWh
3,7 kWh/m² 309 €
1,1 €/m²



Pihla 2, Tartu

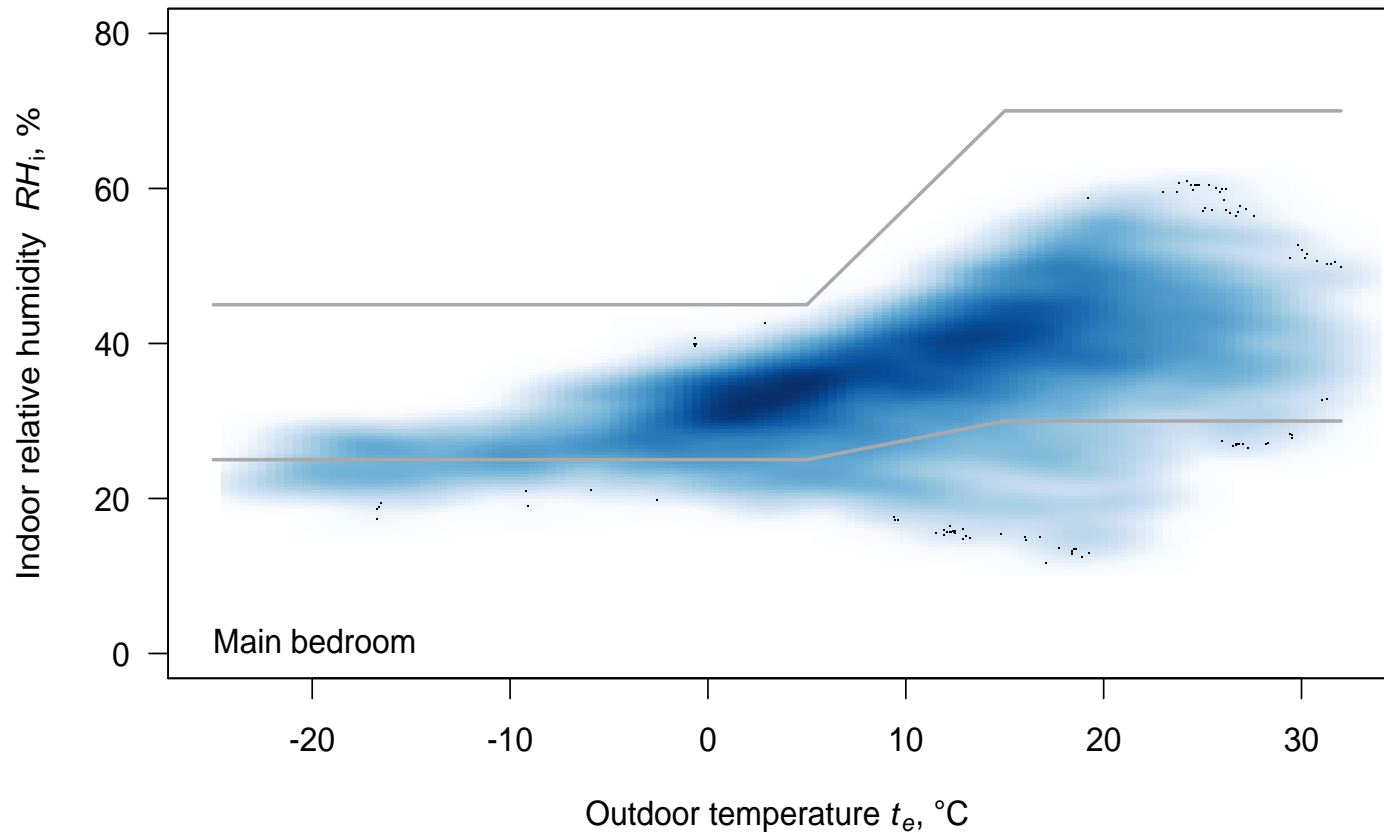
Ostetud energia, aasta
Elekter 3765 kWh
Gaas 423 m³ = 3934 kWh
Kokku 7699 kWh

51 kWh/m²

Elekter 436 €
Gaas 250 €
Kokku 686 € 4,6 €/m²

Tulemused: sisekliima, RH

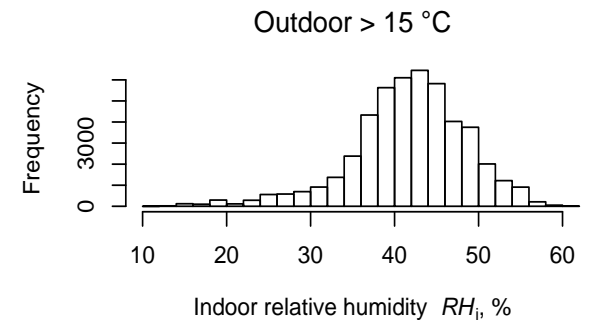
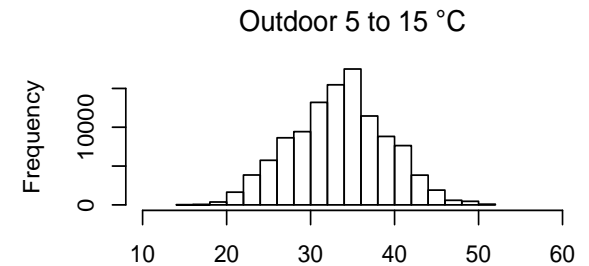
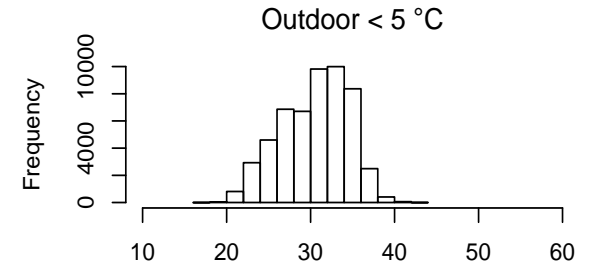
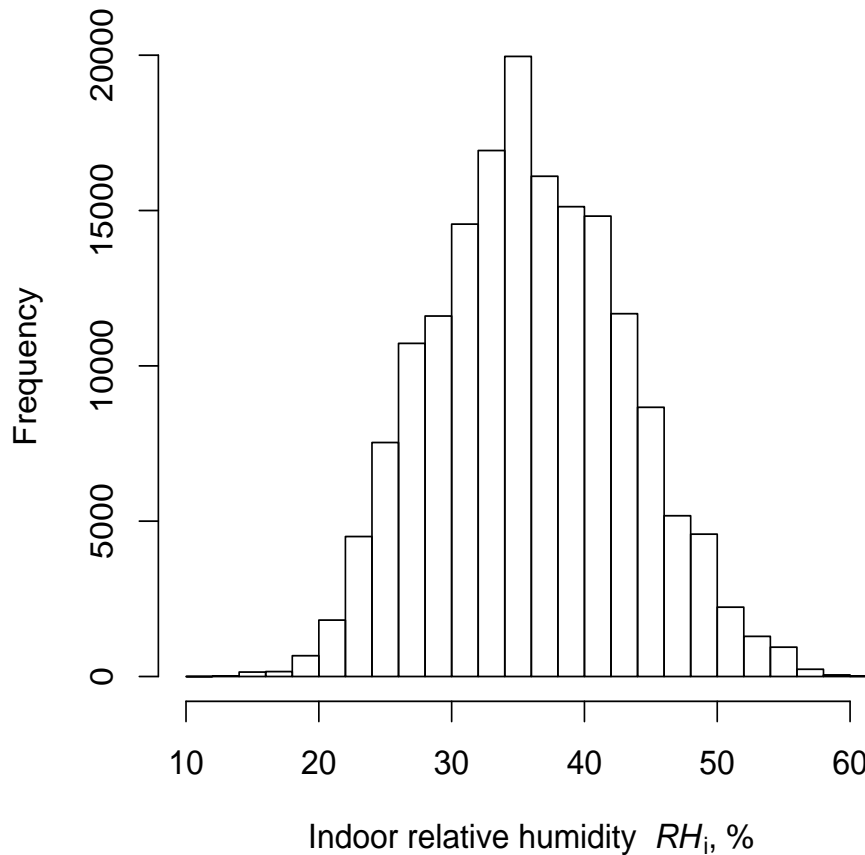
5 min dataset until 2014-10-31



Tulemused: sisekliima, RH

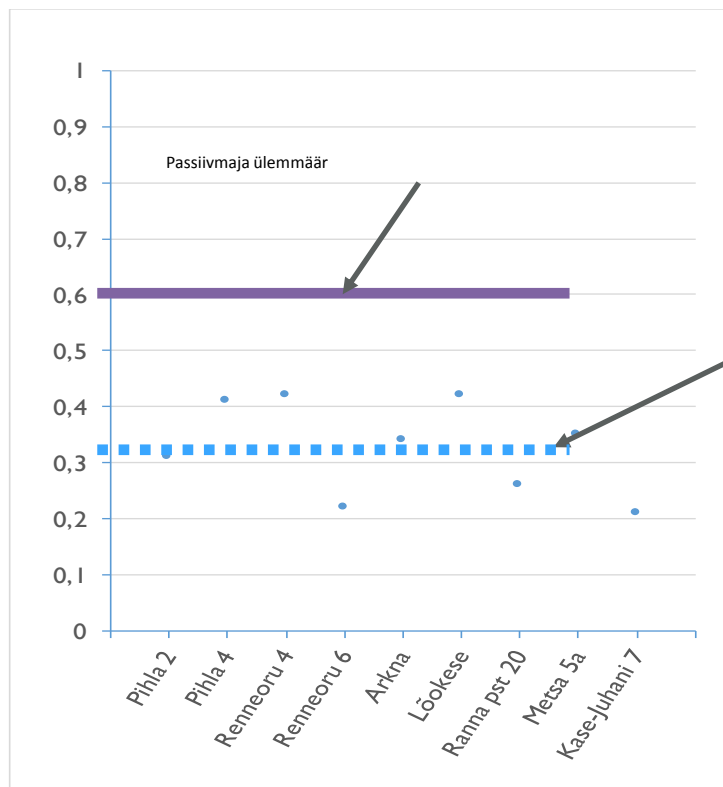
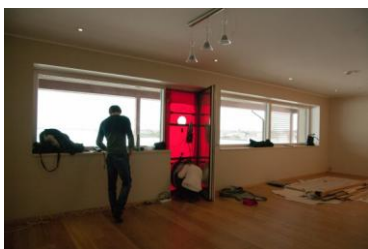
Main bedroom
all period until 2014-10-31

Histogram of 5 min data



Väga kvaliteetne majakarp

iga maja kvaliteet tõendatud rõhutestil



Sense majade
keskmine
 $n_{50} = 0,33 \text{ 1/h}$

Rahvusvaheline tunnustus

Sisuline tunnustus arendustöele – ettekanded erialakonverentsidel ja avaldatud teaduskirjandus

Tunnustus valminud hoonetele – Sense majad on **esimesed ja ainsad rahvusvaheliselt sertifitseeritud passiivmajad Eestis.**

Copenhagen, 20-21 August 2015
7. Passivhus Norden | Sustainable Cities and Buildings
 Brings practitioners and researchers together



A model for prefabricated timber passive house in Estonia



A prototype architecture for passive and plus energy building in Estonia

The performance of subsoil frost protection system of mechanical heat recovery ventilation unit in a cold climate in the context of net zero energy building

Jaanus Hallik, M.Sc.¹
 Kristo Kalbe, M.Sc.¹
 Tõnu Mauring, Ph.D.¹

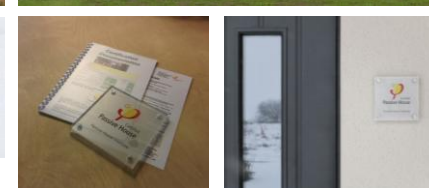
¹ Energy Efficient Building Core Laboratory, University of Tartu, Estonia

KEYWORDS: net zero energy building, frost-protection, ground-source brine heat exchanger.

POSTER

Winter performance of certified Passive House building in Northern European cold climate

Tõnu Mauring, Jaanus Hallik, Kristo Kalbe, Margus Valge
 University of Tartu, Nooruse 1, 50411 Tartu, Estonia, tel +37255566988, e-mail tonu.mauring@ut.ee



Energieinstitut Vorarlberg

KODUMAINE TUNNUSTUS

Kaks aastat järjest (2015. ja 2016. aastal) Eesti Puitmajaliidu ja puitmajaklastri “**Aasta tehase maja**” konkursil tunnustus ja eripreemia kategoorias “**aasta energiatõhusaim hoone**”.

“Sense OÜ näol on tegemist majatootjaga, keda võib Eesti kontekstis nimetada passiivmaja kontseptsiooni maaletoojaks. Sellise tulemuse tagavad vaid põhjalik tootearendus, kaasaegsed ehitusmaterjalid ning standardiseeritud ehitusprotsessid. “

- Lauri Kivil, Eesti Puitmajaliit MTÜ





Mis järgmiseks?

Riigigümnaasium Põlvasse –

Eesmärk:

valmis 01.09.2016

**Esimene koolihoone Eestis
liginullenergiahoonena ja
passiivmajana**

Algus

- 27.12.2013 Põlva vald ja HTM kokkulepe Riigigümnaasiumi rajamise kohta
- **01.2014 Põlva visiit RKASi tollaste juhtide juurde**
- 02.2014 kohtumine RKASis, osalesid ka HTM, Põlva vald, Tartu Ülikool, Tallinna Tehnikaülikool. Moodustati töögrupp **projekteerimishanke tingimuste väljatöötamiseks**. See oli meie jaoks **maailma kõige tähtsam otsus!**

Osapooli palju (probleem)

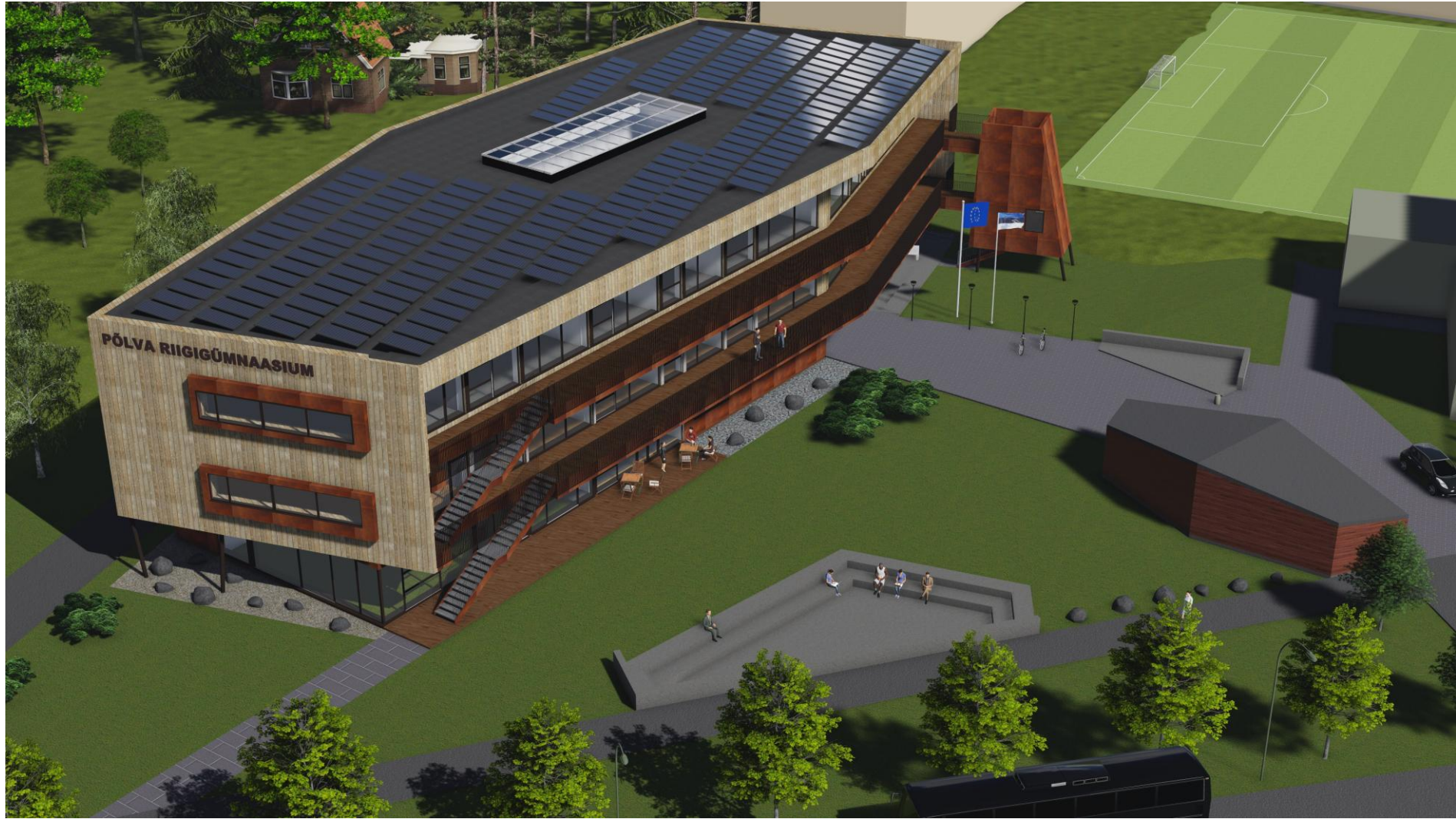
- Kuhu? – Põlva linn
- Omanik – Haridusministeerium
- Tegija – Riigi Kinnisvara AS
- Raha – EAS, Innove (ka Rahamin)
- Riigihange:
 - Projekteerimine
 - Ehitus
 - Järelevalve

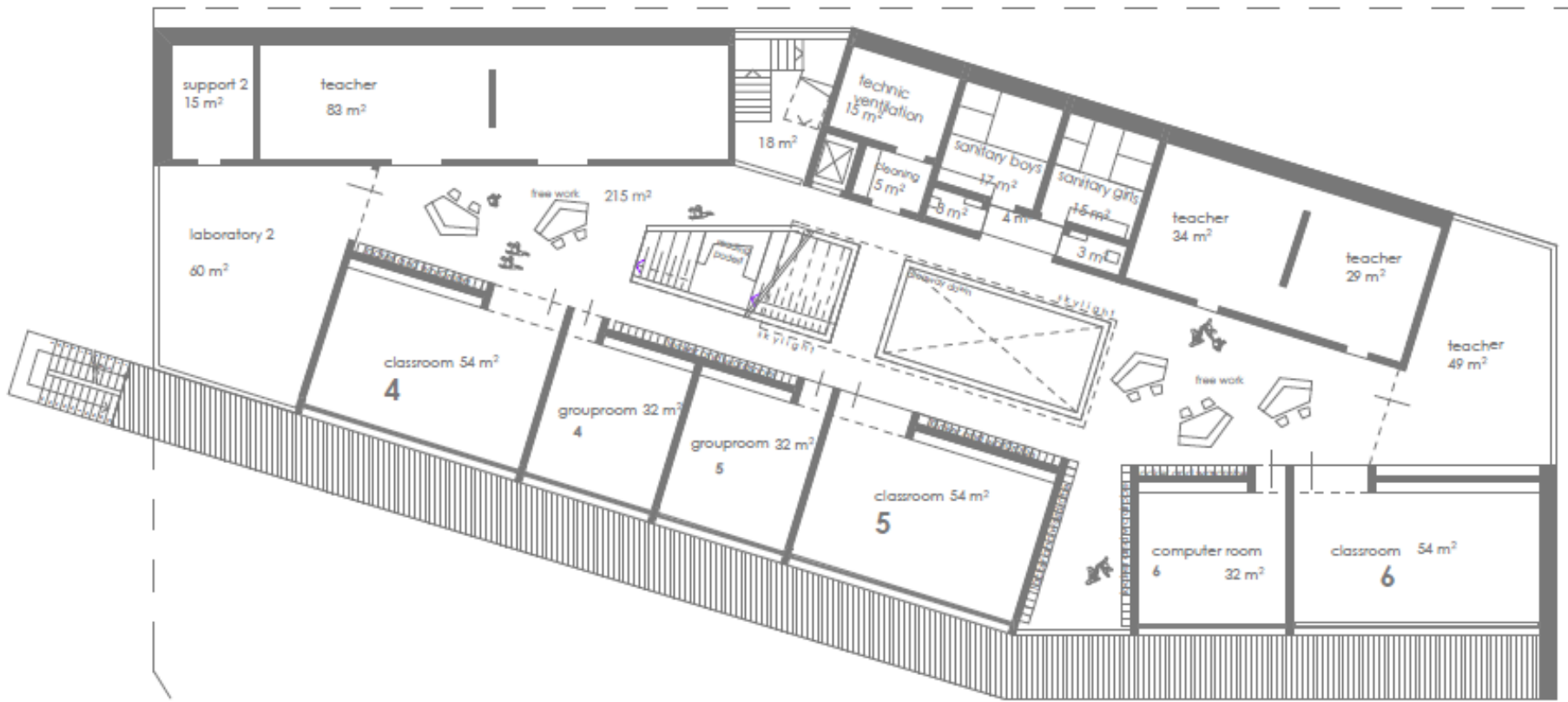
Projekteerimine

- Hange 6 kuud, projekteerimine 8 kuud
- Hanke võitis kohalik firma **Resand** koos Saksamaa passiivmajade arhitekti **Gernot Vallentiniga** (maailma esimese passiivmaja koolimaja arhitekt)
- Loogika ja eskiis Saksast, teostus Eestist (Põlvast)
- Sakslastel abiks Tõnu Muring, Jaanus Hallik
- Energiamärgis A,
 - energiatõhususarv 75 kWh/m²a
 - PV paneele 66 kW,
 - $q_{50}=0,6 \text{ m}^3/(\text{h} \cdot \text{m}^2)$ – Nordic Energy Solutions, Indrek Raide









third floor 1:250



Samal ajal...

- Miks peaks Põlva saama parema kui teised?
- **KALLIS!!!**
- Miks peaks klassiruumidest rõdule saama?
- **Kallis!**
- Sellest tuleb teil üks saun
- Kallis
- Ehitaja keerab nagunii kõik nässu
- kallis

Ehitus ja järelvalve

- Hange 5 kuud, ehitus 10,5 kuud
- Kogu protsessi üks lihtsamaid valikuid
- Ehitaja **Ehitus5ECO OÜ**, väga tublid, energiatõhususe konsultant Nordic Energy Solutions, Indrek Raide

- Järelevalve hange 5 kuud, tööd 5 kuud
- Järelevalve tegija OÜ **Keskkonnaprojekt** (energiatõhususe abi TÜ (Kristo Kalbe)+Sense)

Lõpptulemus

- $q_{50} = \mathbf{0,47} \text{ m}^3/(\text{h} \cdot \text{m}^2)$ – (planeeritud 0,60)
- Energiatõhususarv **54** kWh/m²a – (plan. 75)
- PV paneele **37** kW - (plan. 66)
- Pind 2321,6 m²
- Hind 3,023+km mEUR, **1302** eur/m²
- Õppetöö algus 09.01.2017

















Aitäh



sense

- <http://www.sense.ee/>
- Veel infot:
kuldar.leis@polva.ee