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D5.5 Realization of 2 Real life lab environments for in deep testing of basic modules and special features

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REALIZATION OF 2 RLLL's: CZECHIA AND THE NETHERLANDS

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OBJECTIVES

In MORE-CONNECT there are to locations where Real Life Learning Lab (RLLL) situation were used. These RLL situations are more suitable for the in deep testing of specific solutions like the smart plug & play connections, advanced controls, building physics, moisture behaviour, zero energy solutions and testing of special and specific materials like super insulation, biobased composites, 3D printed materials in a small scale semi-lab setting. There will be two Real Life Learning Lab settings organized in Czech Republic and in The Netherlands).

- Czech RLLL:
  - Testing of connections among modules
  - Testing of advanced control systems
  - Provision of a showcase for dissemination
- Dutch RLLL:
  - Testing of prefab multifunctional facades, roofs and 'engines' (installation platforms)
  - Monitoring on energy use
  - In deep monitoring on thermal comfort and health

CZECH RLLL

FULL-SCALE testing of façade elements

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- The testing consisted of two samples – one full scale prototype and (left) one full-scale mock-up of the upper part of a façade element (right)

DEVELOPMENT

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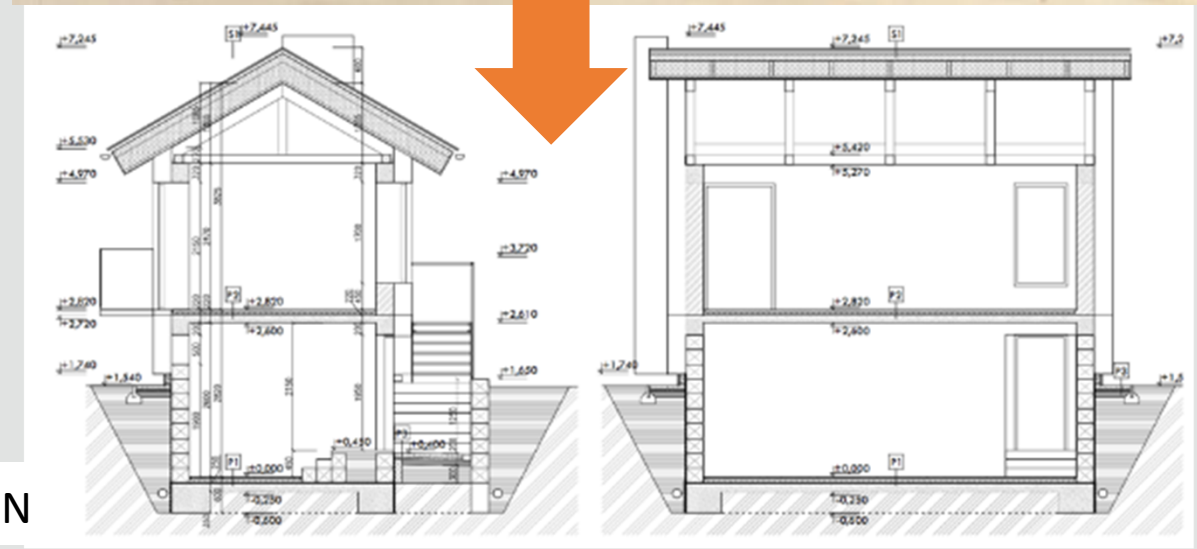
- The original intention described in the project proposal was to produce a section of wall modules and hang it on the frame on the south façade of UCEEB main building and an in addition and exterior structure to test selected details of modules and their connections.
- During the course of the project became obvious that besides the wall modules there is also need to look deeper into the details of wall/roof modules' connections and onto the external accessories of HVAC engine.
- Therefore we decided to combine the two RLLL settings into one larger, that would include a complete set of critical details that occur on a typical representative of Czech post-war residential block of flats.

ORIGINAL IDEA OF RLLL INSTALLATION

On experimental areas the frames with details mock-ups and smart connector installations will be located

On this wall mock-up prototypes of façade panels will be installed for monitoring and testing



FINAL DESIGN

CZECH TYPOLOGY AND RETROFITTING OPTIONS

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- The Czech typology and development of modules was in detail described in WP2, especially in D2.2
- We have designed variable set of retrofitting interventions, ranging from low-cost variant of net zero energy retrofitting to a hi-tech variant with creation of new attic flats and advanced control of the indoor environment.

MODULARITY

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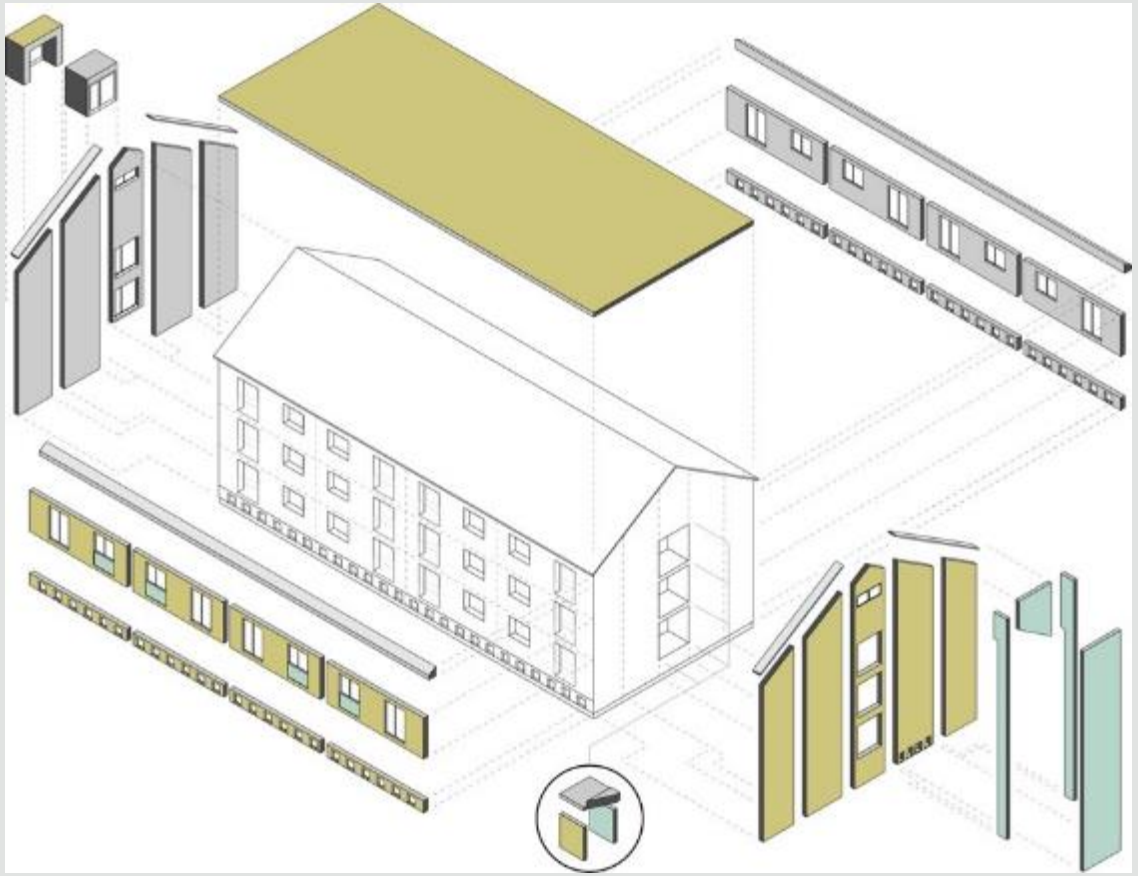
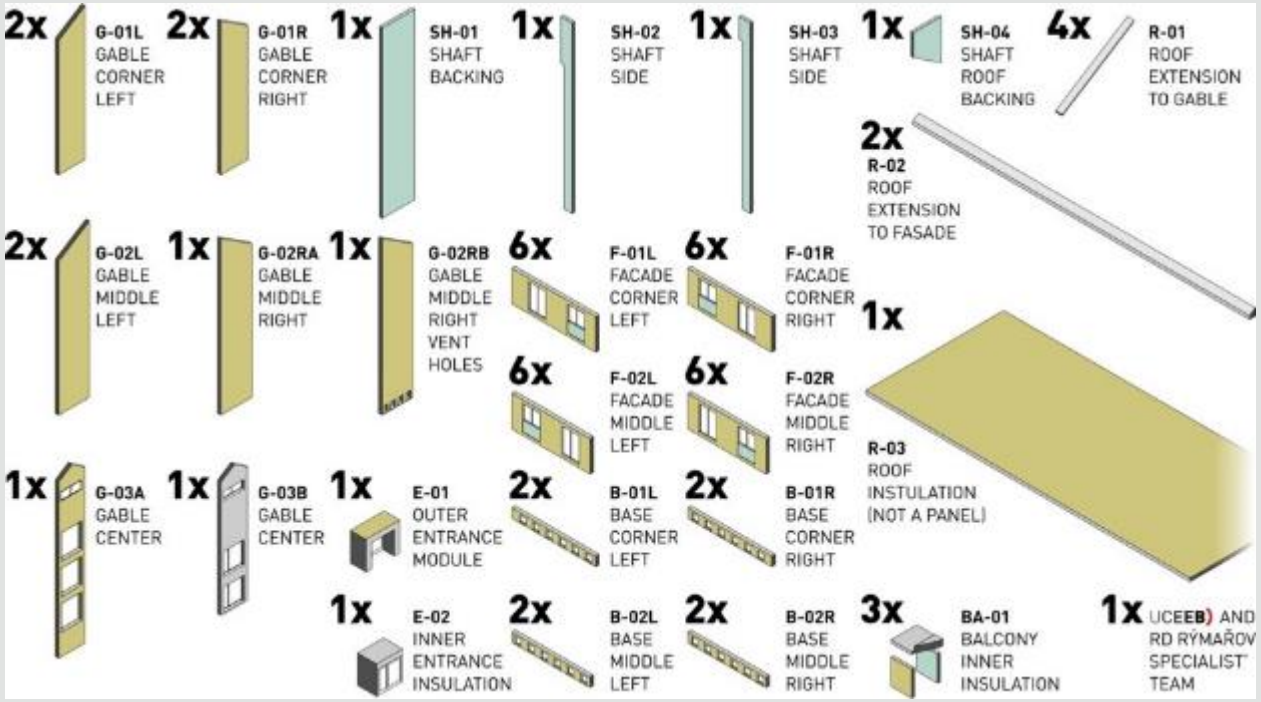
- Each of the retrofitting variants consists of a set of modules
- Many of the modules repeat on a standard building – it is not necessary to test all, selected subset is sufficient





DESIGN OF THE RLLL MOCKUP-BUILDING

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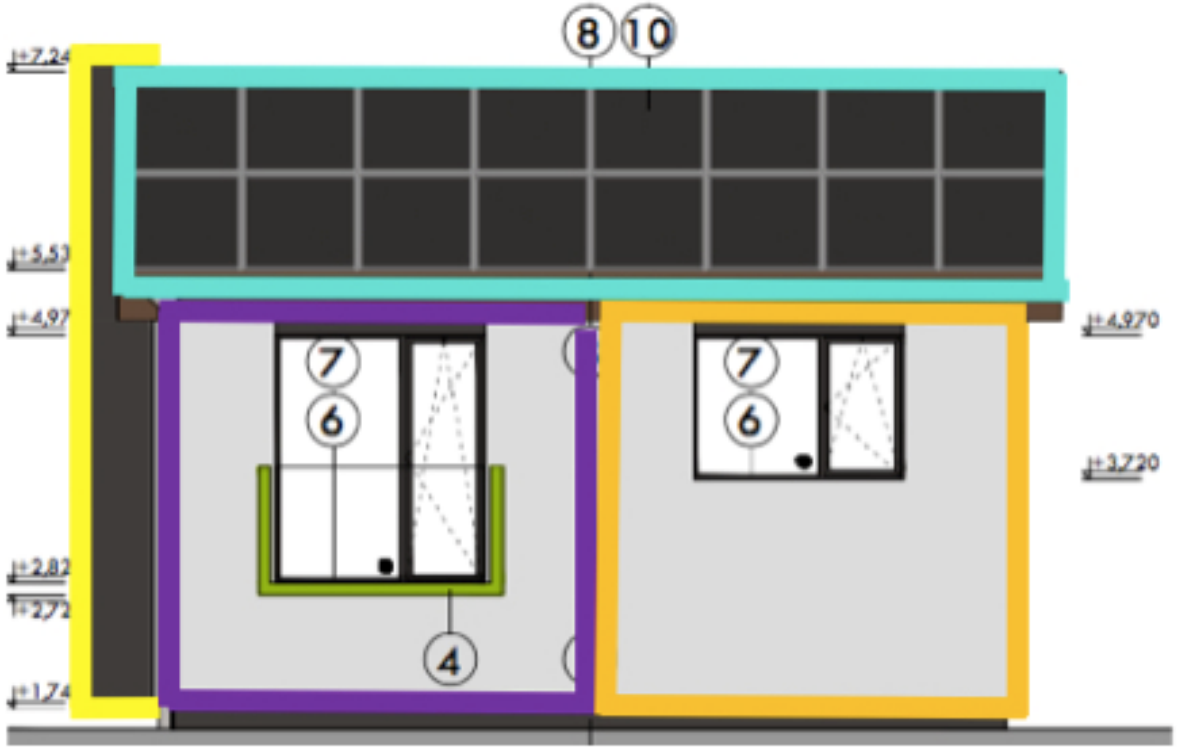
- The extent of the RLLL setting was designed to test variety of modules and their connections



MOCK-UP BUILDING

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SITUATION – LOCATION IN RED

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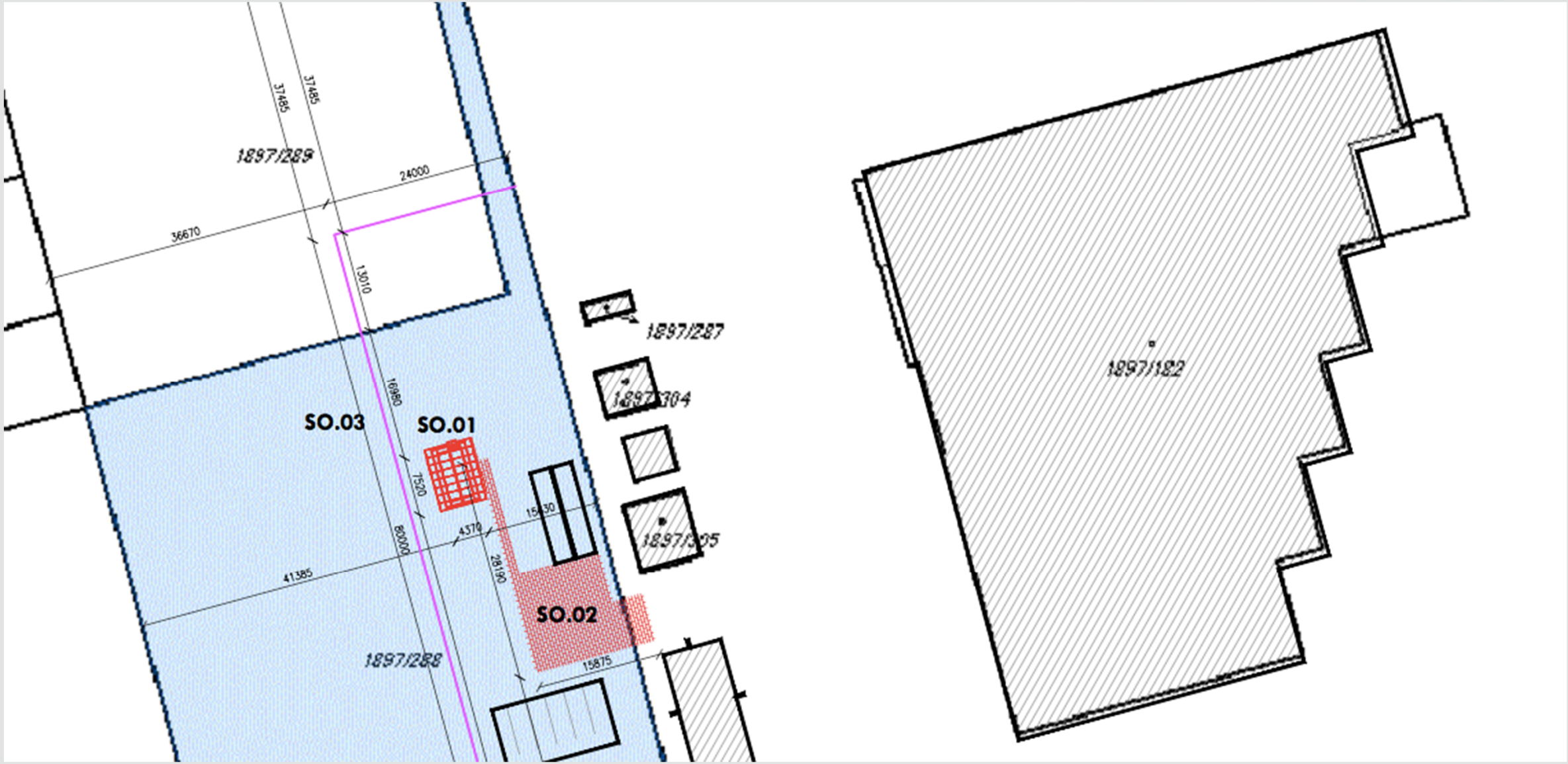

CZECH RLLL – OVERVIEW OF EXTERNAL MODULES

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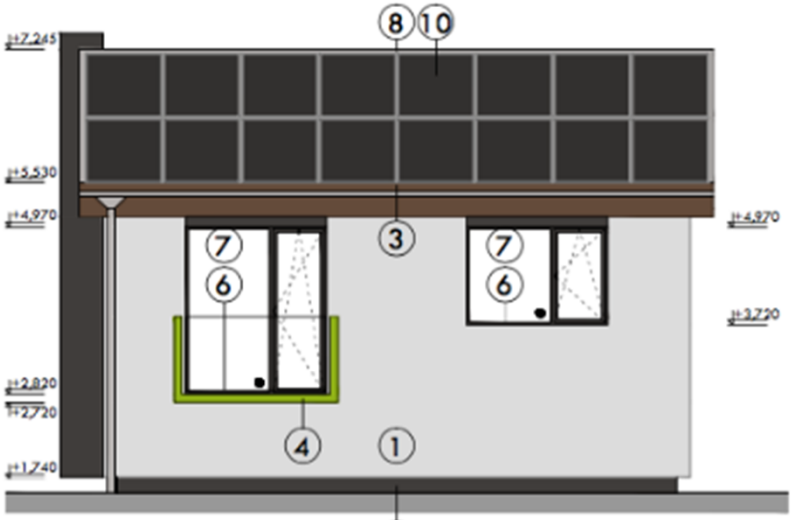
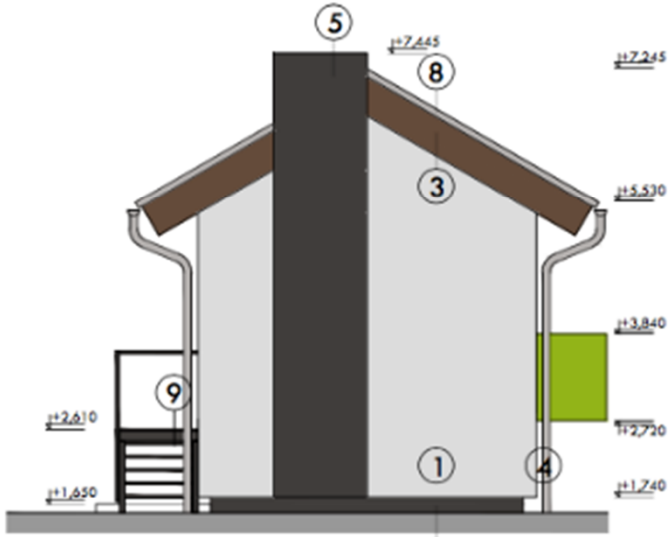
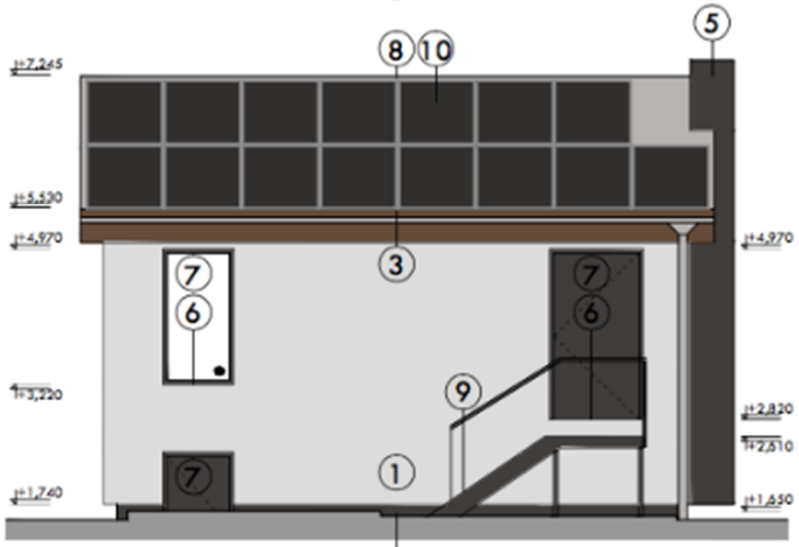
SOUTH ELEVATION



WEST ELEVATION



NORTH ELEVATION



EAST ELEVATION

DESIGN OF HVAC ENGINE

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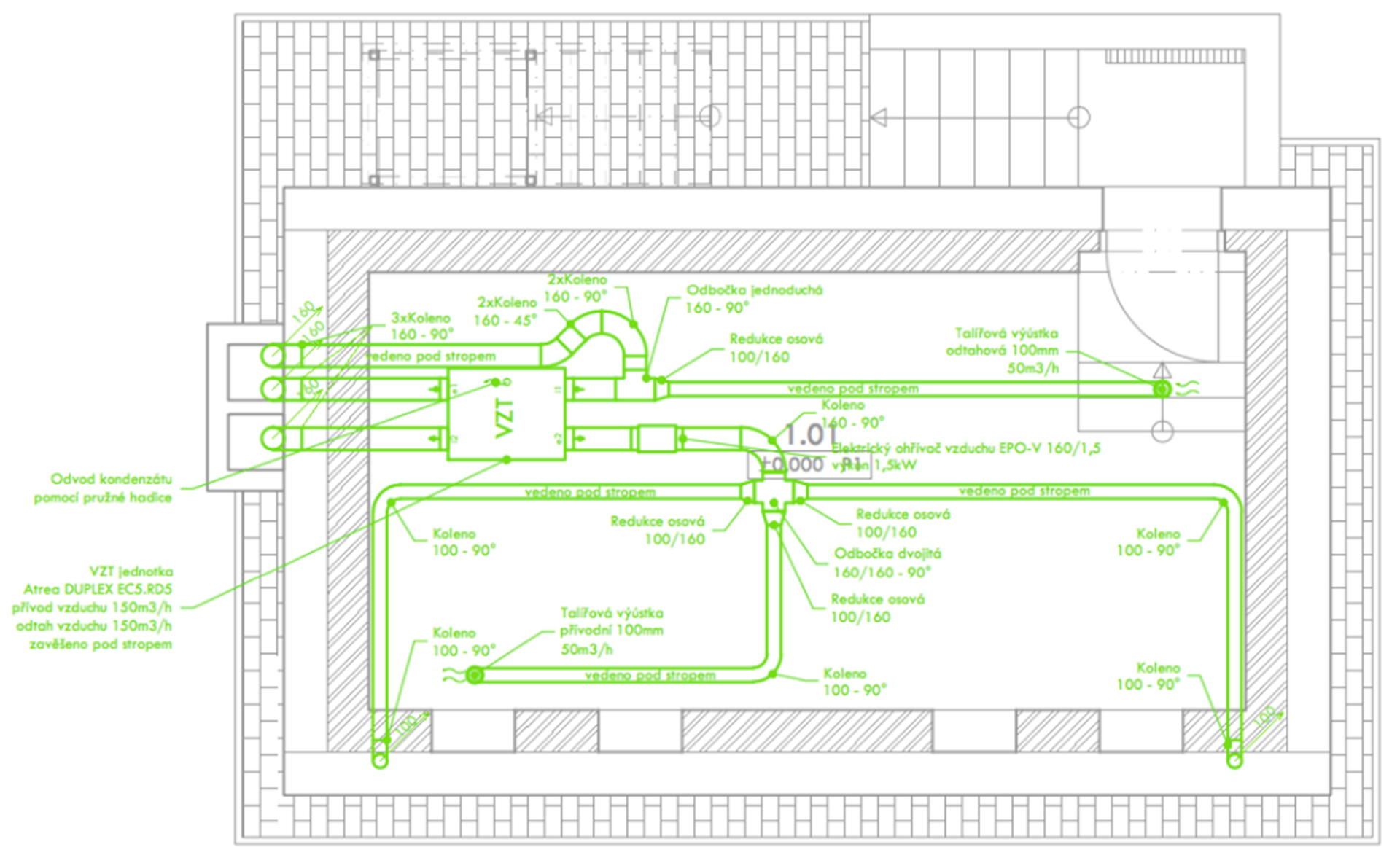

DESIGN of monitoring and control system

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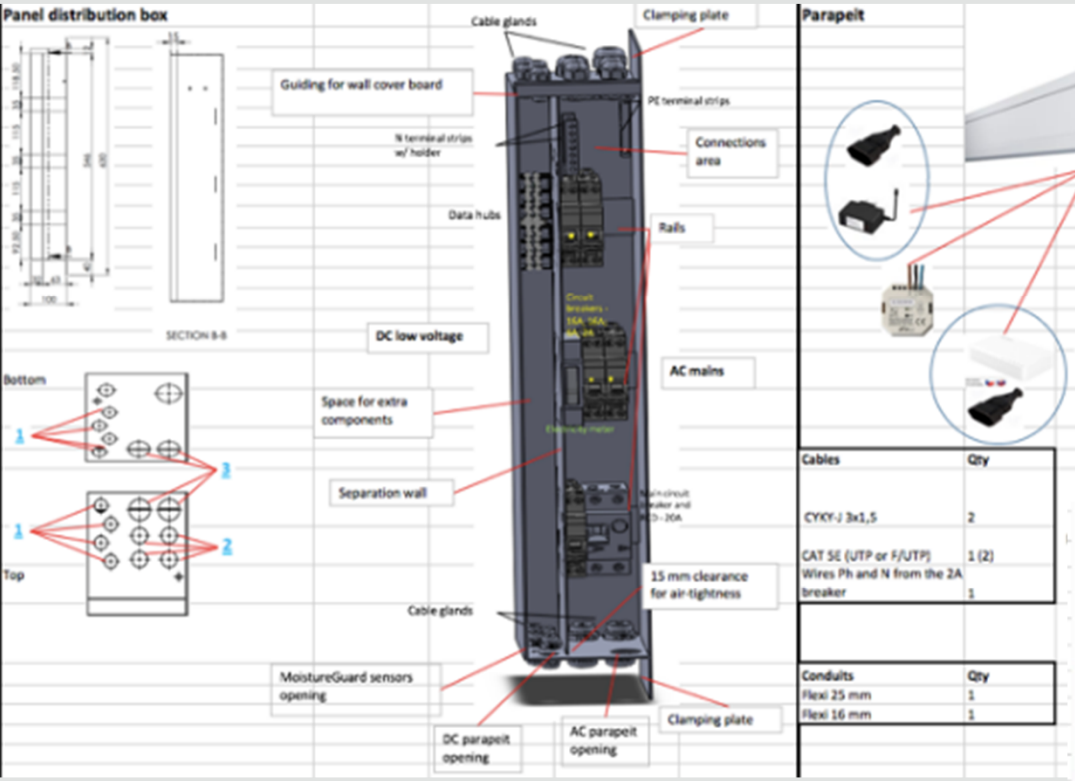
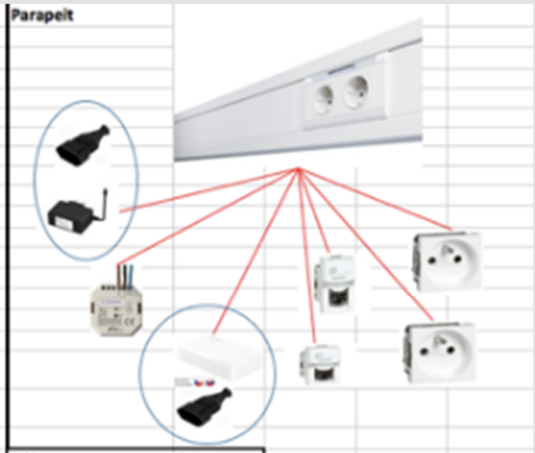
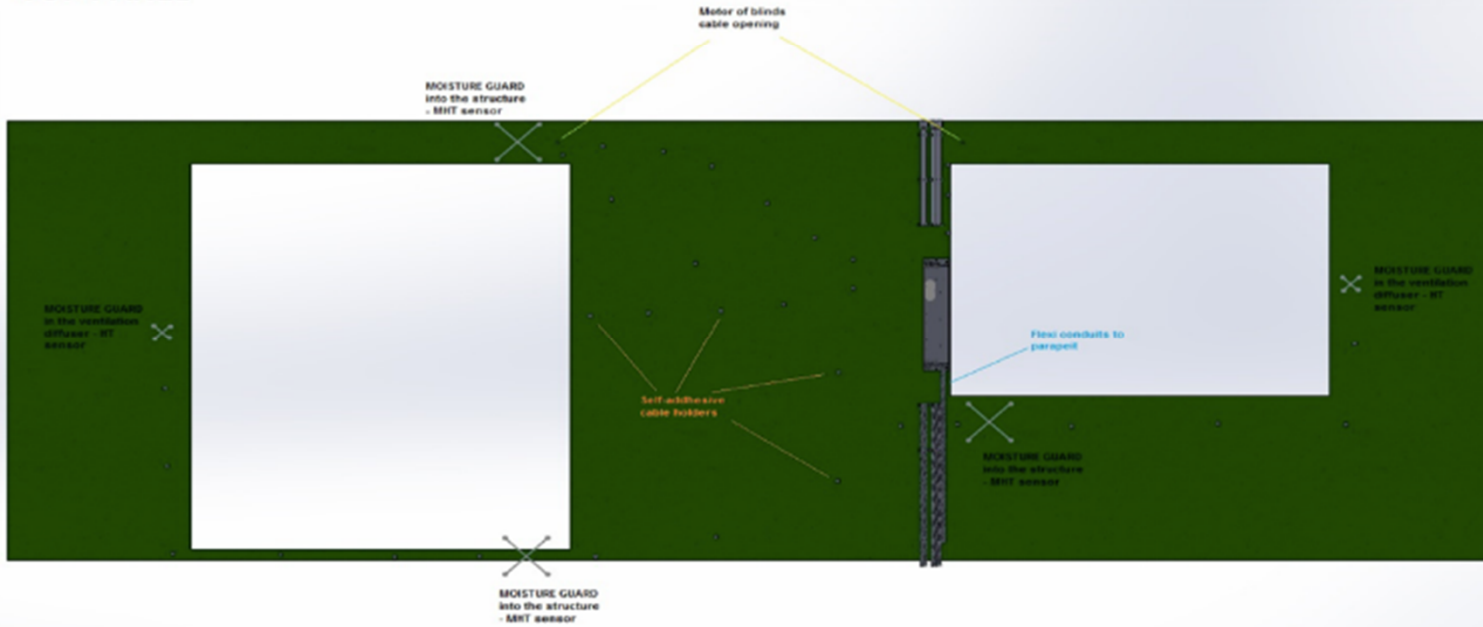




Cables	Qty
CYKY-J 3x1,5	2
CAT 5E (UTP or F/UTP)	1 (2)
Wires Ph and N from the 2A breaker	1

Conduits	Qty
Flexi 25 mm	1
Flexi 16 mm	1

TOP PANEL



DESIGN of airtight switchbox encapsulation

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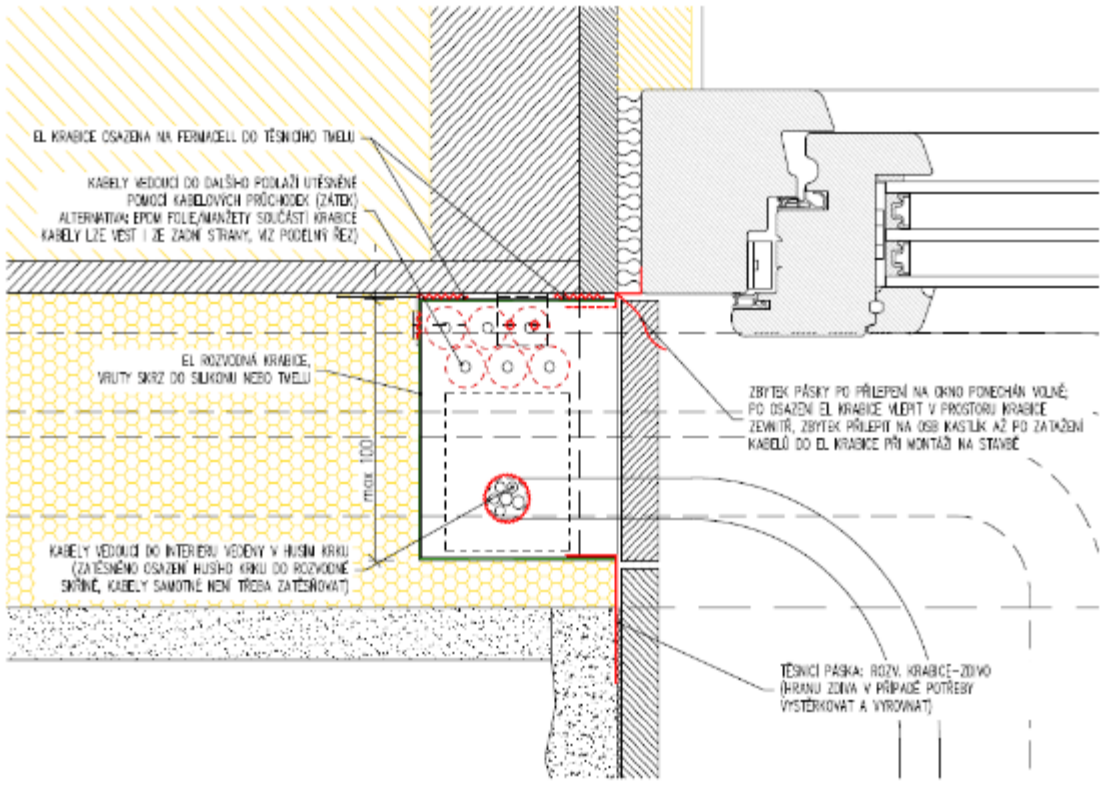

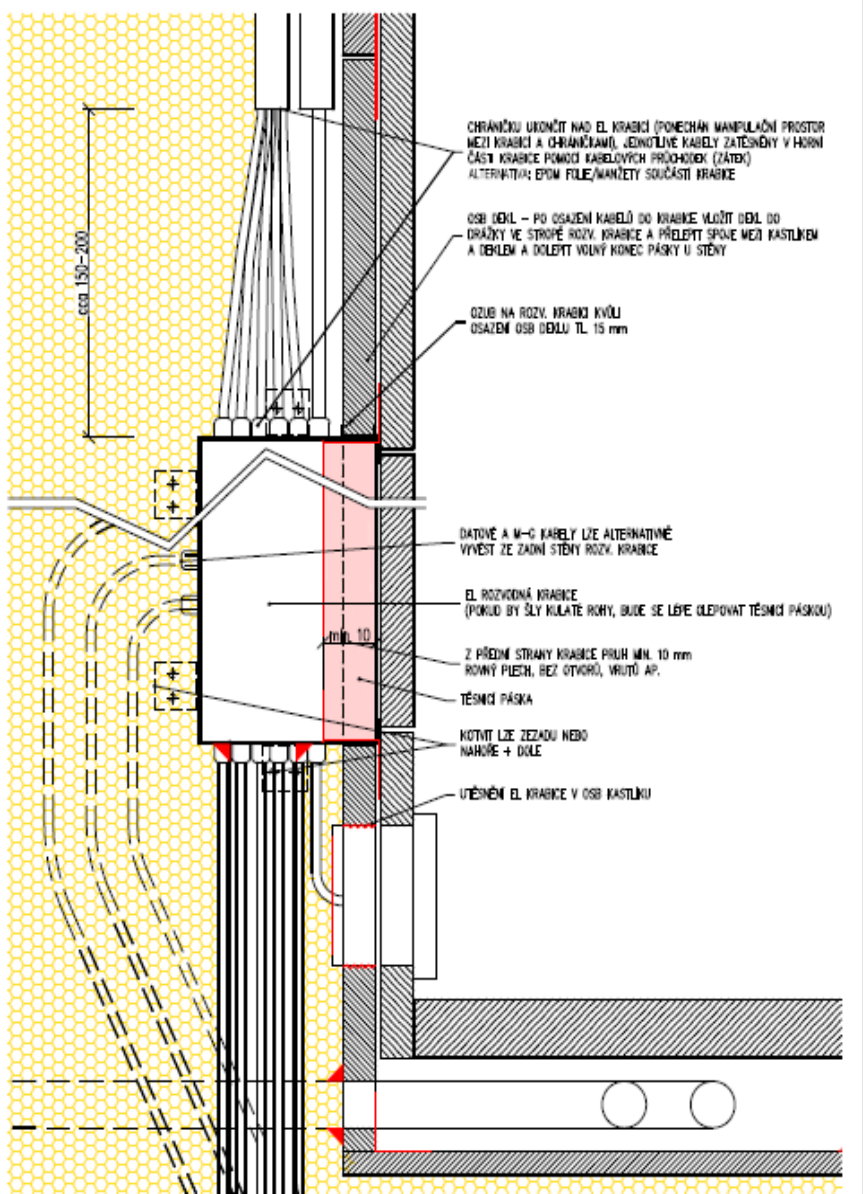

SECTIONS (FROM BUILDING PERMIT DOCUMENTATION)

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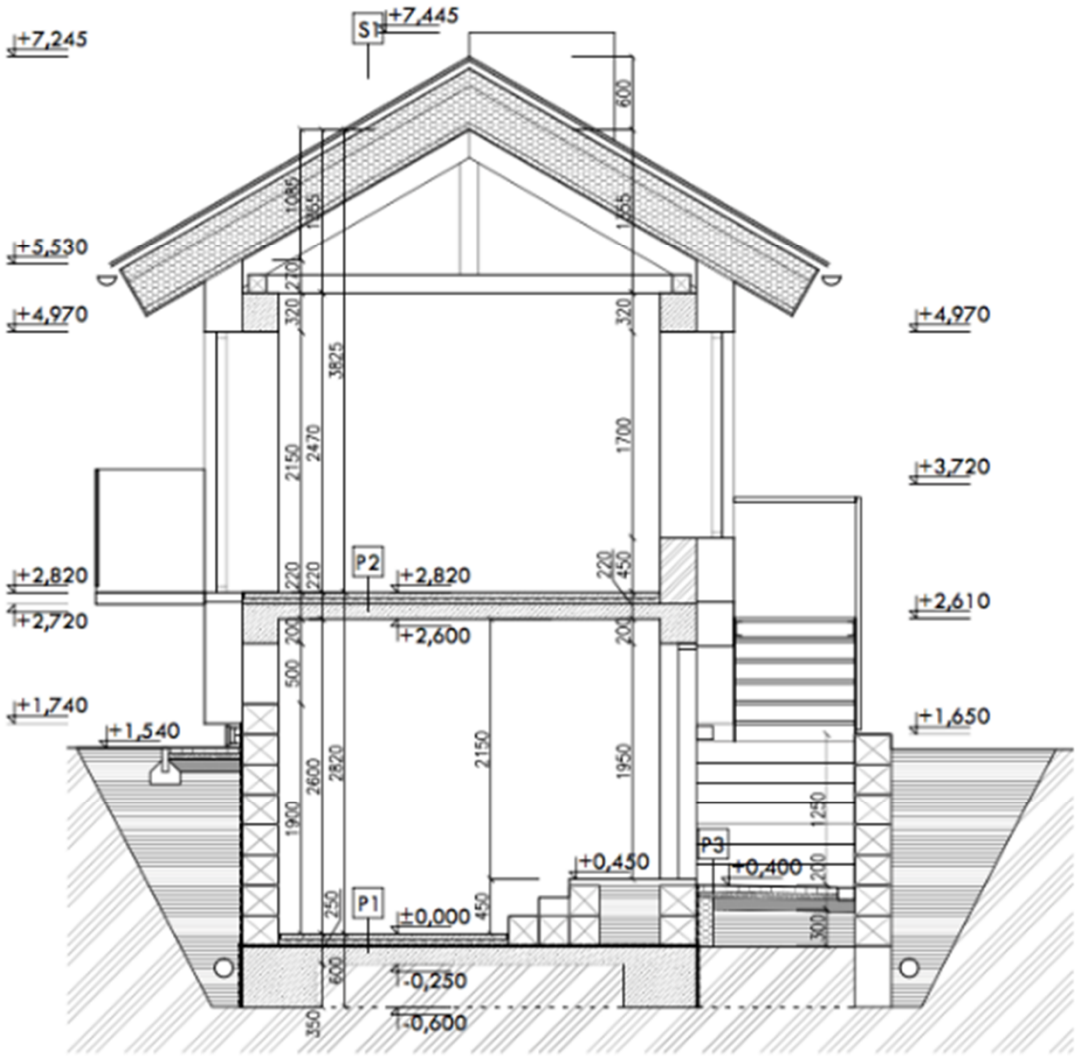

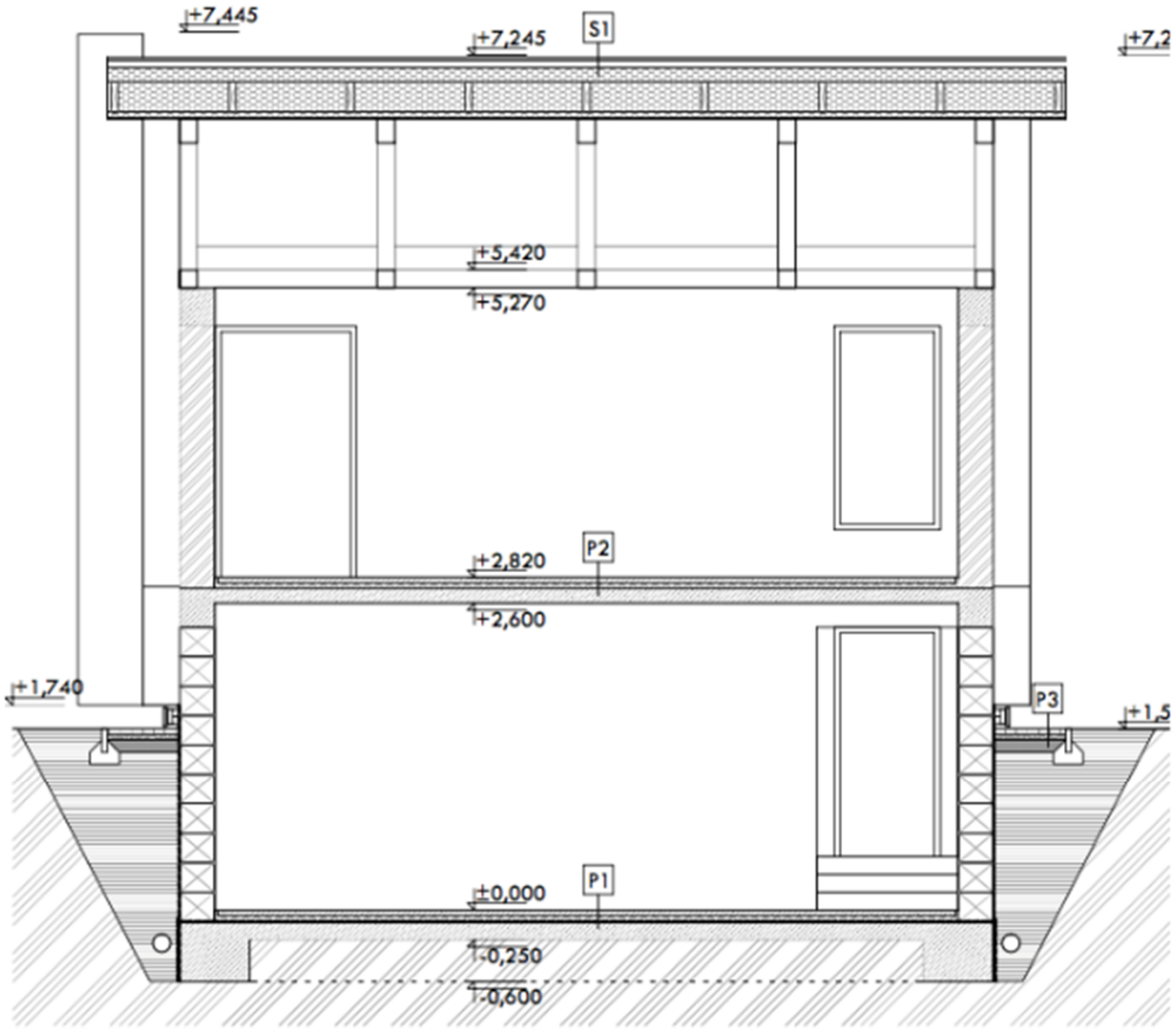

ASSEMBLY Plan for WEST and SOUTH WALL modules

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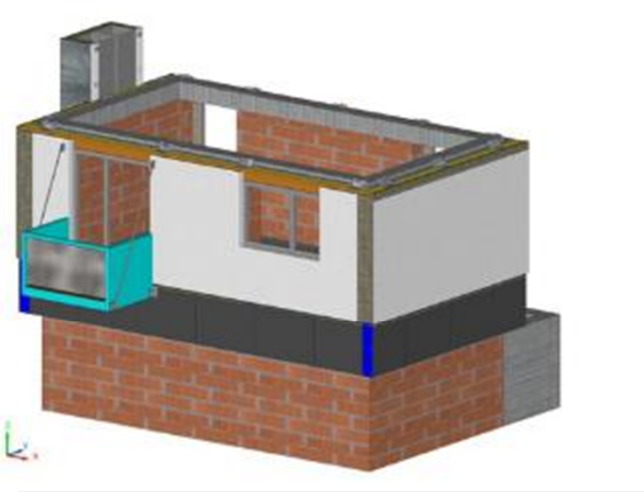

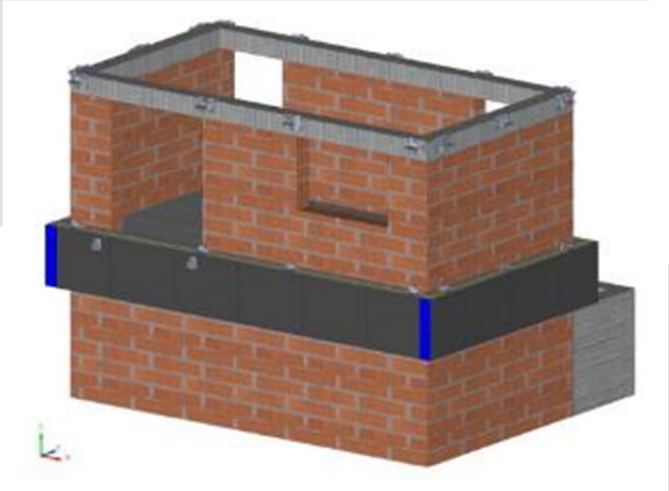

ASSEMBLY Plan for EAST and NORTH WALL modules

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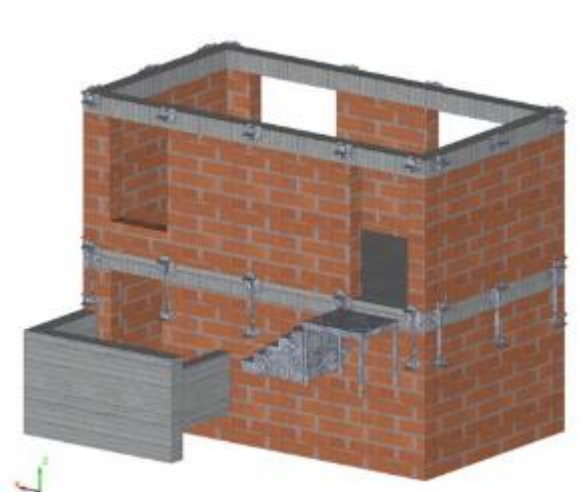

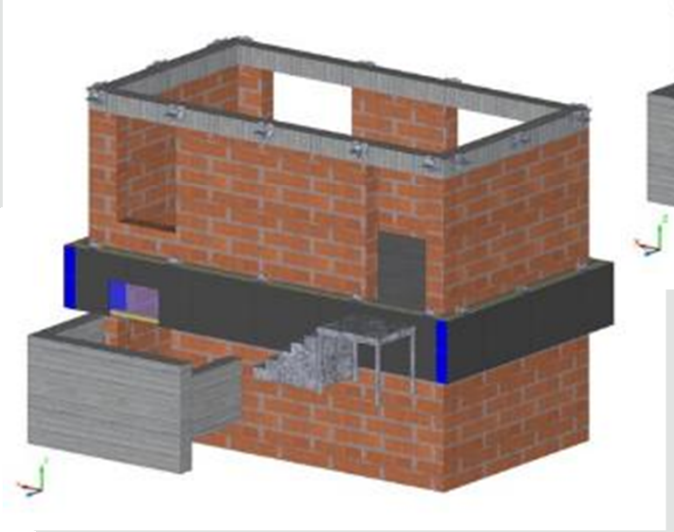

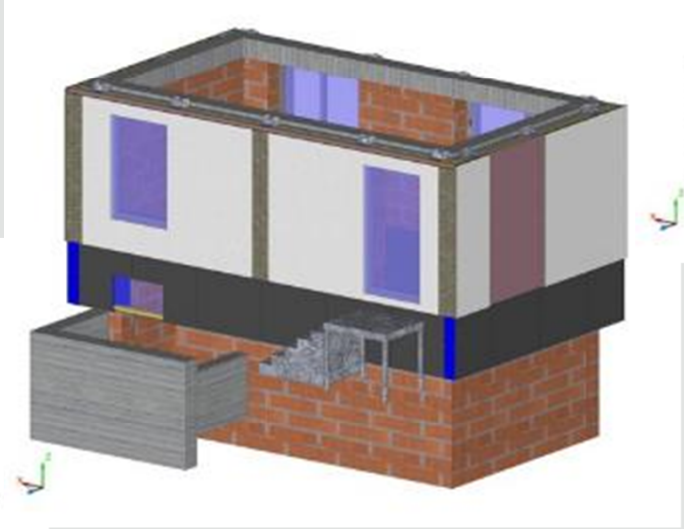

GROUND WORKS AND FOUNDATION

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GROUND WORKS AND FOUNDATION

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WATERPROOFING and floor structure

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CONSTRUCTION OF THE FIRST FLOOR

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Finishing of MOCK-UP BUILDING

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ASSEMBLY OF MODULES AT RD RÝMAŘOV (30/11/2017)

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Prepared set of modules for the installion of integrated systems

ASSEMBLY OF MODULES AT RD RÝMAŘOV (30/11/2017)

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Standard modules (exterior side before application of plaster)

Gable top module (exterior side before application of plaster)

Gable modules (exterior side with first layer of a plaster)

Starting module with maintanance door (e.)

Base module with maintanance door (e.)

ASSEMBLY OF MODULES AT RD RÝMAŘOV (30/11/2017)

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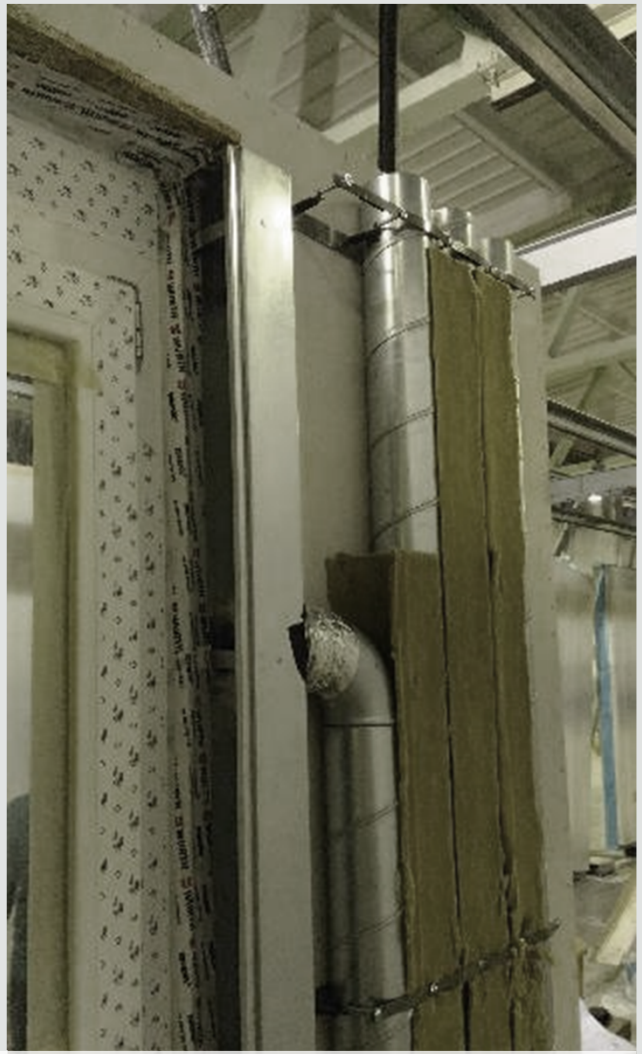

Installation of ventilation system (pipe-pack system developed by CTU) and control elements in the base module

ASSEMBLY OF MODULES AT RD RÝMAŘOV (30/11/2017)

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Installation of monitoring systems (into ventilation system and in the structure) and electrical switchbox

INSTALLATION IN ONE DAy

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6:27

INSTALLATION IN ONE DAy

MORE — CONNECT

7:57

INSTALLATION IN ONE DAy

MORE — CONNECT

11:21

INSTALLATION IN ONE DAy

MORE — CONNECT

11:49

INSTALLATION IN ONE DAy

MORE — CONNECT

16:06

INSTALLATION IN ONE DAy

MORE — CONNECT

18:54

INSTALLATION IN ONE DAy

MORE — CONNECT

19:36

INSTALLATION OF PV ROOF

MORE — CONNECT

INSTALLATION FINISHED

MORE — CONNECT

EXCURSIONS

MORE — CONNECT

EXCURSIONS

MORE — CONNECT

EXCURSIONS

MORE — CONNECT

DUTCH RLLL

Background Dutch RLLL – experiences ‘Stroomversnelling’

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- Since 2007 several deep retrofitting projects have been completed based on a prefabricated, modular building envelope. These projects involve typical Dutch terraced (single family) housing owned by social housing associations.
- Major experiences have been done in the national program ‘Stroomversnelling’
- However, directions for improvement have been identified and possibilities for upscaling (new markets) have been suggested.

Background Dutch RLLL - early experiences

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Background Dutch RLLL

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Technological innovation:

- Plug-and-play connection between façade module and building structure: click-and-span
- Retrofitting without the application of scaffolding on-site
- Improvement prefabrication efficiency (improvement design of façade elements)

New markets:

- Private housing market (homeowners)
- Apartment buildings

Process innovation:

- Minimal hindrance, dwellings remain occupied during the project: retrofitting within a single day
- Improvement office processes
  - Supply chain average office cost in chain is appr.30% (NL)
- Shorten the supply chain
  - Appr. 10% profit & matketing costs per cut out (NL)
- Smoothen the supply chain
  - Multidiciplinary design
  - Integrated processes
- Scale ; production (and purchase)
  - Upscale from 500 pa to 10,000 pa appr. 30%
  - Design and materials innovation for production

Background Dutch RLLL

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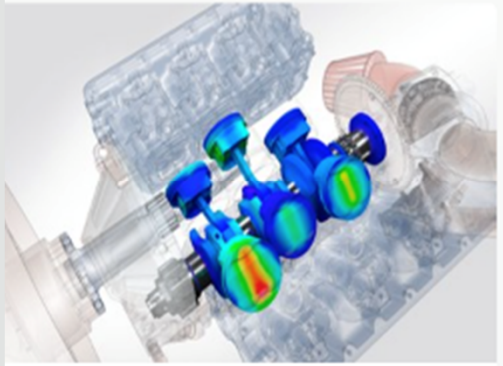
Engineering Collaboration

Document Control & Collaboration

Bouw Informatie Model (BIM)

Process innovation key to the success of (affordable) modular deep-retrotting solutions



Simulation

Product Data Management

Project Management Support

Dutch RLLL house Heerlen

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- Breitnerstraat 23 Heerlen
- Terraced house ’60’s
- Building envelope totally removed and replaced by:
  - Multifunctional facades (prefab) including decentral combined heating and ventilation units (heat recovery, CO2 controlled)
  - Solar roof (partly prefab)
- Building services replaced by ‘prefab engine’ (installation platform)
- Completed spring 2015

Design of the renovation

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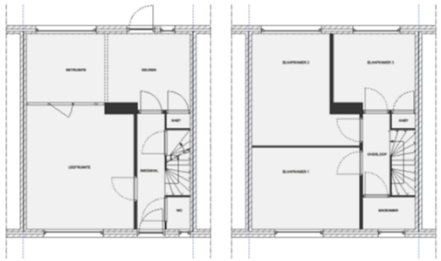
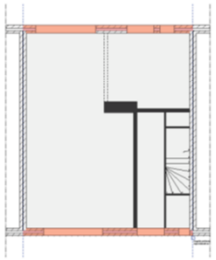


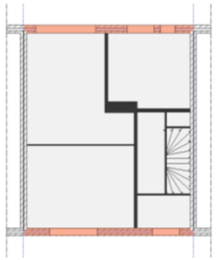
gelijkvloers OUD

verdieping 1 OUD

voorgevel

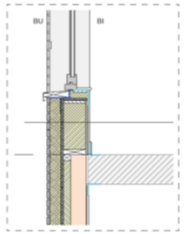


gelijkvloers
Wegbreken achter + voorgevel

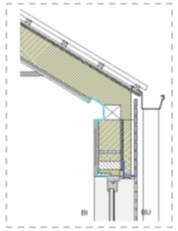


verdieping 1

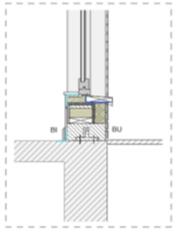
achtergevel



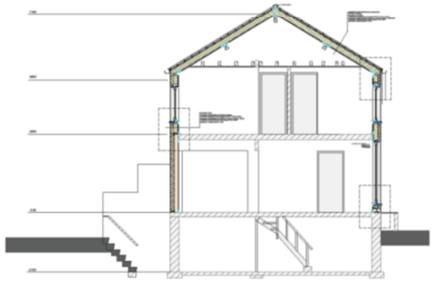
DETAIL verticale snede



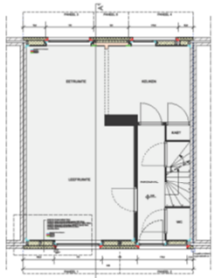
DETAIL verticale snede



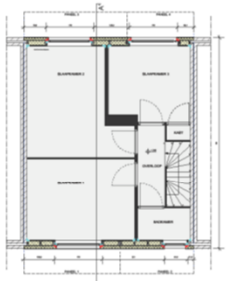
DETAIL verticale snede



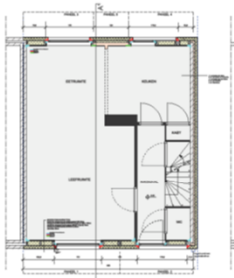
WONING 23 + 28
SNEDE AA'



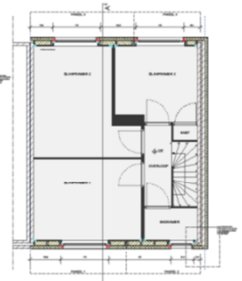
WONING 23
gelijkvloers NIEUW



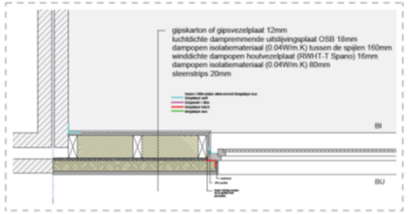
WONING 23
verdieping 1 NIEUW



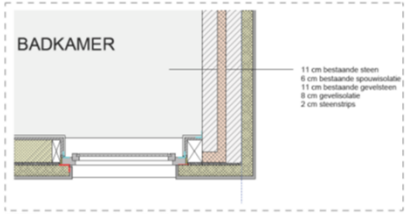
WONING 28
gelijkvloers NIEUW
optie 2 kopse gevel



WONING 28
verdieping 1 NIEUW
optie 1 kopse gevel



DETAIL horizontale snede woning 23



DETAIL horizontale snede woning 28

WIJZIGINGEN	VO	BAU	URV	AS-BUILT	DATUM	ID

URBAN DOTS studio

ULTIMATUM ARCHITECTEN BVBA

PLANNR 1/1
JOBNR 1316_VDK

BOUWHEER:
BOUWADRES:
PLANGEGEVENS
SCHAAL
DATUM
ARCHITECT
CONTACTPERSOON: RUBEN HERMANS +32 497 473 085
CONTROLE: RHE

BIM controlled production process of the basic façade elements

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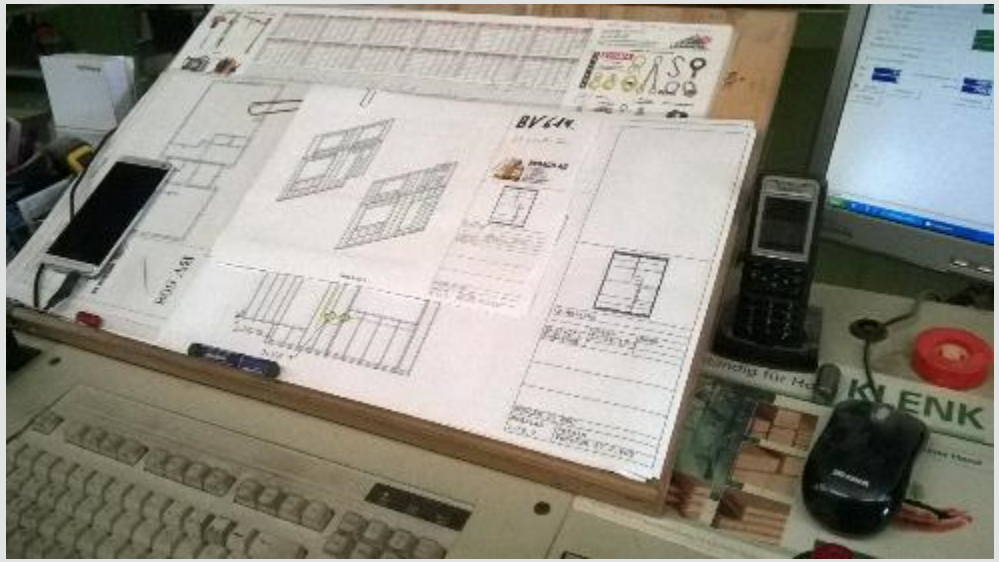

Integrated heating and ventilation systems with ducts, pipes
Finishing of the cladding (not automated yet)

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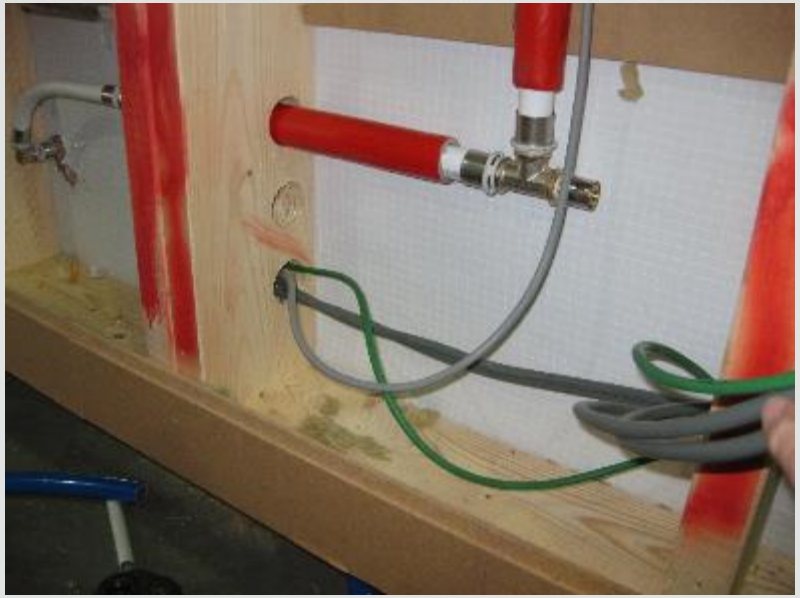

Prefab roof elements with PV, box for the ‘engine’ and integrated pipes and ducts for heating and ventilation

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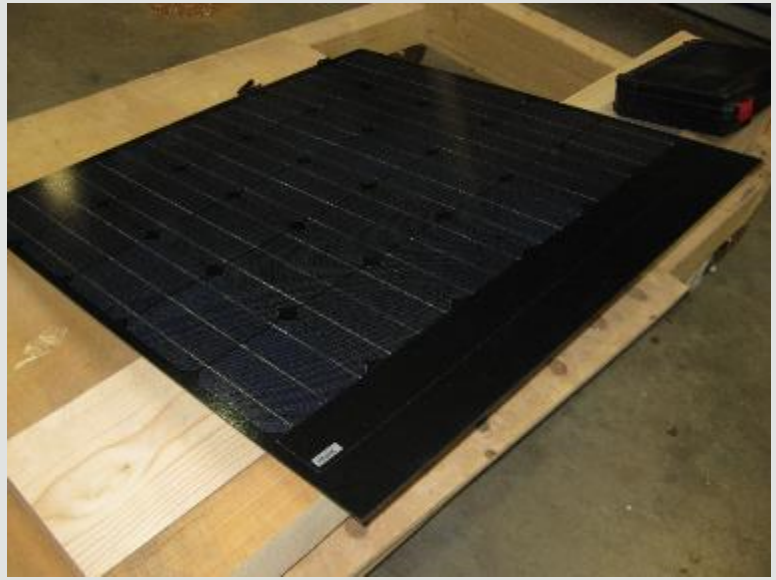

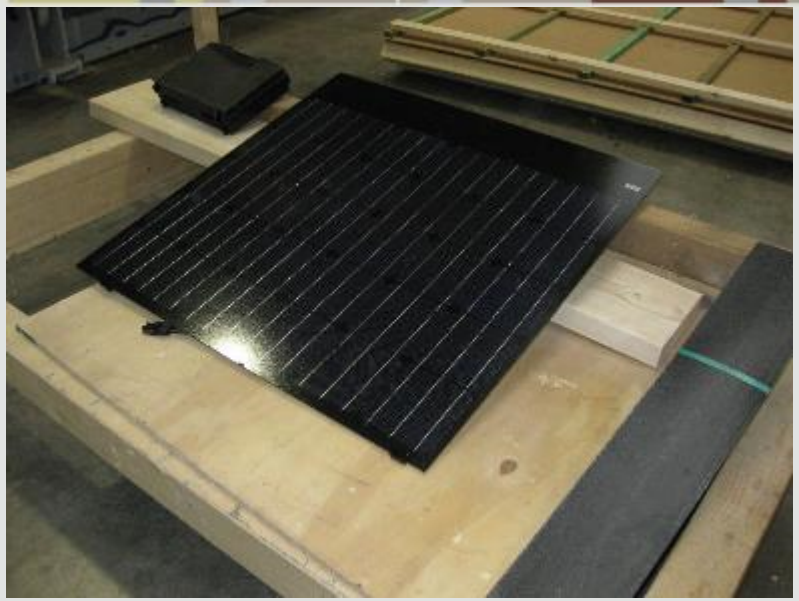

Design and building of the ‘engine’ (not automated yet)

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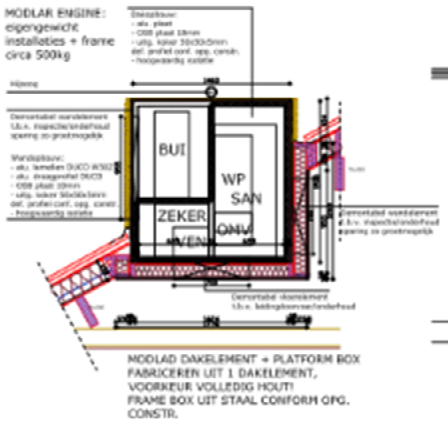
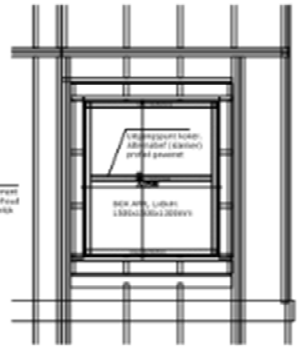
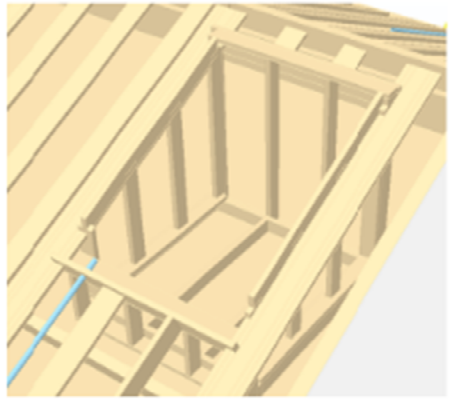


DOORSNEDE



BOV. AANZICHT



3D AANZICHT

Transport of the façade elements

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Removal old outer blade and mounting new prefab façade elements

MORE — CONNECT

Installing PV roof and Engine

MORE — CONNECT

After completion of the renovation

MORE — CONNECT

Monitoring

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- Energy flows
  - Total (heat flows heat pump)
  - Partial (raspberry pi's)
- Indoor air quality
- Thermal comfort and <u>personal health</u>
- Air tightness (poor quality, still $n_{50} \sim 6.5$ after renovation! Major leakages through ceiling and roof)

Monitoring user aspects

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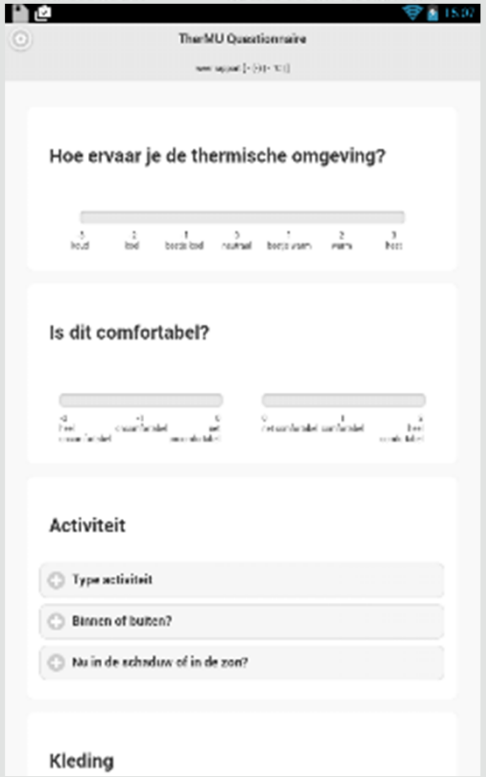
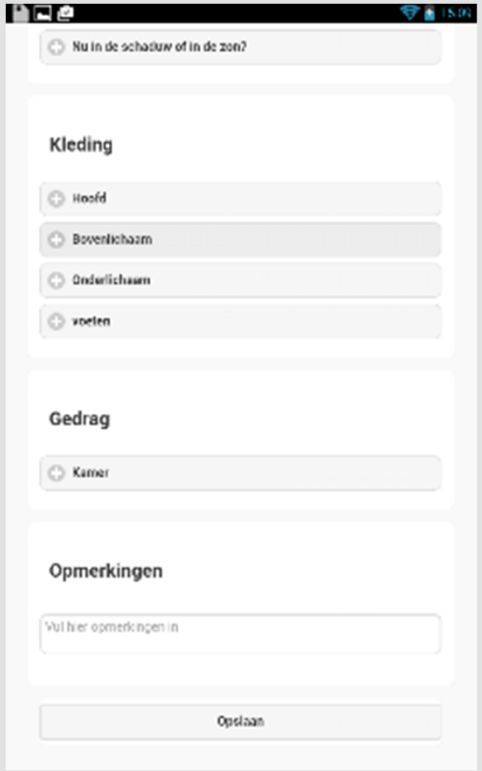
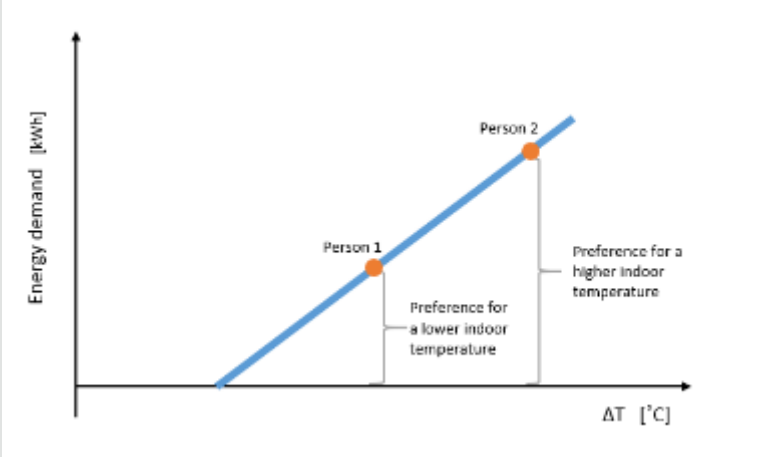
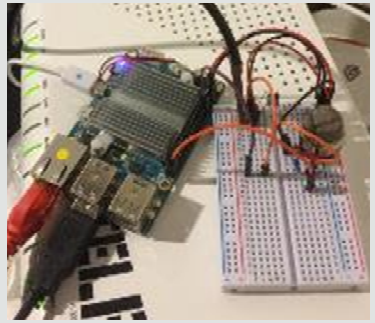
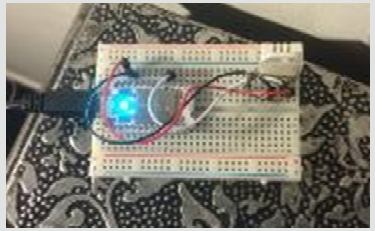
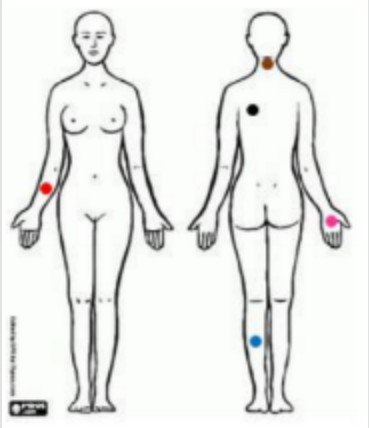


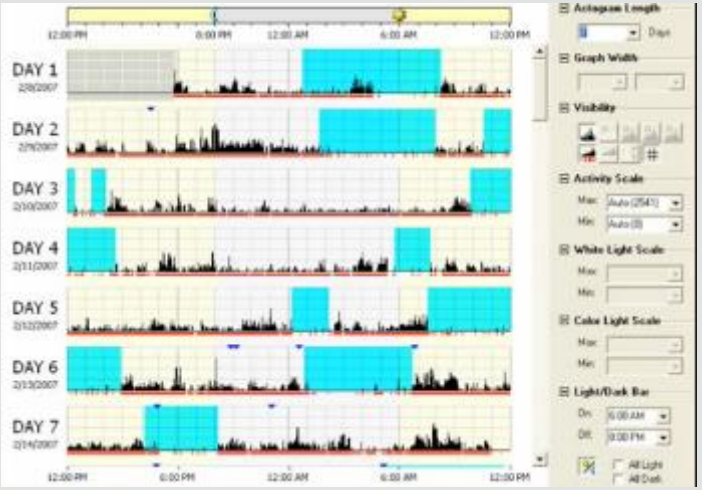


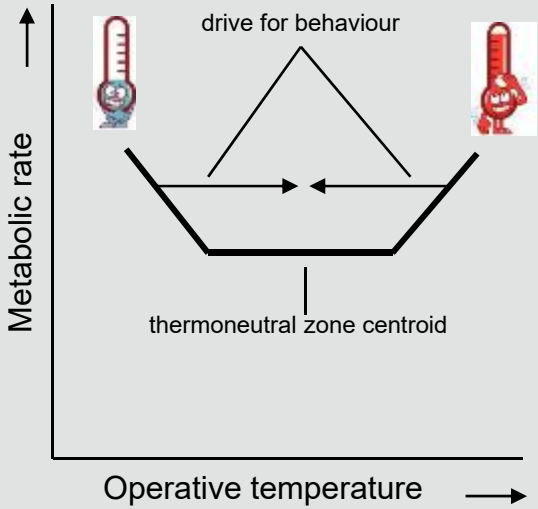


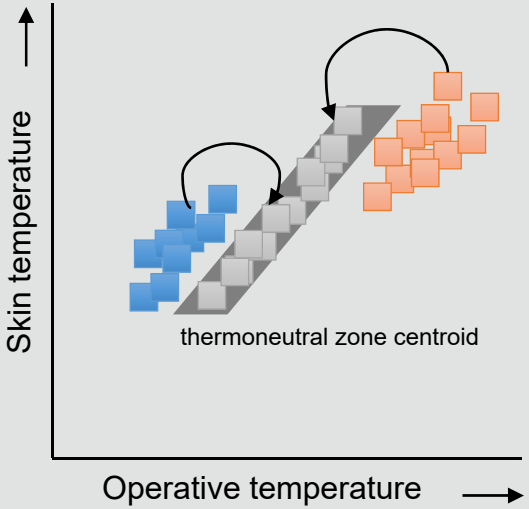


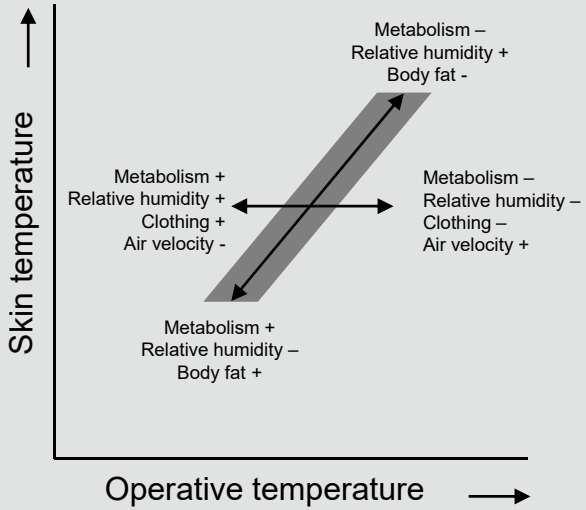


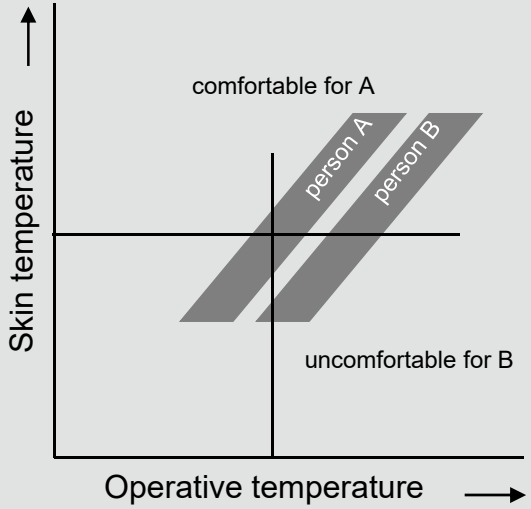


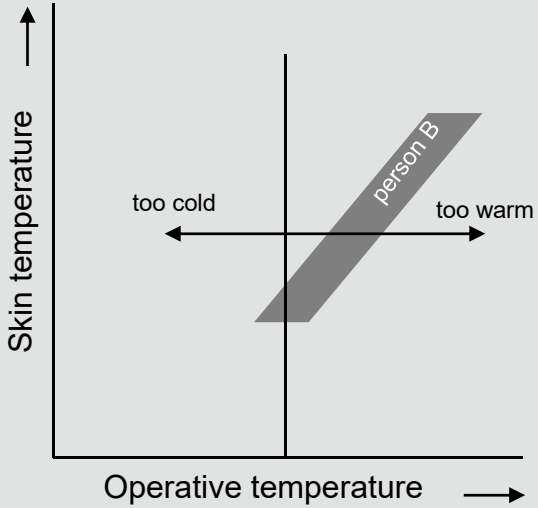


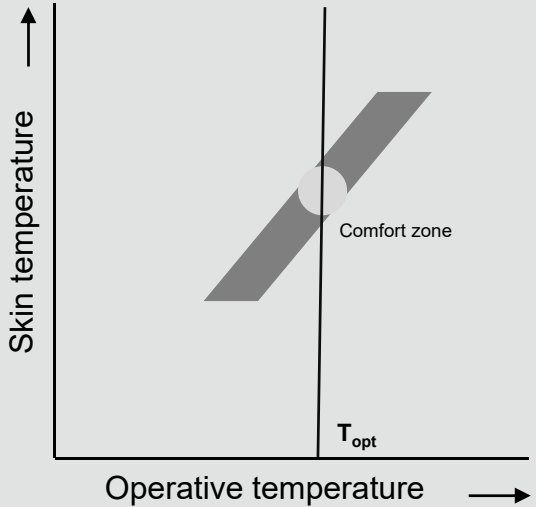

drive for behaviour
Metabolic rate
thermoneutral zone centroid
Operative temperature


Skin temperature
thermoneutral zone centroid
Operative temperature

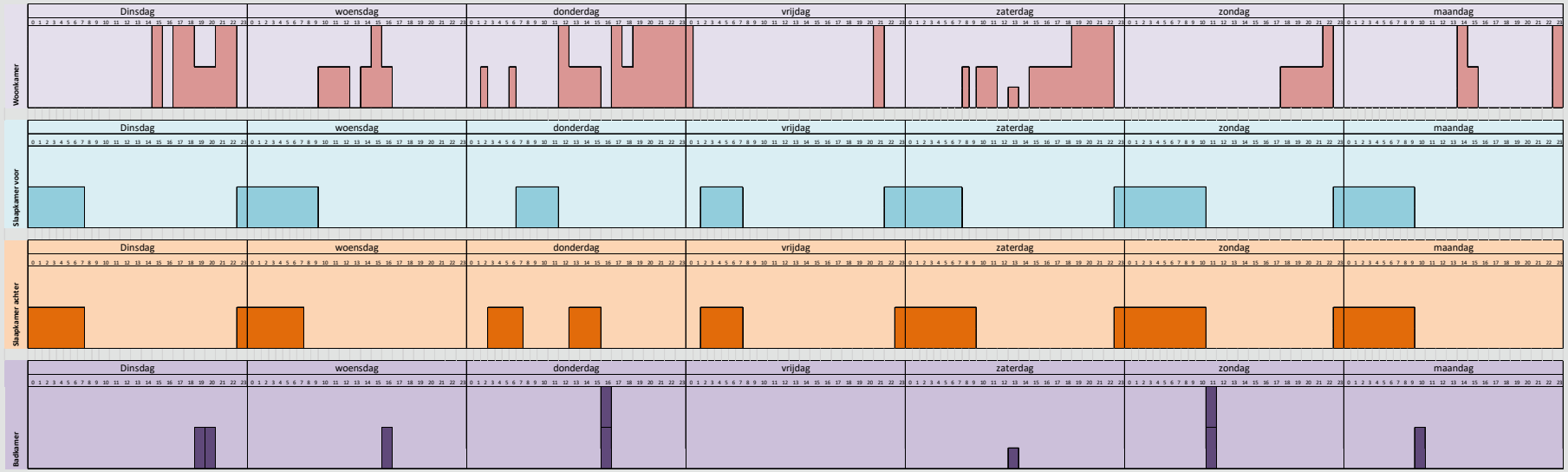

Metabolism –
Relative humidity +
Body fat -
Metabolism +
Relative humidity +
Clothing +
Air velocity -
Metabolism –
Relative humidity –
Clothing –
Air velocity +
Metabolism +
Relative humidity –
Body fat +
Skin temperature
Operative temperature


comfortable for A
person A
person B
uncomfortable for B
Skin temperature
Operative temperature


too cold
too warm
person B
Skin temperature
Operative temperature


Comfort zone
T_{opt}
Skin temperature
Operative temperature

- Analyses on presence of the occupants



Monitoring energy use

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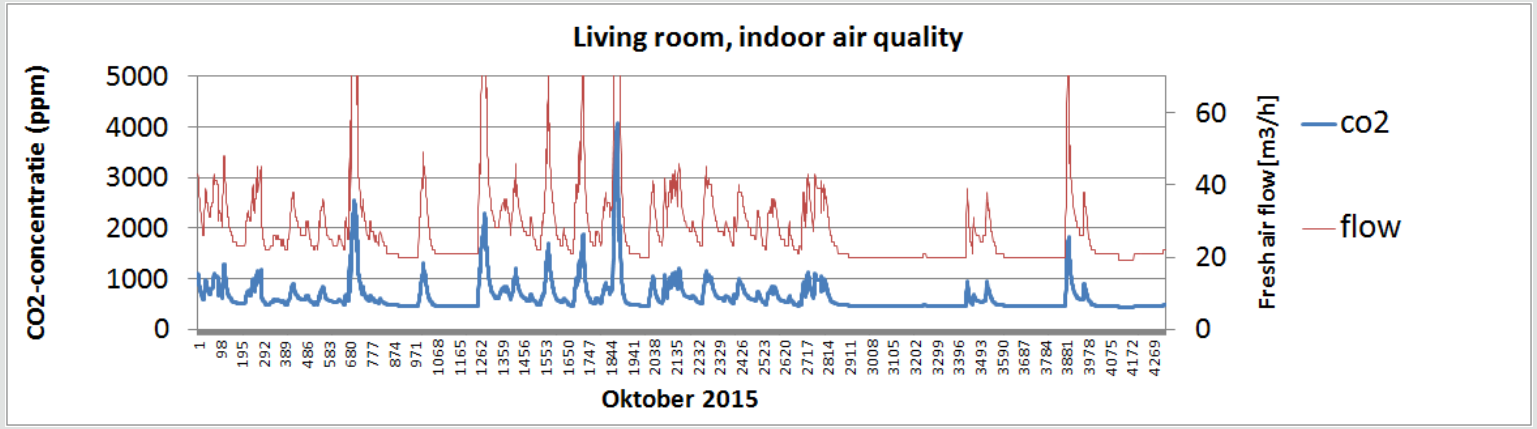
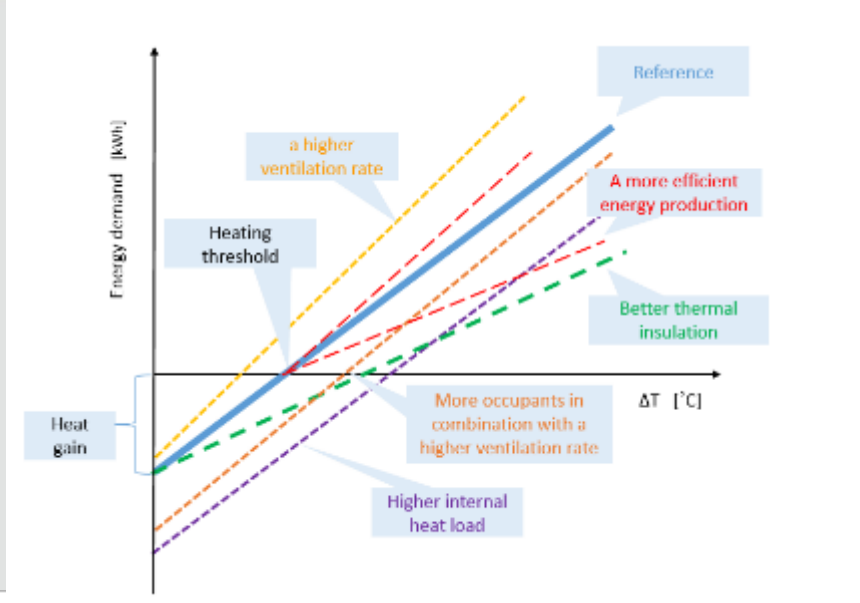
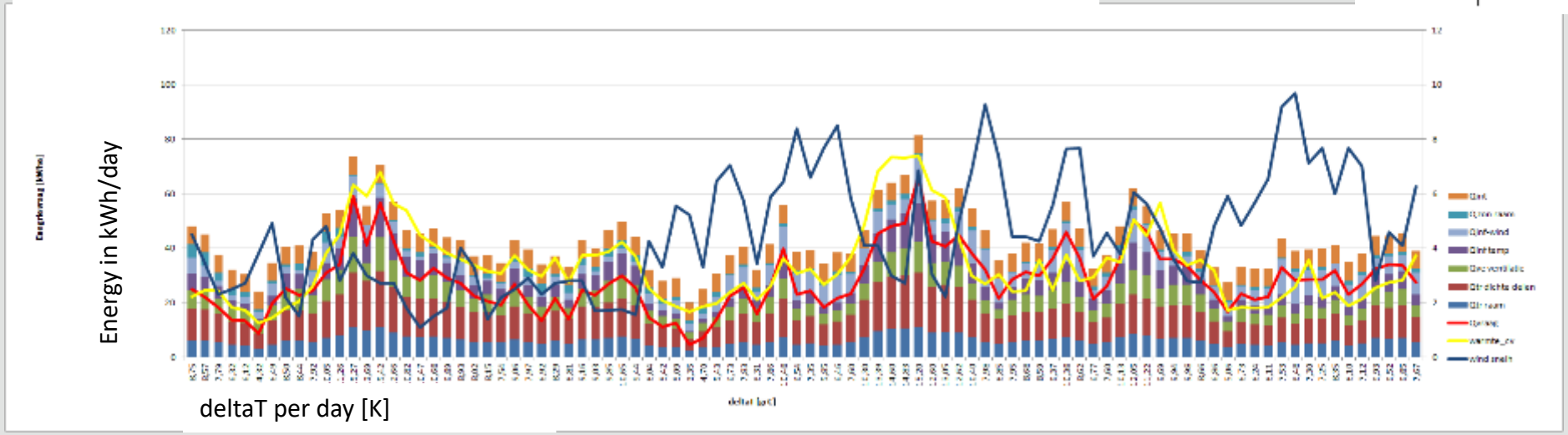




Energy demand – Heat measurement (yellow) and calculation



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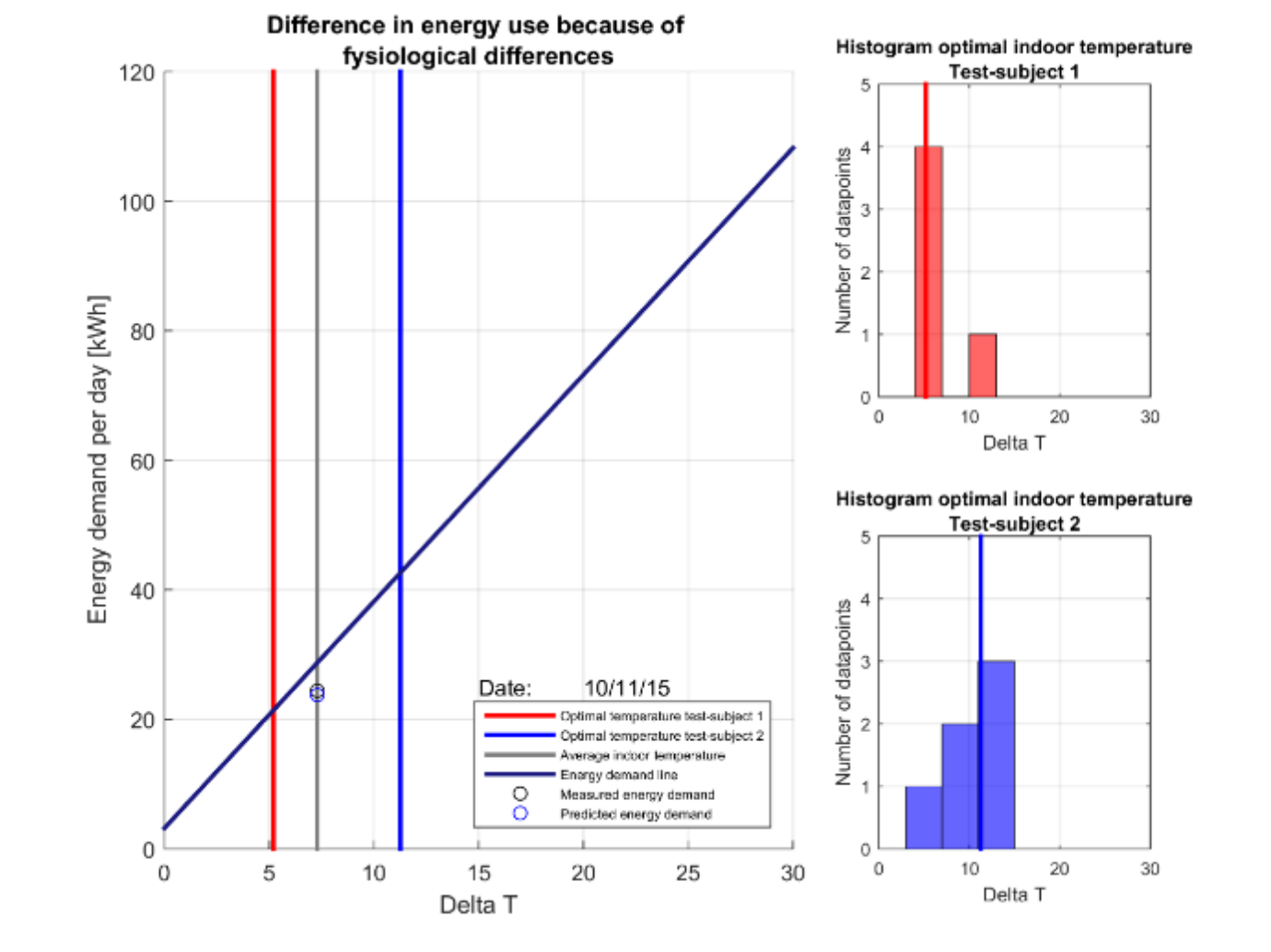

Measured optimal indoor temperature per test-subject per measuring day (red and blue lines)

Date	Test subject 1	Test subject 2
10-nov-2016	19.42 ˚C	25.48 ˚C
11-nov-2016	19.45 ˚C	28.16 ˚C
12-nov-2016	20.20 ˚C	24.73 ˚C
13-nov-2016	20.20 ˚C	24.04 ˚C
14-nov-2016	20.73 ˚C	24.28 ˚C
15-nov-2016	24.61 ˚C	25.69 ˚C
16-nov-2016	18.99 ˚C	25.84 ˚C

Conclusions:

- The thermostat setpoint was always set by the test-subjects as an approximation of the avarage optimal indoor temperatures of both test-subjects (grey line)
- If the test-subjects would act on their own optimal indoor temperature, test-subject 2 would probably use twice as much energy for heating as test-subject 1

Monitoring performances of heat pump

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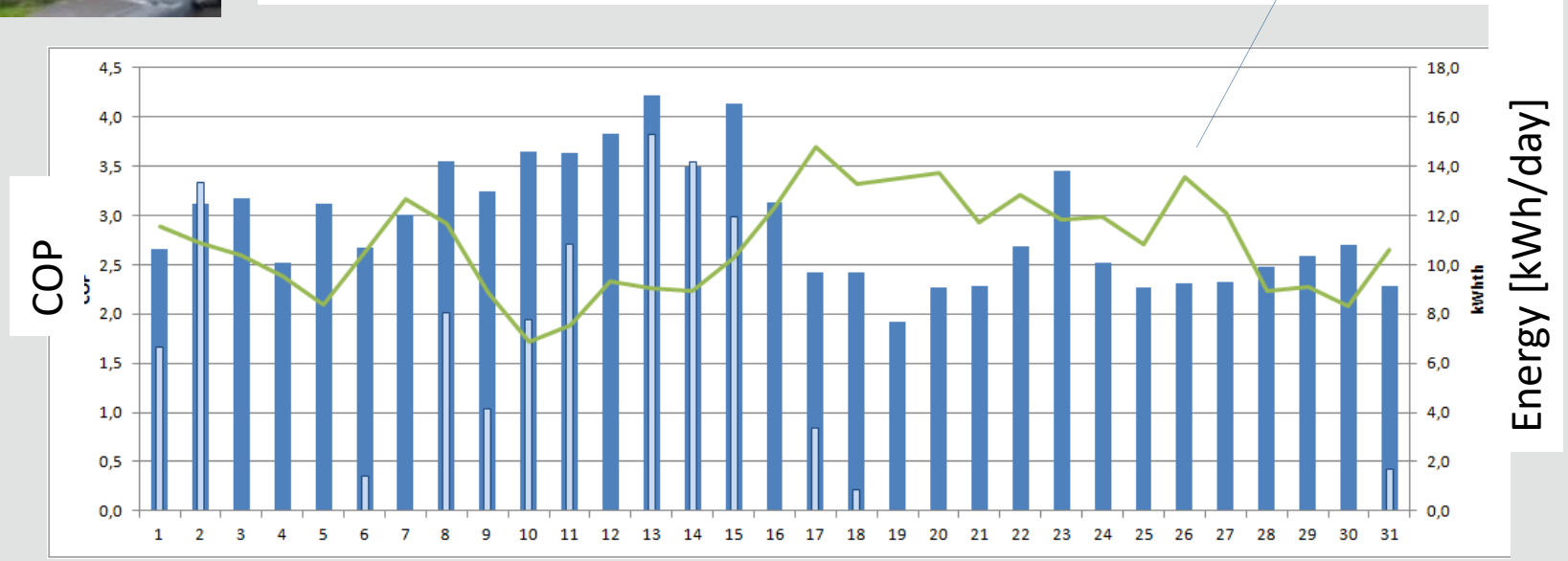
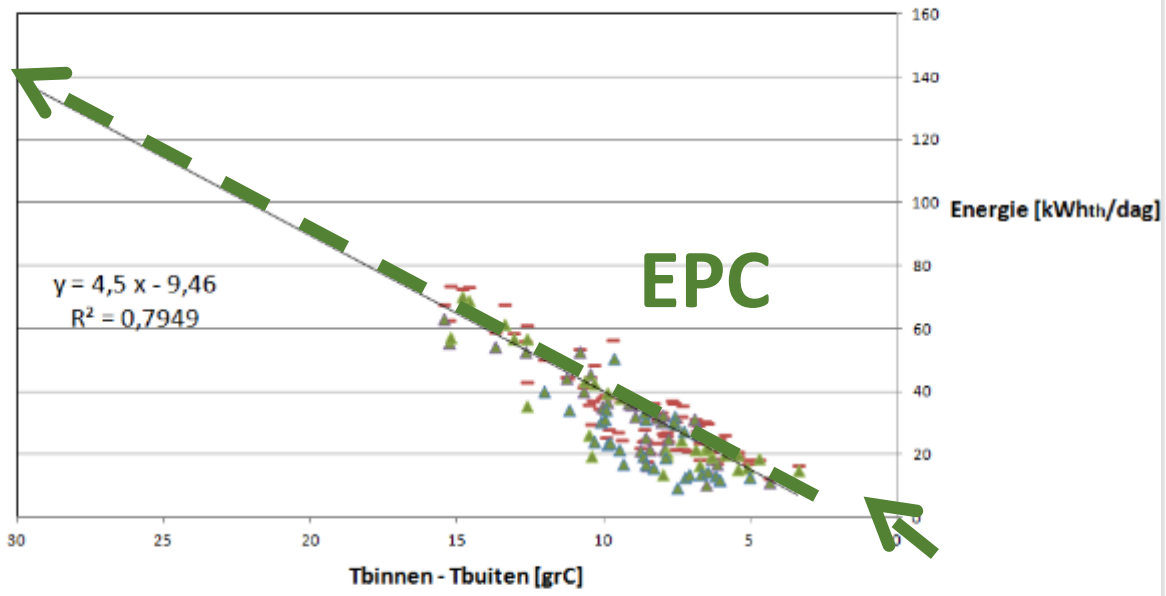
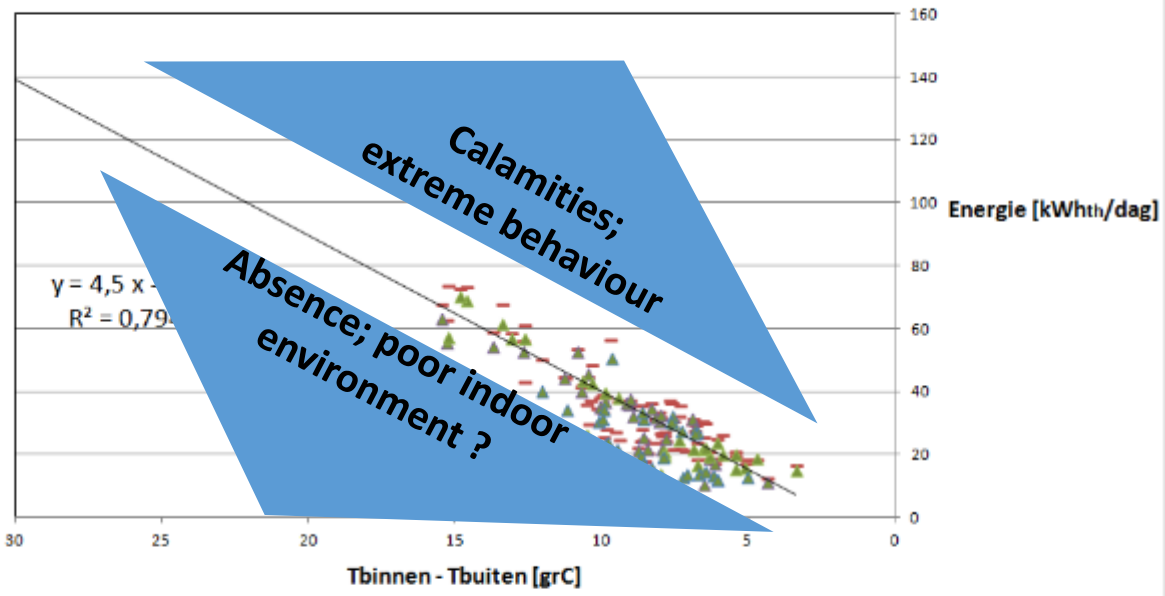
Air-to-water heat pump
(‘*engine*’)

Daily avarage outdoor temperature

COP and energy use for heating and hot tap water



Comparing Predicted and Monitored energy use

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