refomo

Energy-Conscious Utilization of the Meter House Building at the Óbuda Gasworks

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MINUSPLUS
CUSTOM MADE ARCHITECTURE

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contents

01

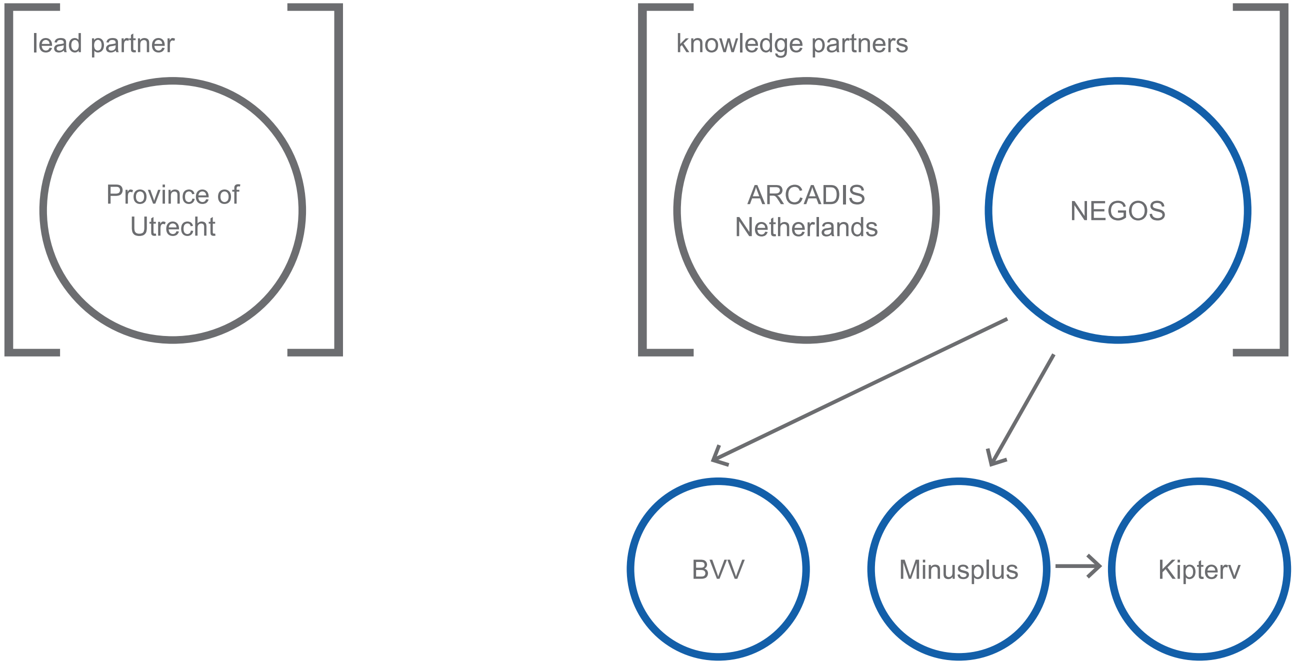
refomo

introduction

reduce footprints of monumental structures, landscapes and buildings[01]

Refomo is an initiative by Climate-KIC02 – one of Europe's largest development partnership – aiming at the sustainable and energy-conscious refurbishment of historic buildings. It's main objective is to reduce the footprint of unique heritage buildings, since their high energy consumptions is not acceptable with today's standards of energy efficiency. Ten percent of EU buildings are officially listed by heritage protection, responsible for significant energy consumption03. Refomo is developing a strategy that can deliver appropriate options and techniques based on unique cases for later refurbishments. The project aims to improve energy performance of historic buildings through practical means, thus achieving a commercially viable use.

EU building stock



organizational structure

04

business partners

Utrecht University - Utrecht Sustainability Institute

UNIBO, CIRI buildings and construction

Utrecht University - Energie, Milieu, Energie-wetenschappen

AIDICO Instituto Tecnológico de la Construcción historic buildings

energy consciousness

innovation

refomo

commercially viable utilization
of heritage buildings

aim and objectives

improvement of energy performance of heritage buildings

through involvement of independent experts

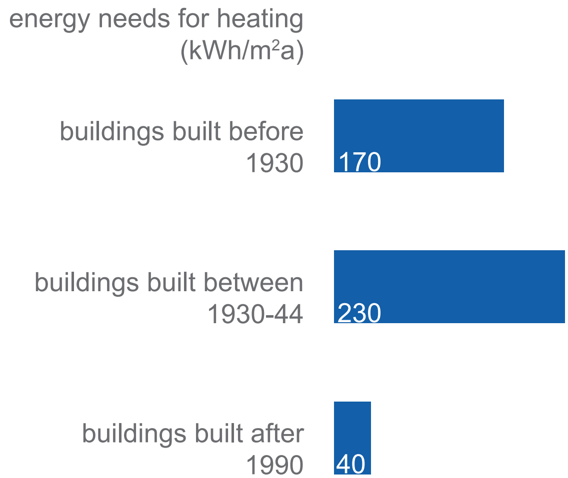
through market analysis

by practical means

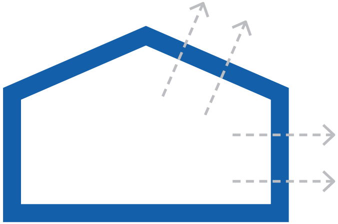
in a standardizable, typifiable way

tools

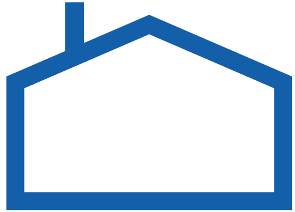
Energy consumption of historic buildings is very high compared to today's up to date ones. Yet EPBD (Energy Performance in Buildings Directive) doesn't apply to them. The creation of custom norms is hindered by the impossibility of making destructive tests on structures of historic buildings. Unique structures of protected historic buildings require special solutions and processes. Further difficulties are raised by outdated structural and building services systems, which have only limited possibilities for renovation, since this would compromise the architectural value of a building.



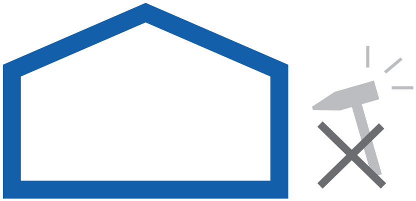
issues



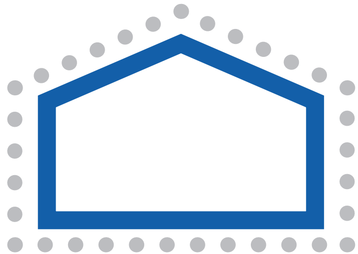
issues of the outer shell



outdated building services systems



outer development not allowed



limited possibilities for intervention

Refomo deals with three European listed heritage buildings, the locations, climate conditions and use of which are different. In the case studies, an optimal condition of energy consciousness and efficiency specified according to the given environment is analized by market actors with regards to economic and environmental aspects. The differendes of the projects (structure, use, location) provides an appropriately wide range for creating complex and innovative solutions. To be able to formulate the requirements for optimal energy conscious operation in the case studies, it is also important to know the final use. By evaluating preliminary examinations and case studies, ideal solutions and tools for heritage buildings can be determined.

three case studies

fortress[05]

Fort de Gagel és Fort aan de Klop
Utrecht, The Netherlands

built in 1819
climate: mild maritime
use: lodging, hospitality units

university[06]

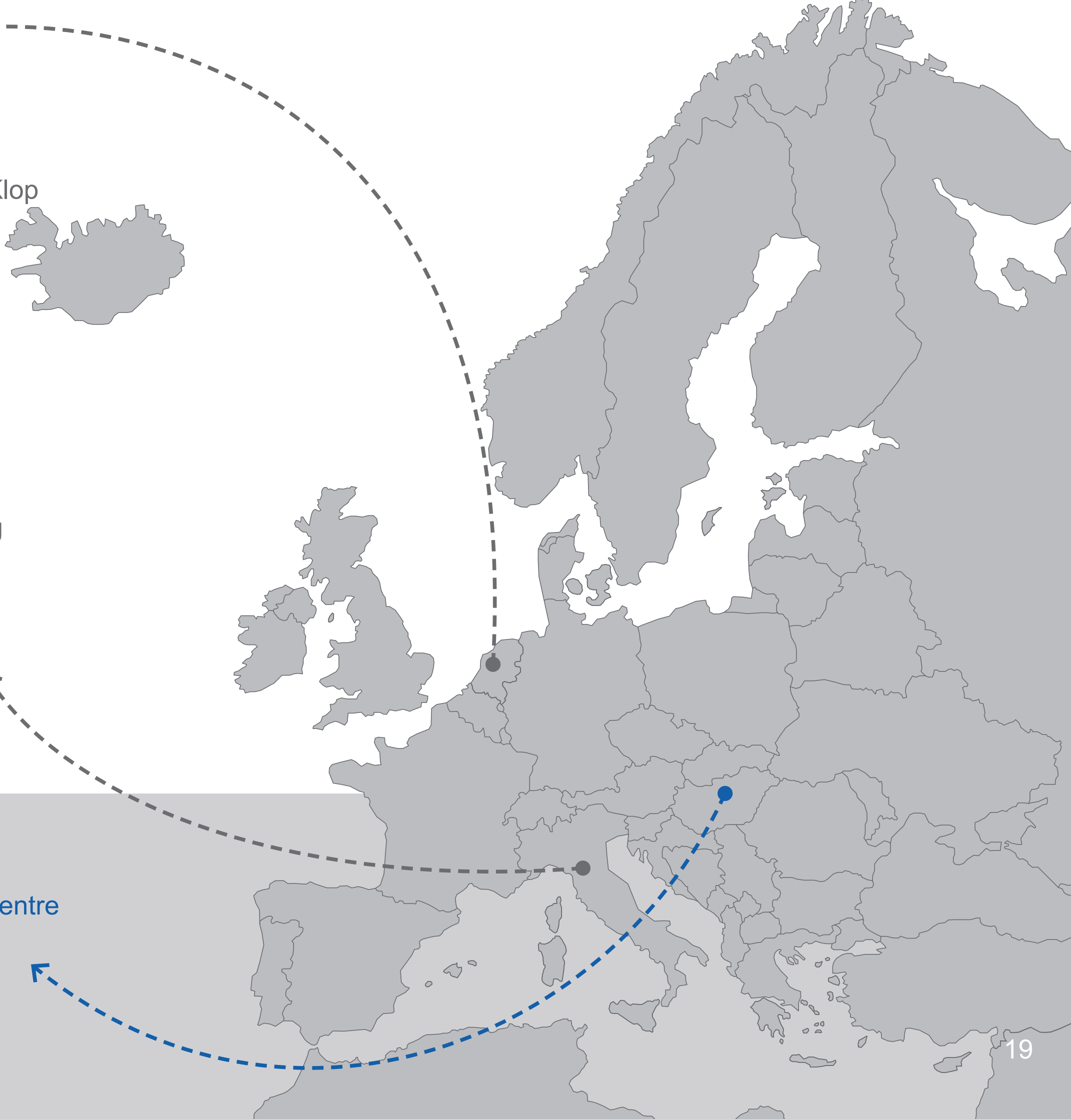
Faculty of Engineering Building
Bologna, Italy

built in 1931-35
climate: mediterranean
use: university, offices

industrial hall

Óbuda Gasworks Innovation Centre
Budapest, Hungary

built in 1910-13
climae: continental
use: cultural centre

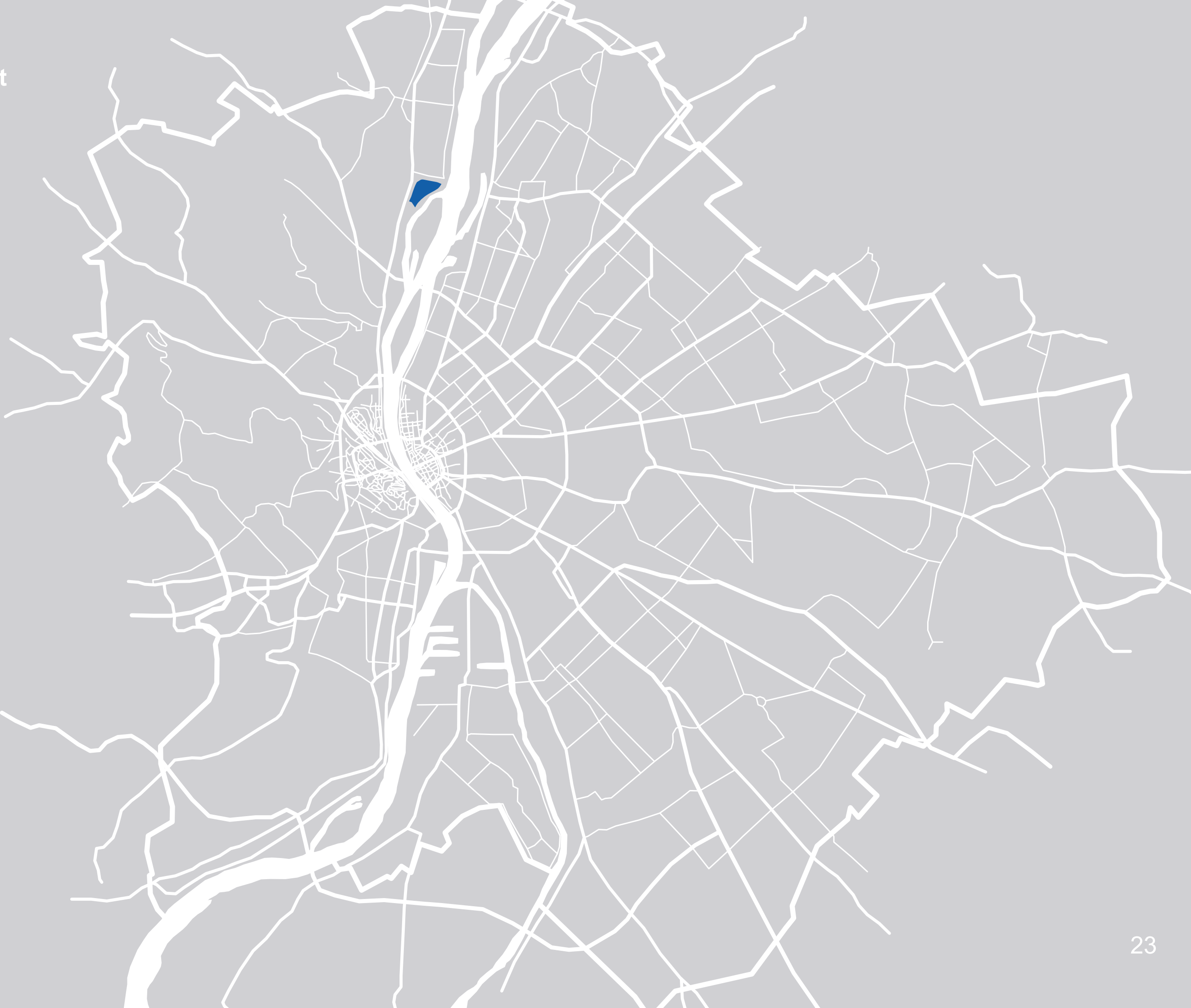


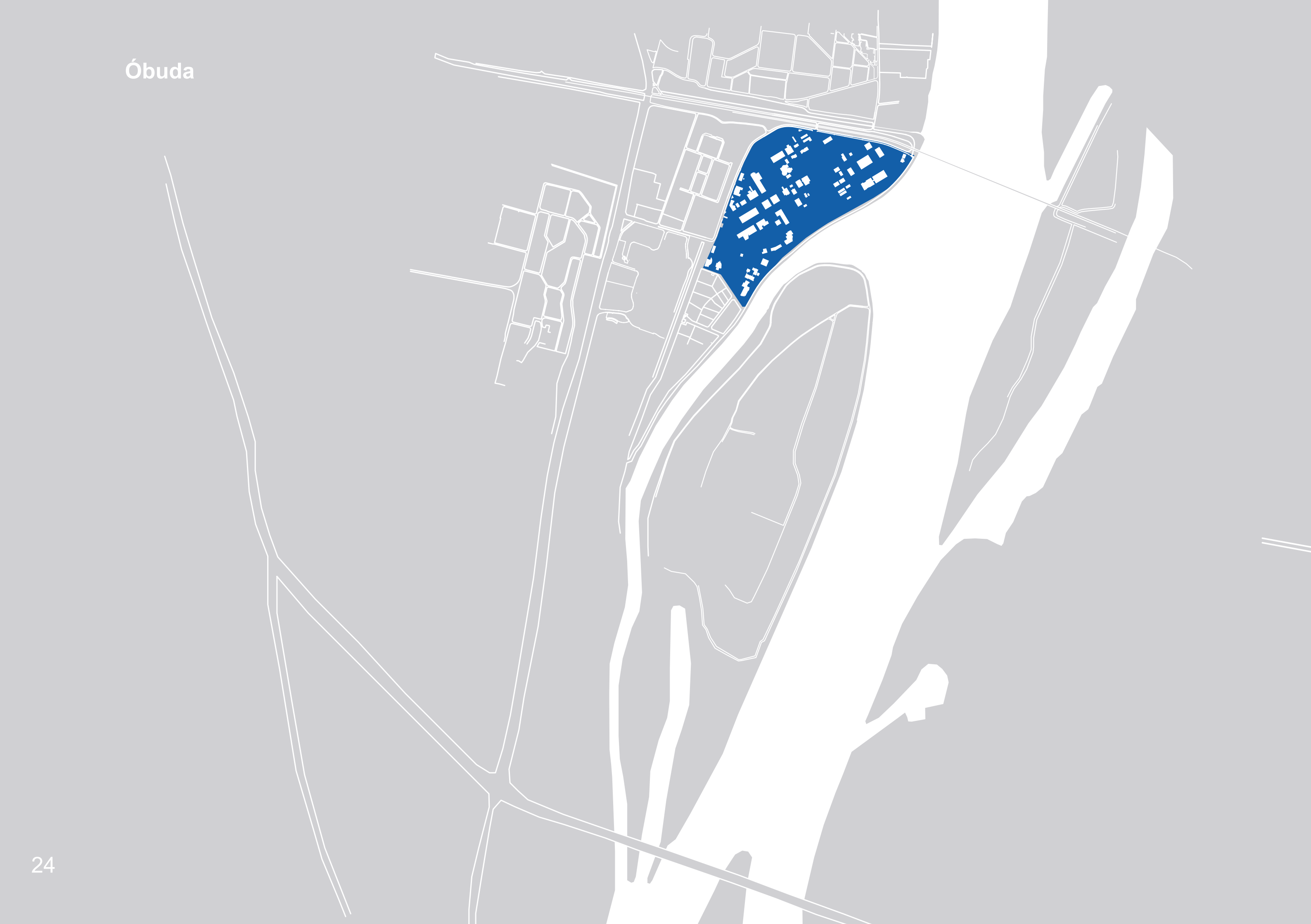
02

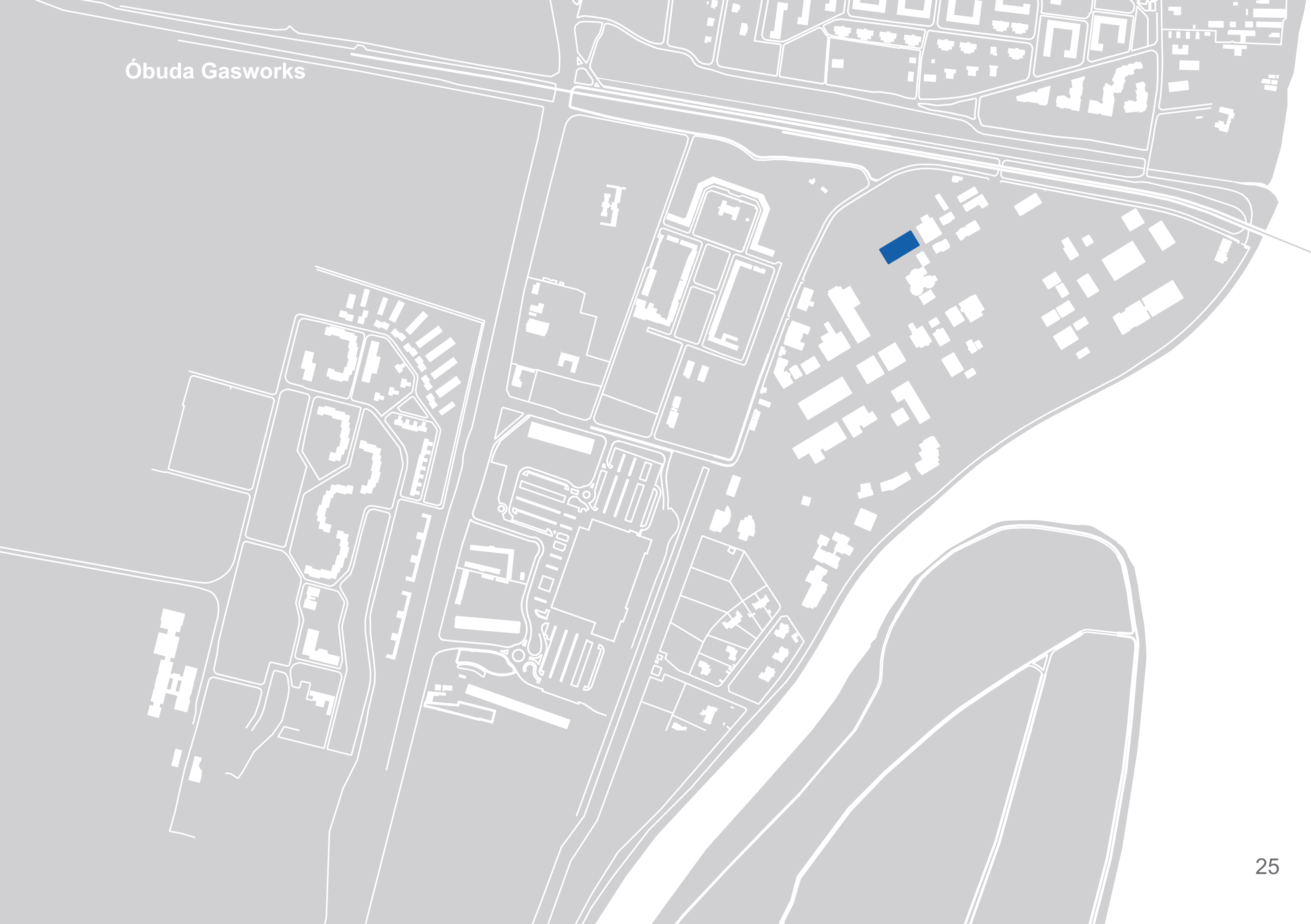
gasworks

location 07

Budapest




Óbuda


Óbuda Gasworks

1900
planning

Due to the ever growing household gas consumption, establishing a new plant capable of supplying the capital with gas instead of several smaller coal gasworks had become necessary by the early 1900s. As for the choice of its location, the availability of road and railway transport was important, as well as the possibility to connect it to the waterway, furthermore, sufficient space for service and storage buildings. These requirements were fulfilled by the site at Homokosdűlő in the 3rd district.

1908
international tender

1910
construction

The plans for the plant were made by Zürich gas-plant owner Albert Weiss with Izidor Bernauer and Győző Schön, with Ferenc Heltai as contractor. Construction works started in 1910, the first test operation was carried out on 16 December 1913. The older plants in Józsefváros and Buda were shut down.

1914
opening

On 15 June the whole gas supply of the capital had been taken over by the Óbuda plant, one of the most advanced factories of the continent at that time.

1917
breakdown

Gas consumption has drastically grown during 1916, reaching a peak in gas output in 1917, due to difficulties coming from coal shortage that started the same year and caused partial breakdown lasting for several days.

history

1920
return to normal operation

By the 1920s coal procurement had returned to normal, but gas consumption was stagnating.

1925-27
gas propaganda[08]

As a result of gas propaganda and the lease of certain gas consumers, income from lease fees had doubled by 1925-1927.

1940-42
peak

By 1940, the gas plant had reached the maximum of its capacity, so developments were initiated. However, it reached its production limits again by 1942, but further developments were stopped by World War II.

1945
air raid
flood
Margit-Bridge blown up

Gas production was suspended because of the severe damages done by natural disasters and war during 1944-45. By the end of March 1945, gas production had returned to continuous operation. War damages were repaired by 1947.

1950
extension

To increase performance, furnace groups were constantly being extended and transformed between 1949 and 1955. Despite the continuous reshapings, the plant could hardly meet the changing demands by the end of the 1950s.

1960
natural gas

In accordance with the changeover to natural gas, processing plants were built, with the aim of further increasing the capacity.

1963
Albertfalva Gasworks

Due to ever growing gas demand, shortage had been a constant issue. This is why a new facility, the Albertfalva Gas Plant had been built in 1963.

1980
decline

Deterioration of the furnaces was causing severe problems, equipment was being torn down constantly.
At the gas plant, town gas had been produced from coal until the ’80s, when the natural gas pipeline connecting Budapest and the Zala oil fields was completed, thus they switched to natural gas.

1984
closer

On 15 October 1984, coal based gas production ceased at the Óbuda Gas Plant.

1985
after shutdown

After the shutdown, the Gas Company was conducting only administrational activities on the premises.

1987
demolition

On 6 April 1987 the Óbuda Gasworks was shut down definitively. After ending the coal based gas production, the demolition of the worn production equipment was started.

1994
listed historic monument

Upon heritage listing (M II 15241) by the National Office for Cultural Heritage, the Gasworks Housing Estate designed in accordance with the coherent spatial and architectural profile of Sujtás Street gained protected status. With a decree issued by the Budapest City Council, the directorial complex received local protection status in February 1994.

1998
Graphisoft Park[09]

Software developer Graphisoft initiated the real estate development project of the southern part of the territory in 1998, resulting in office buildings being built. The new layout was successfully adapted to the existing monuments, that were renovated and transformed to accomodate new use.

2004
listed historic monument

The site of the gas plant becomes property of the capital.

2007
AIT[10]

The Aquincum Technology Institute is established.

2009
environmental remediation[11]

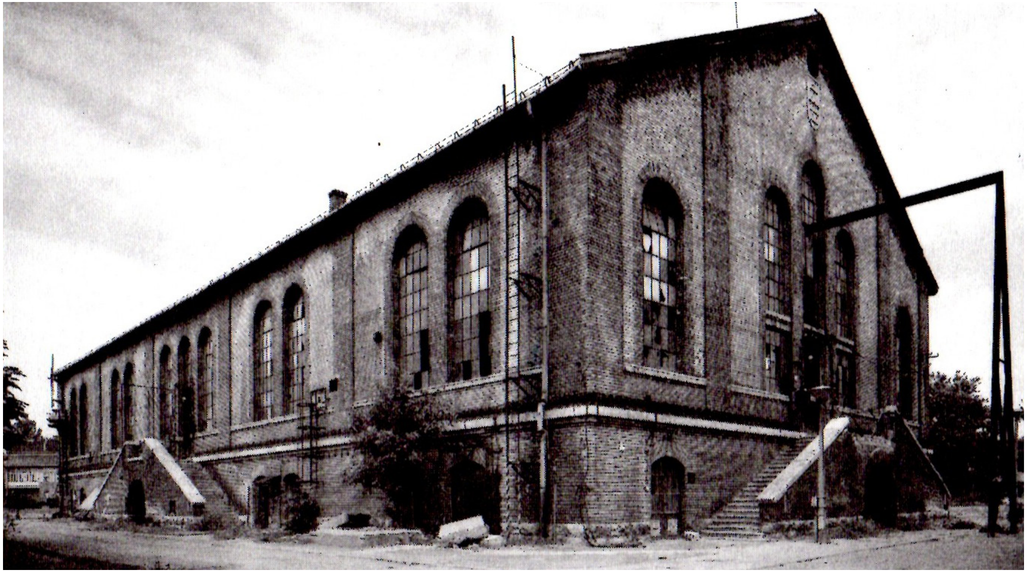
Removing hazardous waste from the gas container foundations was the first important step in the process of cleaning the territory.

2013
refurbishment

Refurbishment of the water and tar towers begins, since their strongly dilapidated condition made it necessary even without utilization. The project started in the spring of 2013 and is expected to last for one year.

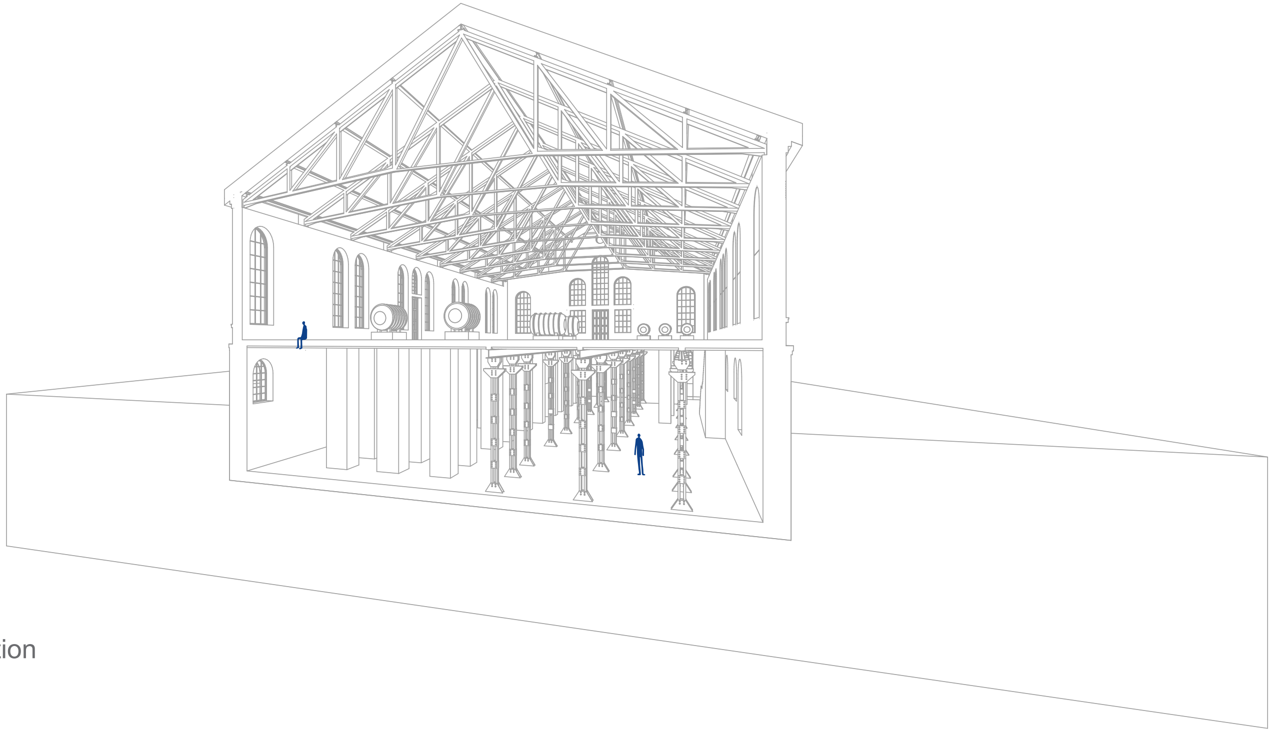
Right from its opening in 1914, the Óbuda Gasworks has almost been like a settlement on its own, with a proprietary railway network, a railway station and public services infrastructure, and also different services were provided (restaurant, housing estate, police station). The layout plan was determined by the Danube and the position of the railroad, designs were made by Zürich gas plant owner Albert Weiss. Since non-production buildings had to be designed strictly by Hungarian architects, concepts by Weiss were totally disregarded when designing the housing estate, so the design is the work of architect Kálmán Reichl. In the designs made by Weiss, buildings could be ordered into two groups according to their appearence. Industrial buildings were made with timber-framing-style walls reinforced with steel girts, while more demanding buildings (directorial building, welfare buildings, housing estate) were carrying historicizing marks. There were less adorned buildings with brickwork cladding, like the Meter House, that represented a transition between the two categories. The visual center of the territory is the emblematic group of containers. Its most remarkable member is the water tower, made up of an upward narrowing body standing in front of the bulkier tar towers arranged into a triangle, and a mace-wise expanding cylindrical head clad with bicolour bricks topped by a lantern roof. Together with the tar towers of a similar architecture, its characteristic silhouette rises above the average height buildings of the plant.

architectural design



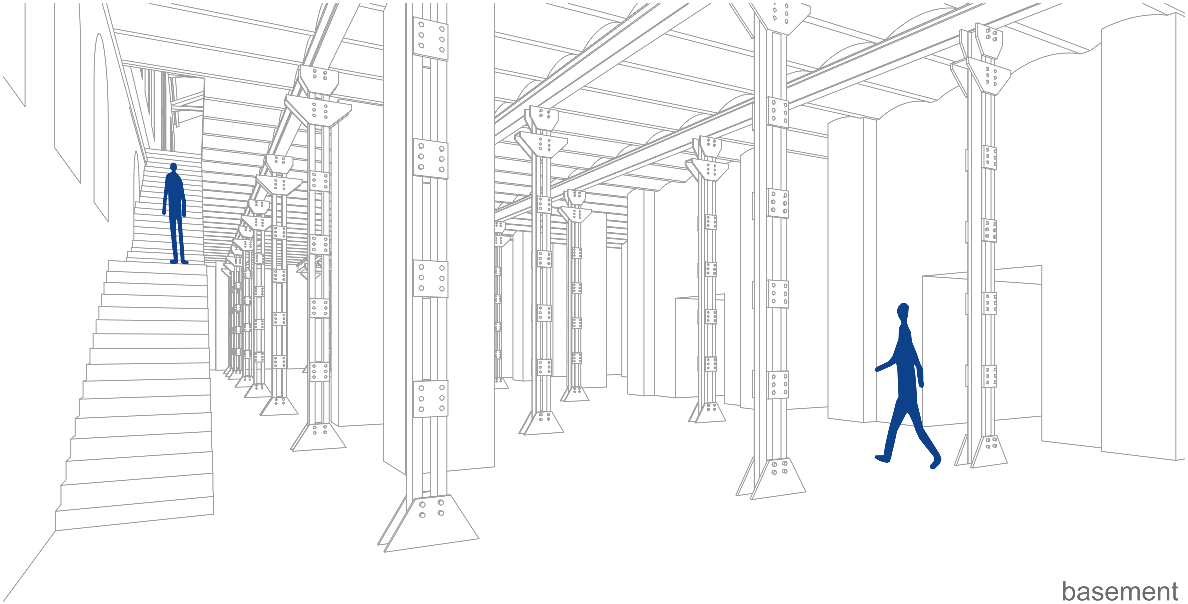
Meter house[12]

The Meter House got its name after the Elster-type industrial gasometers inside it, used for measuring different gases. Today, it is one of the most valuable buildings of the factory complex in terms of heritage aspects. It has a symmetrical, long rectangular floor plan, a dual-pitched roof and is clad with red and yellow brickwork. Its ground floor is elevated by half a storey, with V-shaped stairs leading to it from three sides. The facades are divided into sections by lesenes with groups of two or three slender, vaulted windows between them. The ground floor's interior constitutes a continuous space together with the open steel roof structure, it also used to serve as a ceremony hall for the factory. The basement is 6 metres high, covered with surbased vaults.



section

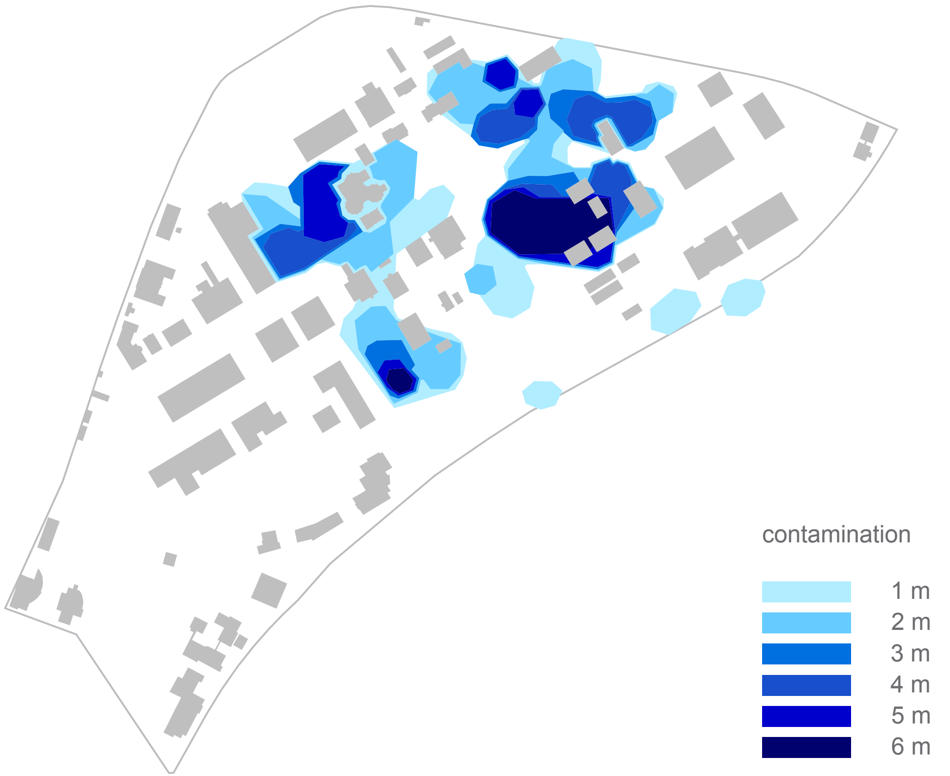
existing condition



basement

The purification of gases produced unrecycled waste that was first handled and stored improperly. Then, after it had been declared hazardous waste in 1982, the MGP waste was put into two in-situ concrete containers. All that wasn't moved into the containers, remained in the ground and ground water. Ever since the building of the plant, the disadvantage resulting from the choice of location persists, that is, smoke/air is carried towards the city centre due to prevailing wind direction. Besides purifier waste, several types of hydrocarbon derivatives were deposited on the territory, plagueing the environment with an unpleasant smell. Excavations and laboratory test results showed that there was MGP, communal and other hazardous waste buried in several spots at the site of the gas plant. The extent of contamination showed an even higher level than before, thus it became clear that the expected washing-cleaning effect of the Danube didn't happen.

extent of contamination


contamination
1 m
2 m
3 m
4 m
5 m
6 m

03

design

Szentendrei way

Népsziget Island

Meter House

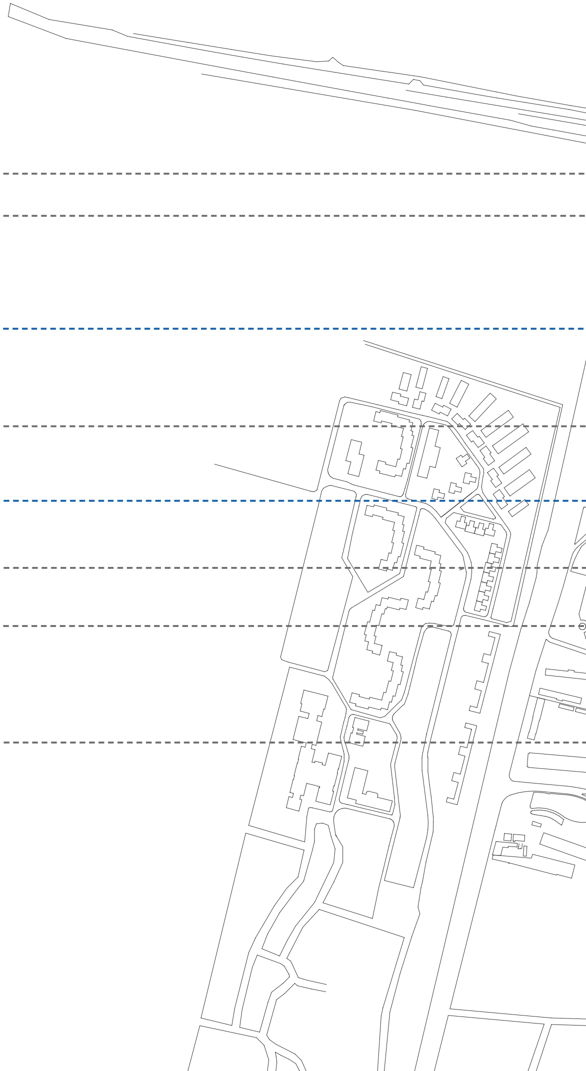
Újpest Railway Bridge

territory of the former Óbuda Gasworks

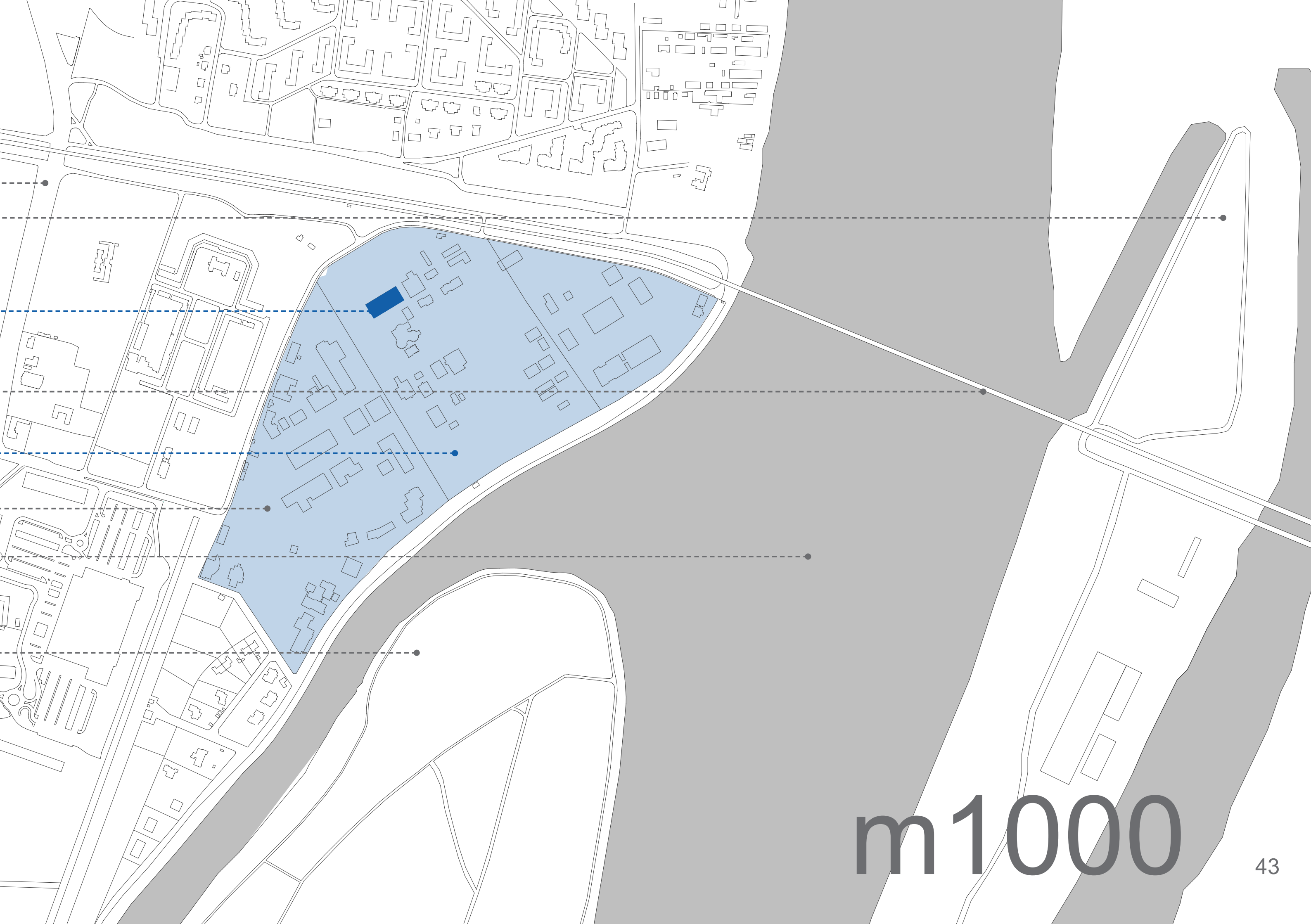
Graphisoft Park

Danube

Óbudai Island



site plan


m1000

weaknesses

listed historic building

hard to reach by public transport

the cleanup of the site is not complete yet

strong presence of Graphisoft Park

missing public services network

strenghts

listed historic building

situated in the close vicinity of the Danube riverbank

renovated iconic water and tar towers

dinamically developing area[13]

low building area percentage

threats

listed historic building

the site remaining isolated

contamination[14]

not attractive enough on its own

opportunities

listed historic building

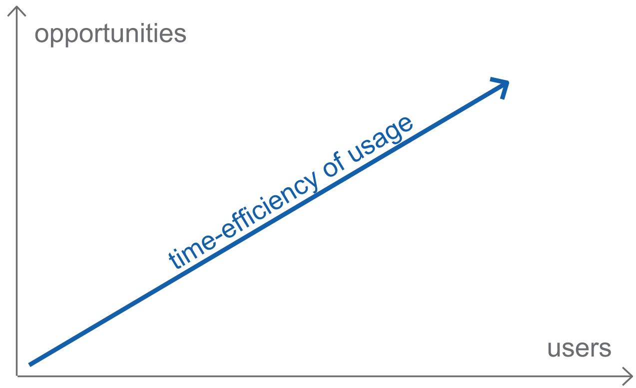
creation of a new cultural-social ground

long-term guidence

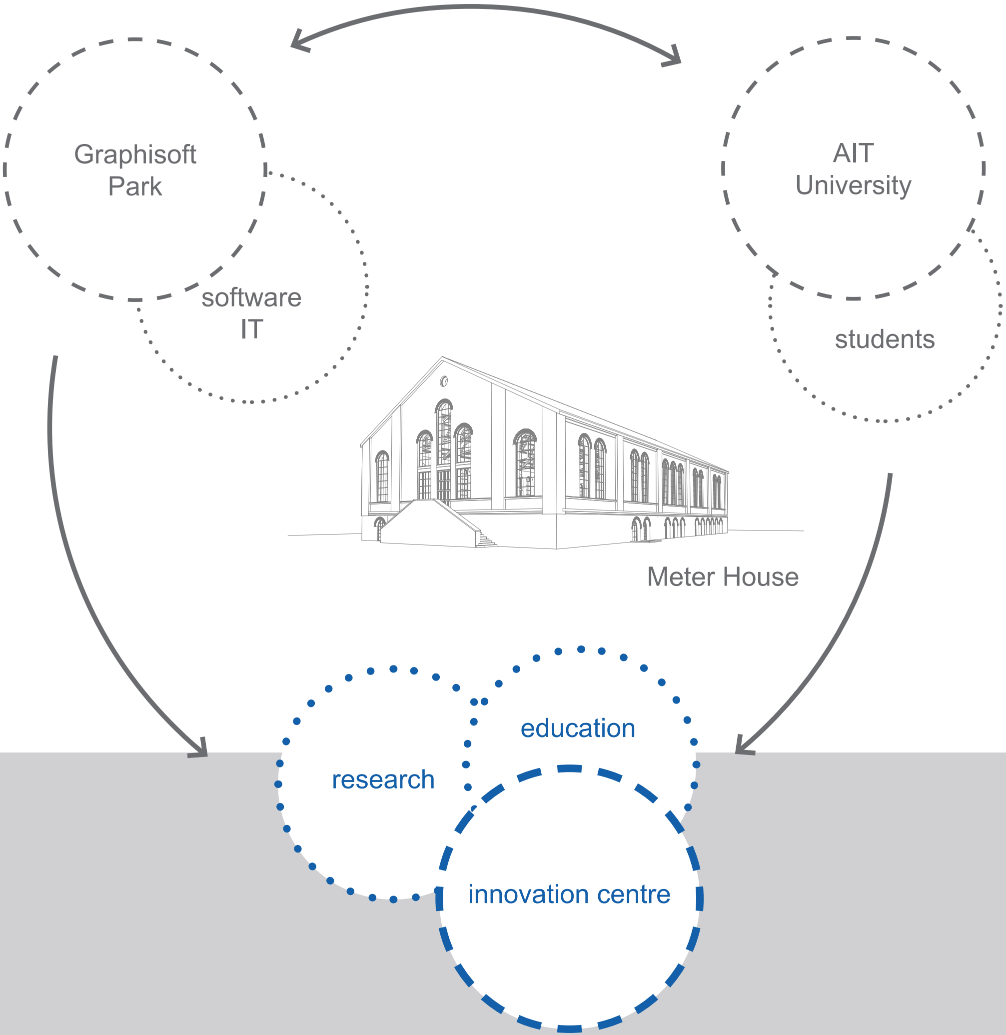
brownfield site in the city

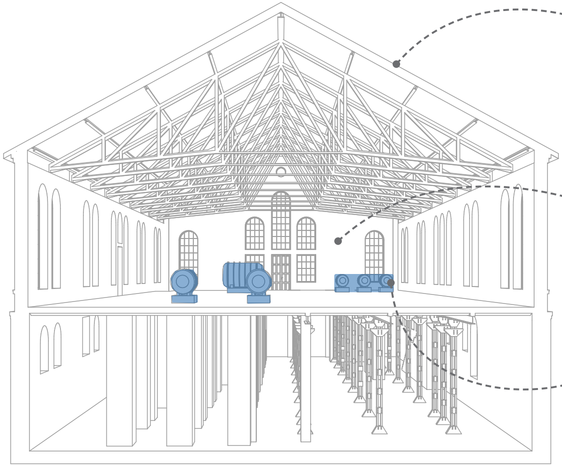
constant renewal

With the remodeling of the Meter House, the IT and educational background of Graphisoft Park was a primary aspect. In relation to this, we created a multi-functional interior that could be used both by the software developing company and students of the IT-university located at the site, thus bringing together different functions of the park in the building of the Meter House. Inside the building, there are research opportunities available for students, which, in cooperation with Graphisoft Park, can provide a self-generating exhibition program. Through this form of utilization, the building will be accessible to a wider audience and its operation will also become more time-efficient.

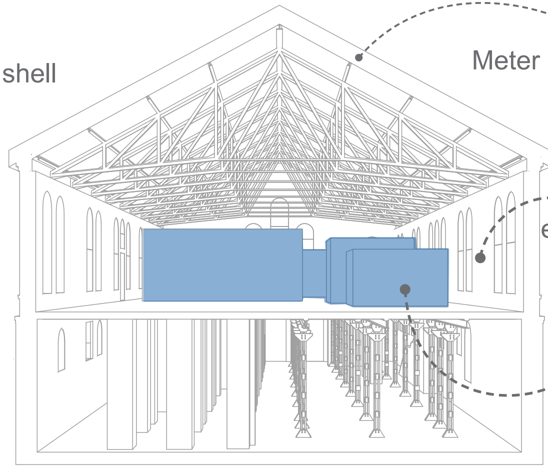


search for possible uses


Graphisoft
Park
software
IT
AIT
University
students
Meter House
research
education
innovation centre



in the past



today

concept

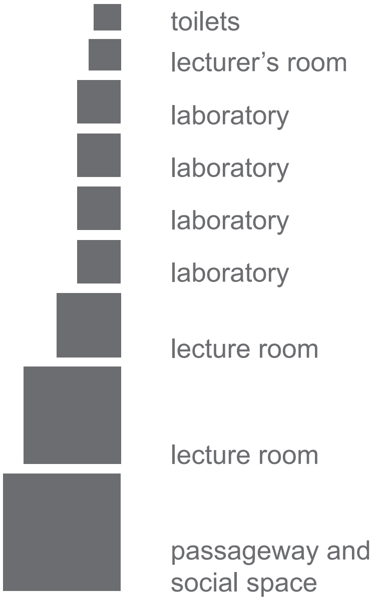
outside

The Meter House is standing behind the tar towers, in a subordinate position, so its approach route and the marking of the entrance got a strong emphasis.

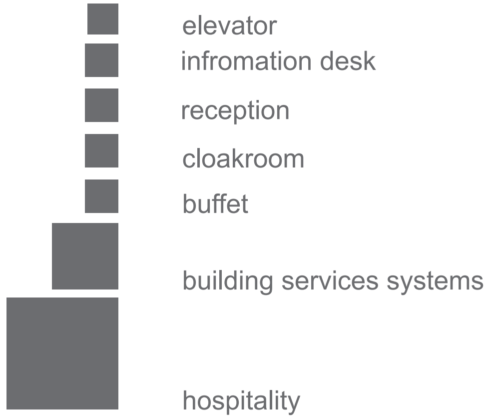
inside

The hall-like form of the Meter House was made for gasometers standing free in space. The new concept adopts the same principle by placing smaller elements into the large contiguous room. This box-in-the-box principle can handle well the multi-use design, and provides favourable conditions in terms of energy consumption.

university
535 m^2



rooms of shared use
305 m^2



program 15

exhibition space
1440 m²

toilets

passageway

exhibition space

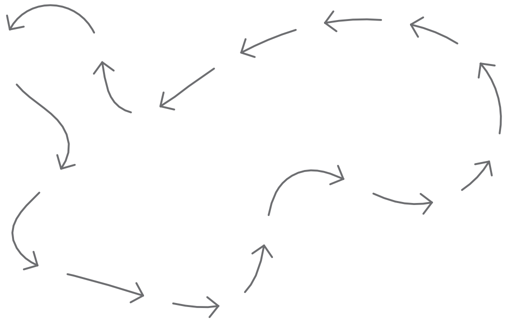
exhibition space

There are research and lecture rooms inside the Meter House serving the AIT university located on the site of the plant. These are served by a lecturer’s room and a toilet on the ground floor.

In the basement, there is a restaurant unit serving both Graphisoft Park, the university and visitors. A shared building services systems room is supplying both functions.

The space surrounding the boxes serves as an exhibition space, with all the necessary servicing functions: wardrobe, information desk, reception.

exhibition space
directed sequence of spaces

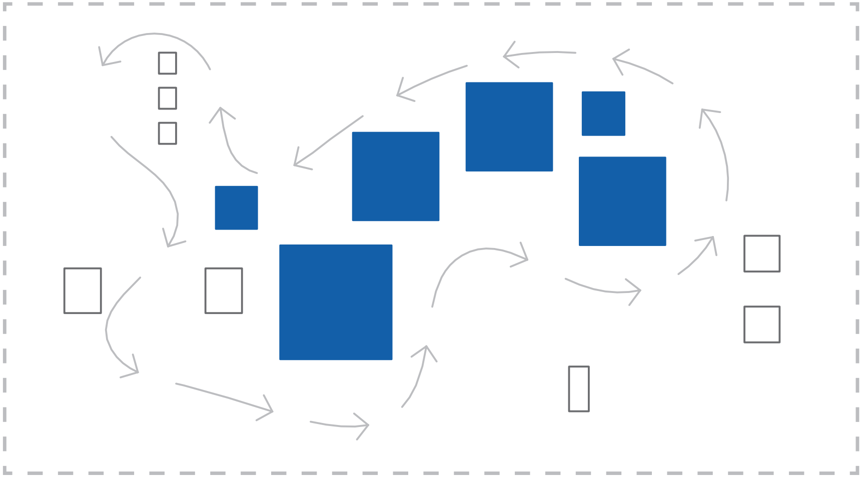


education
smaller units

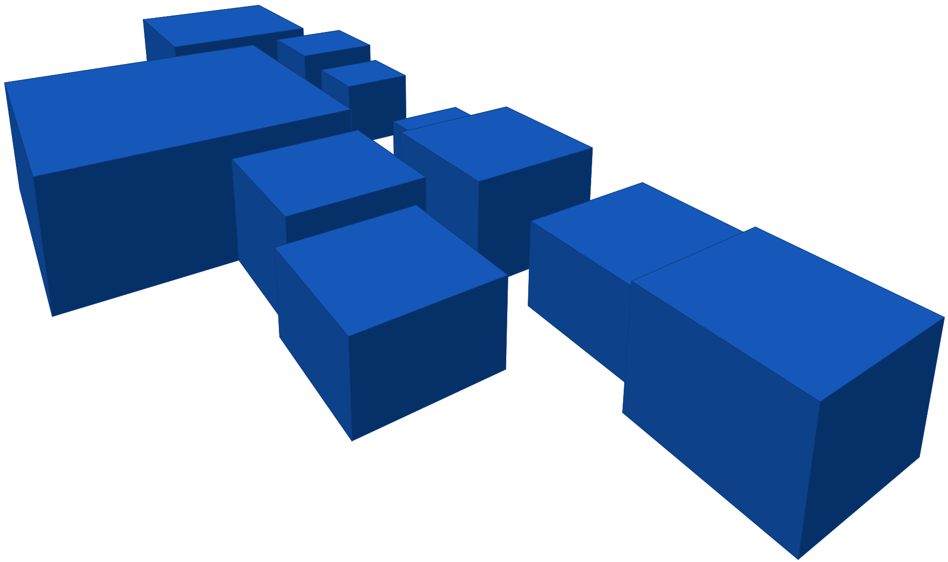
existing industrial equipment
smaller units

During the stages of concept-making we considered the aspects of an ideal layout for museums and universities, as well as the existing industrial equipment on the ground floor. The university rooms were put into floating boxes between the existing industrial equipment, the remaining space between them becoming available for exhibits.

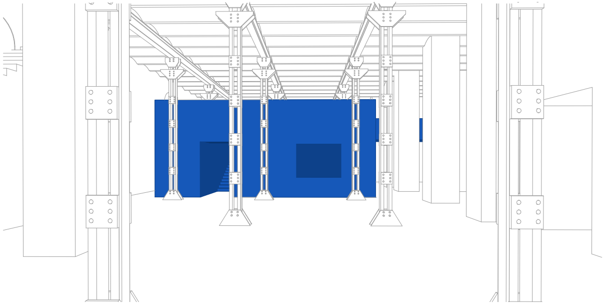
uses



concept

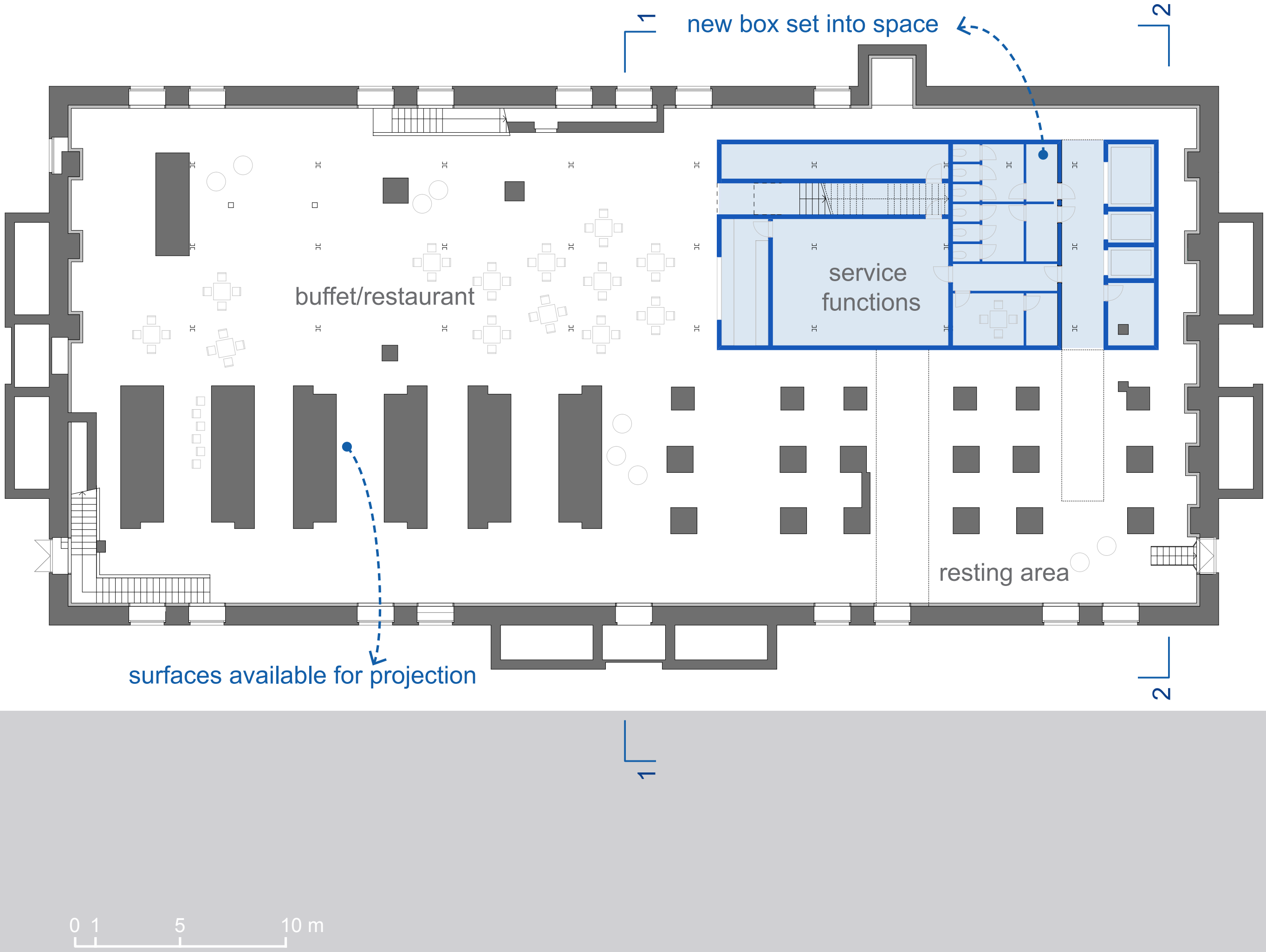


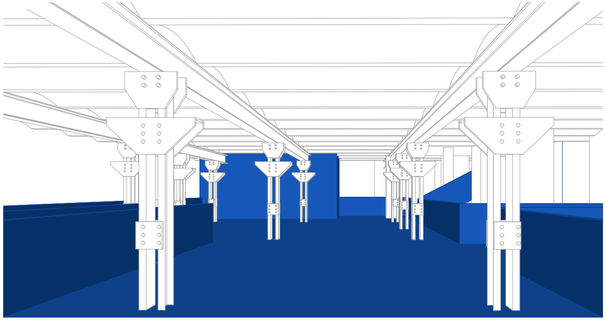
design



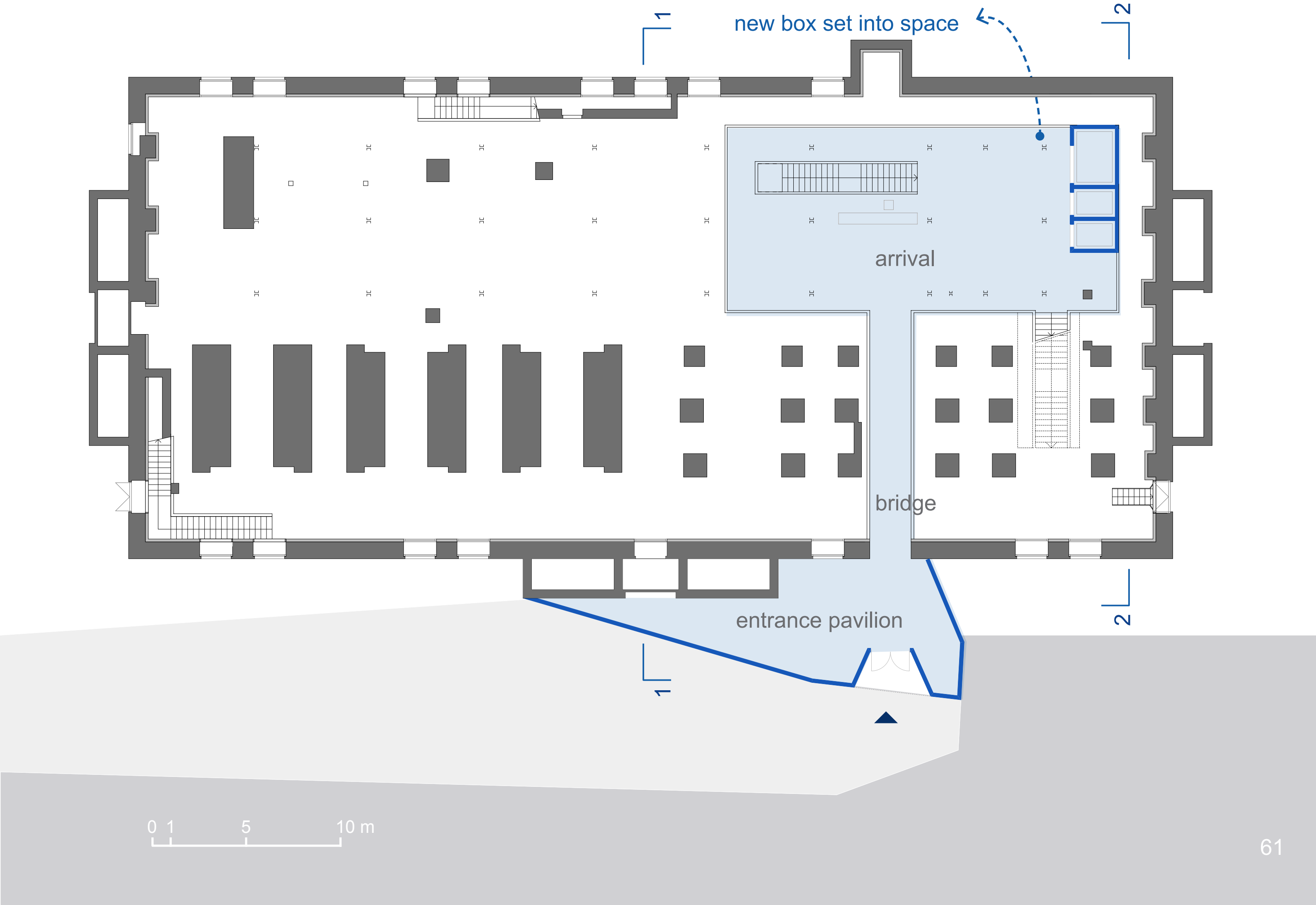
At basement level, a free-standing box is added as a new element, containing all service units. Existing structures in the basement are suitable for projections, as well as for dividing the space into smaller sections. The buffet/restaurant can settle with its tables to the area by the box. The exhibition space on ground level can be approached on the existing stairs.

-1

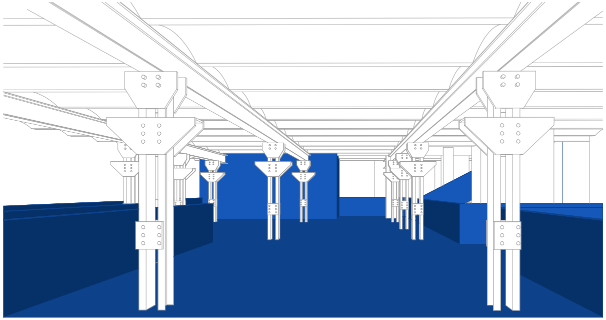

new box set into space
service
functions
buffet/restaurant
resting area
surfaces available for projection
1
1
2
2
0 1 5 10 m



Entrance is marked by the pavilion containing the information desk. We arrive inside the building onto the top of the free-standing box. In the reception area, the two uses are separated, the education centre is upstairs, while going downstairs the exhibition space can be approached.

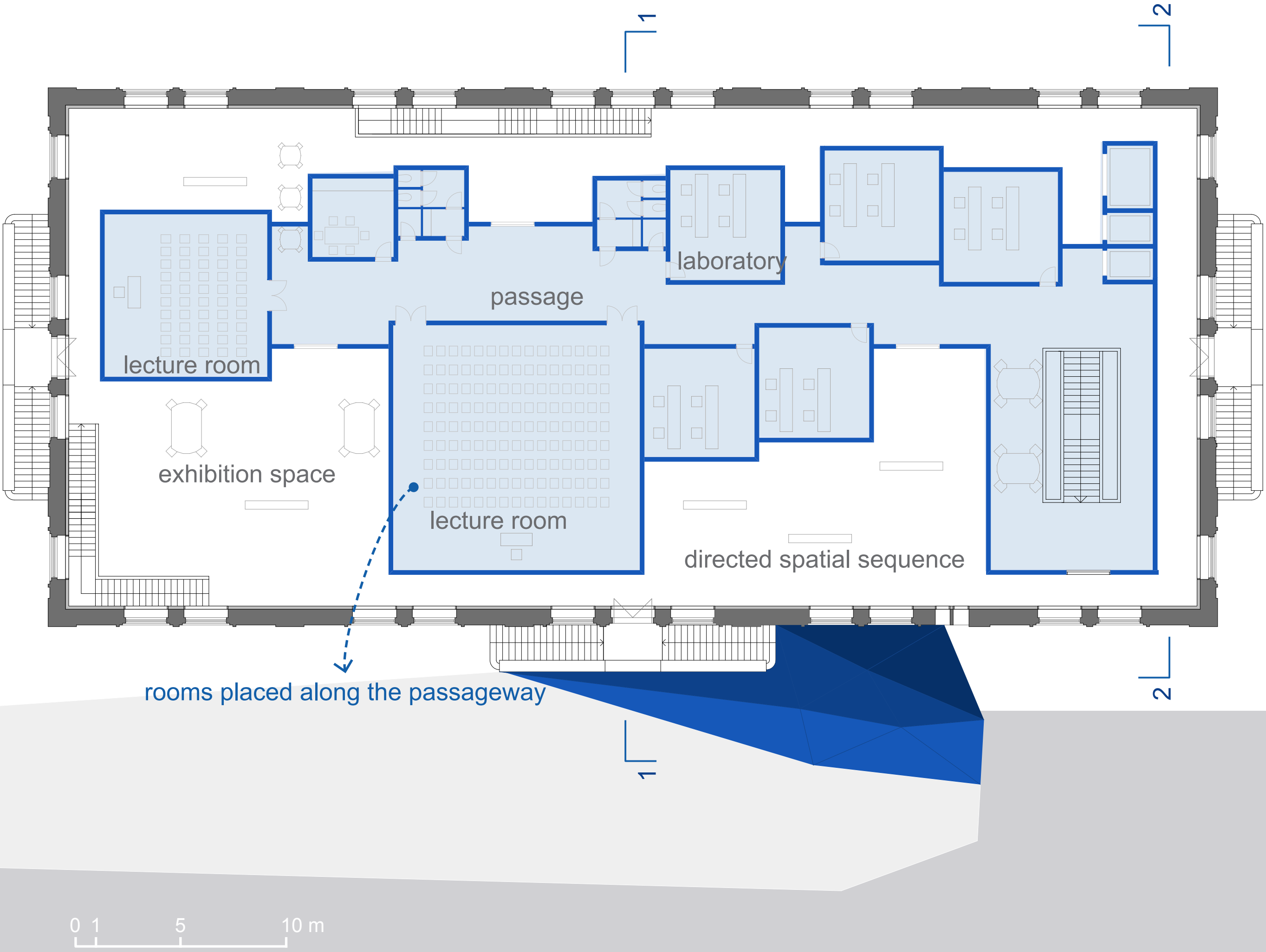


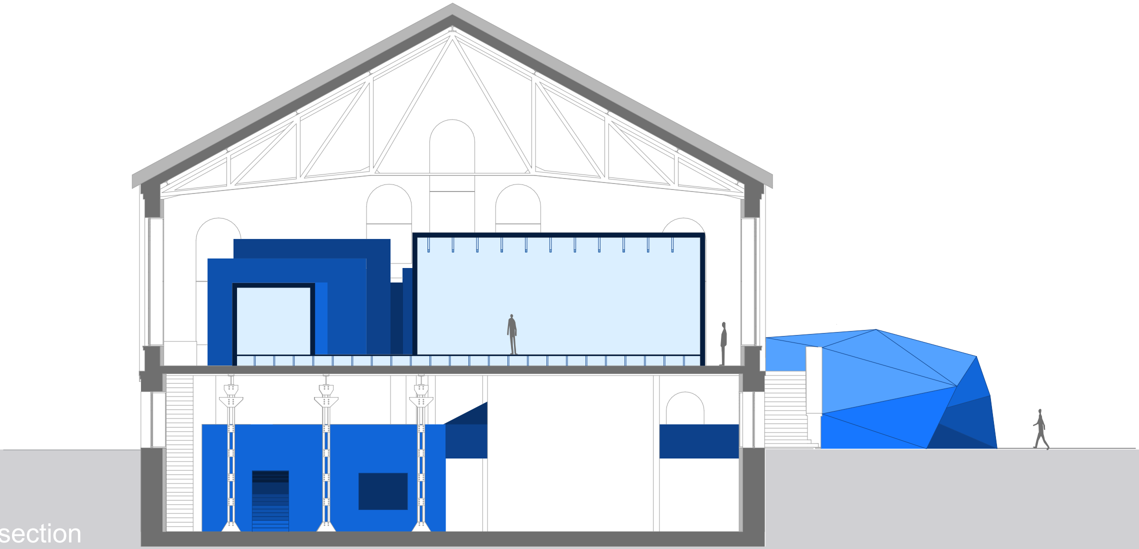
new box set into space
1
2
arrival
bridge
entrance pavilion
1
2
0 1 5 10 m



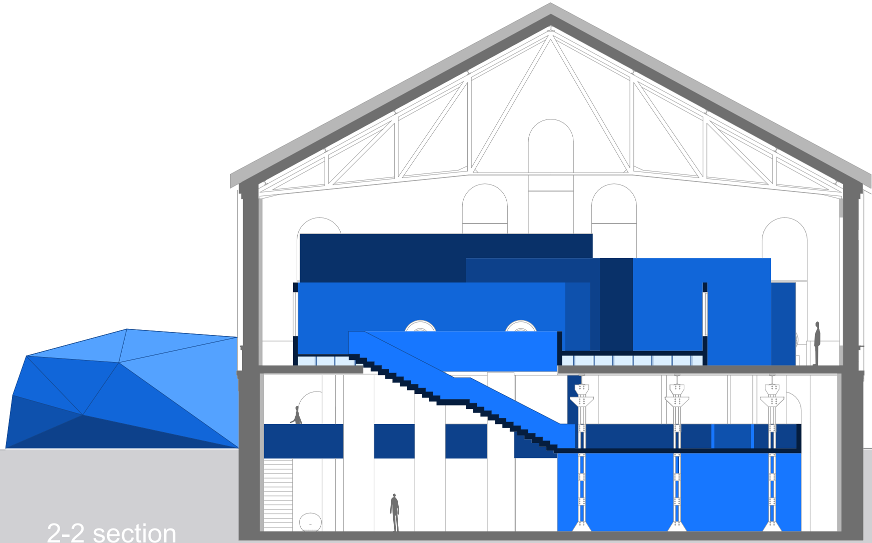
The educational centre is accomodated in the boxes queued along the passageway on the ground floor. Due to a displacement of the boxes, the directed sequence of the exhibition space is either expanding or narrowing. Visual connection between the exhibition space and the passageway is ensured by windows.

+1

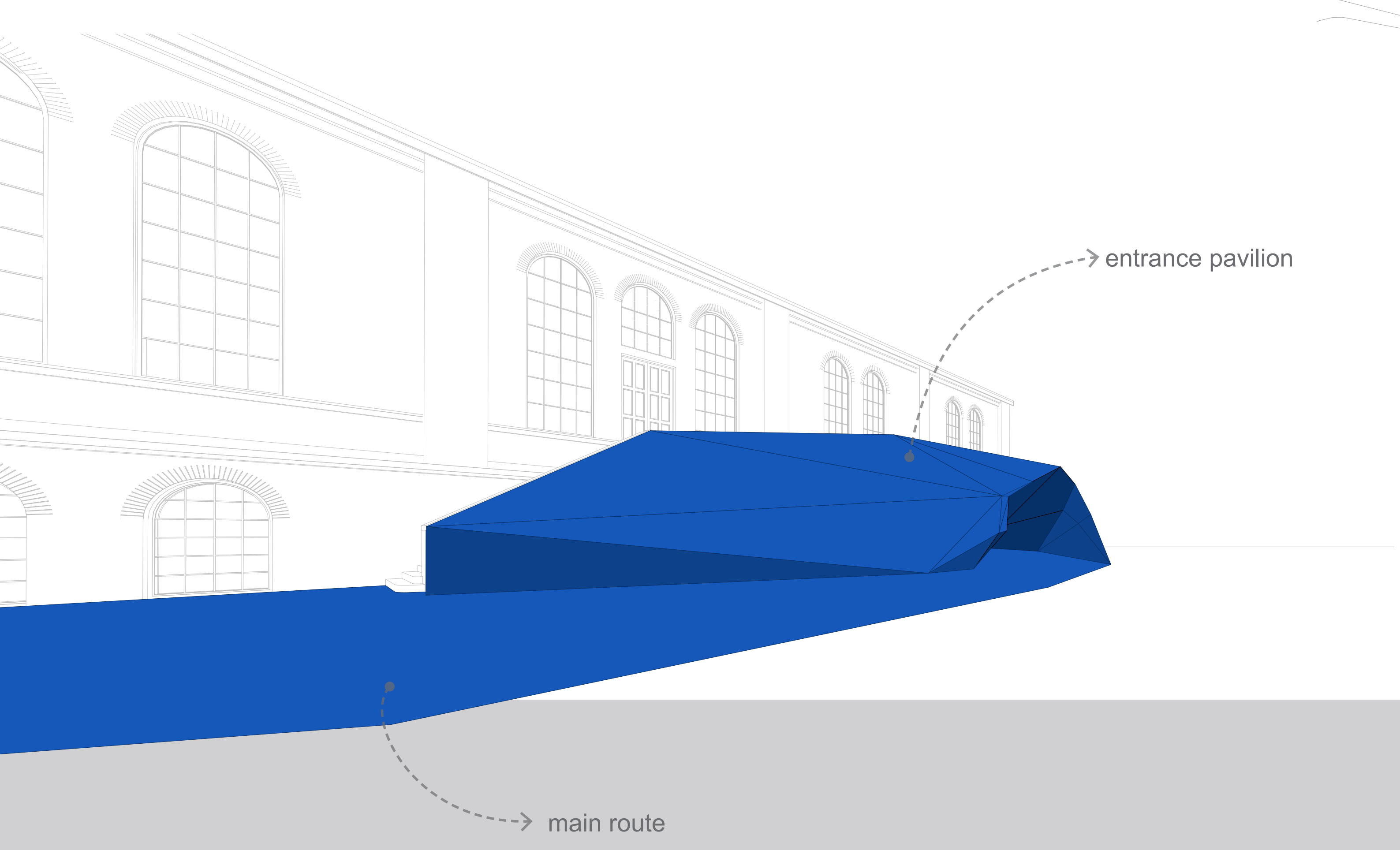

1
2
lecture room
passage
laboratory
exhibition space
lecture room
directed spatial sequence
rooms placed along the passageway
1
2
0 1 5 10 m



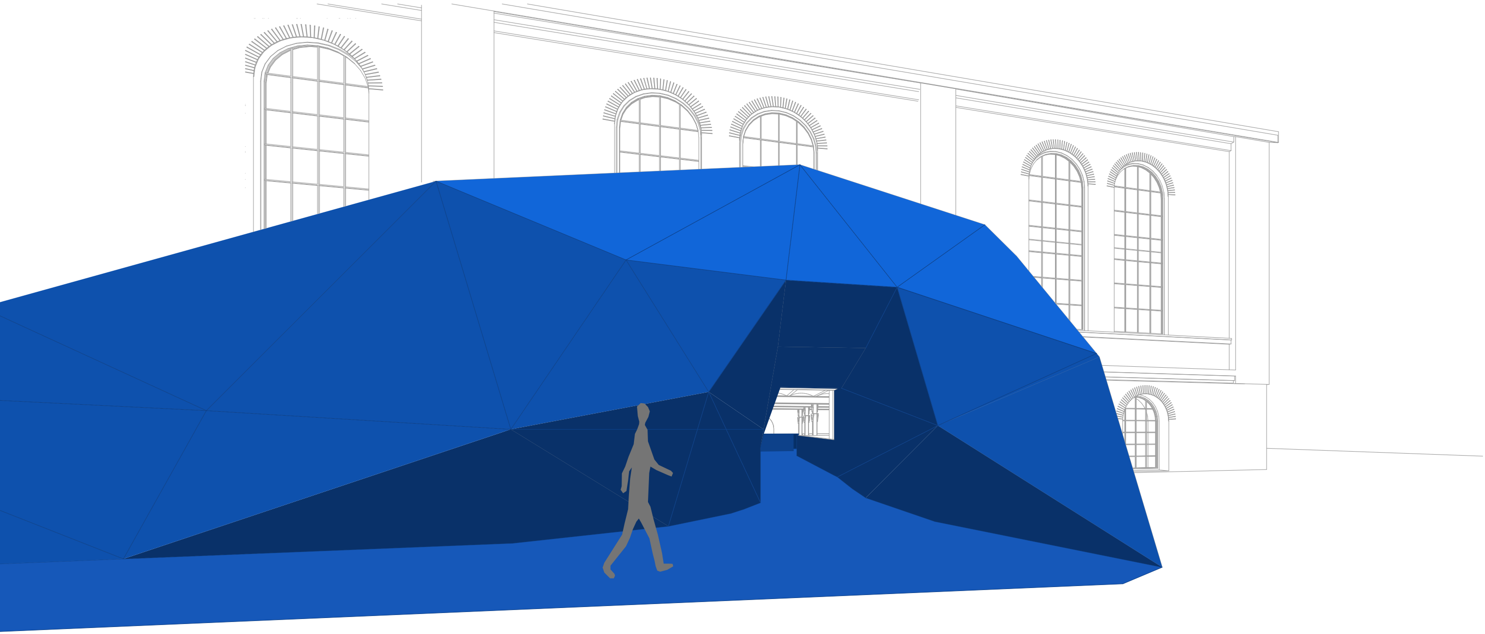
1-1 section



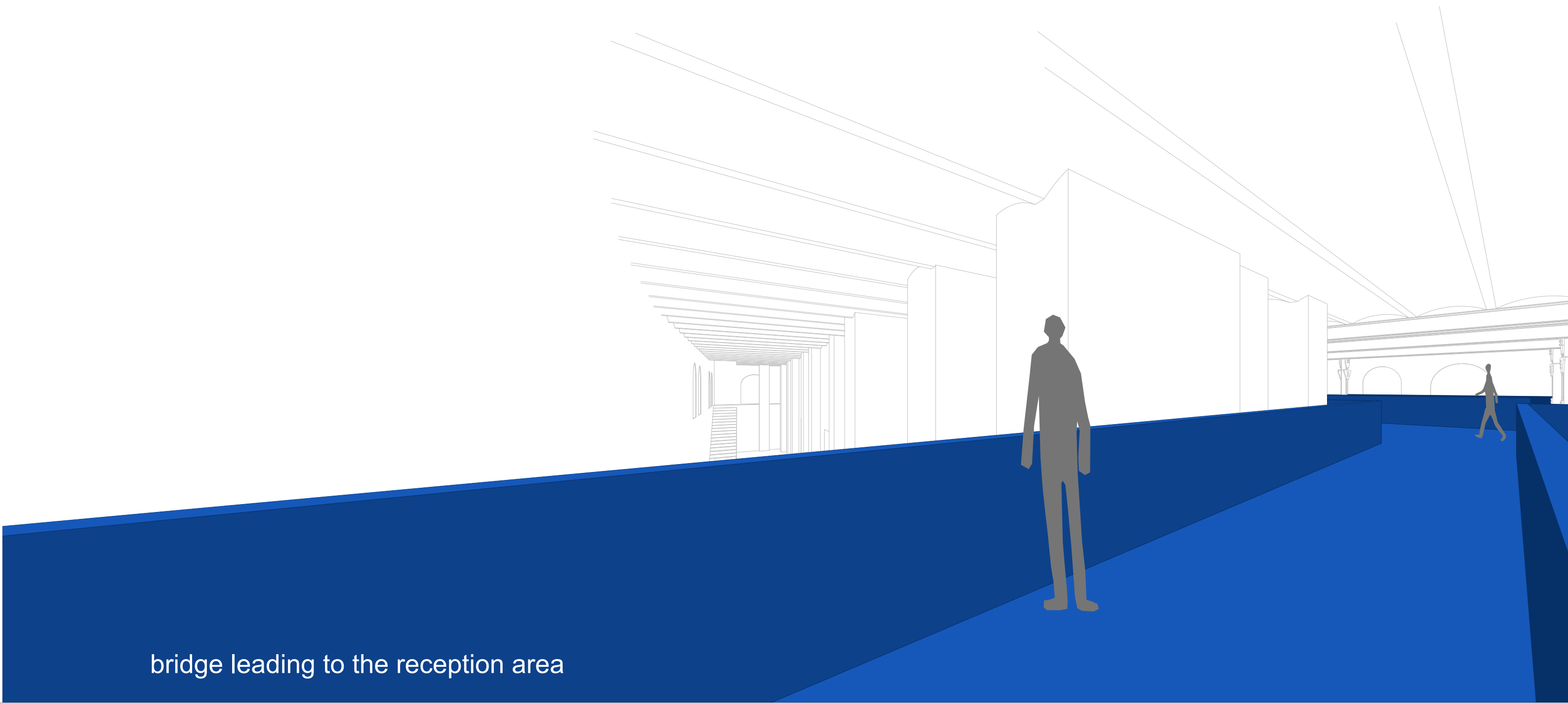
2-2 section

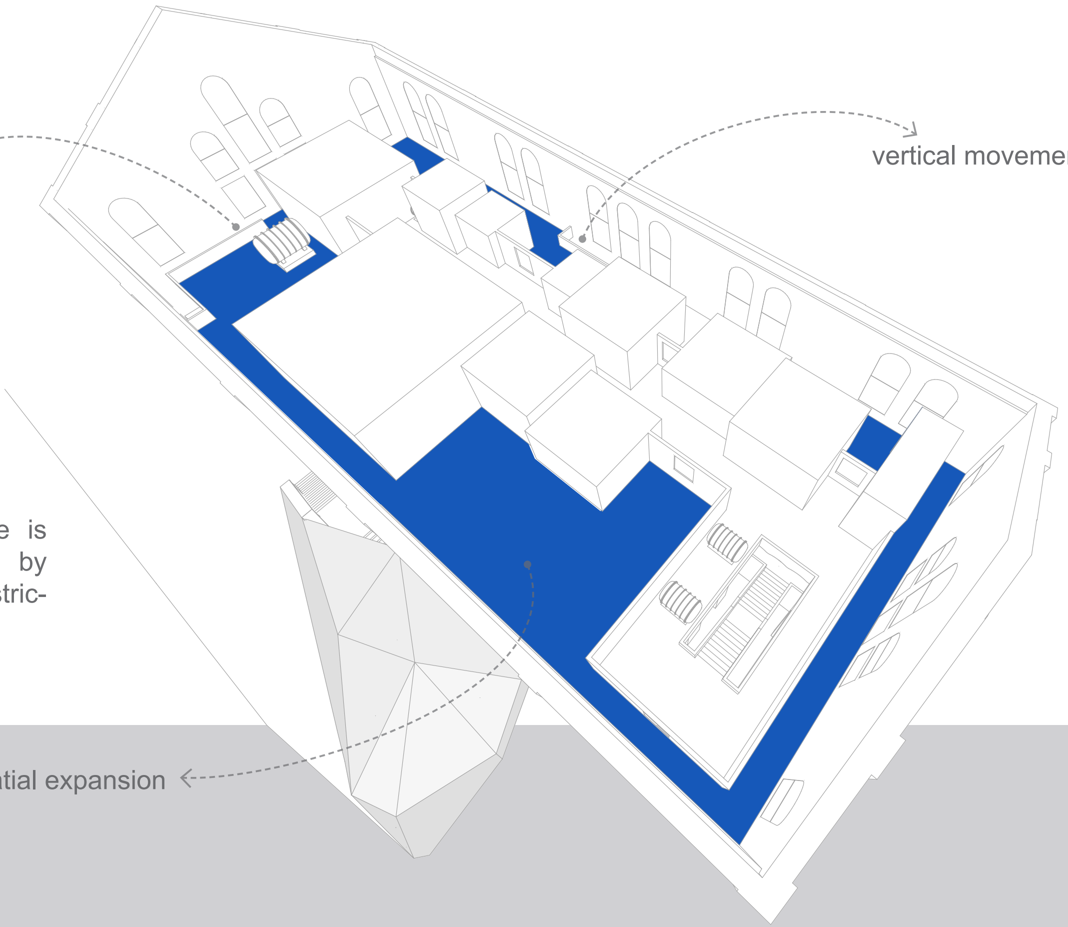

entrance pavilion
main route

Due to the concealed position of the Meter House, both approach route and entrance are of substantial importance. Since it is standing behind the iconic tar towers, it can be approached through an accented route leading to the bold entrance pavilion applied onto the building.

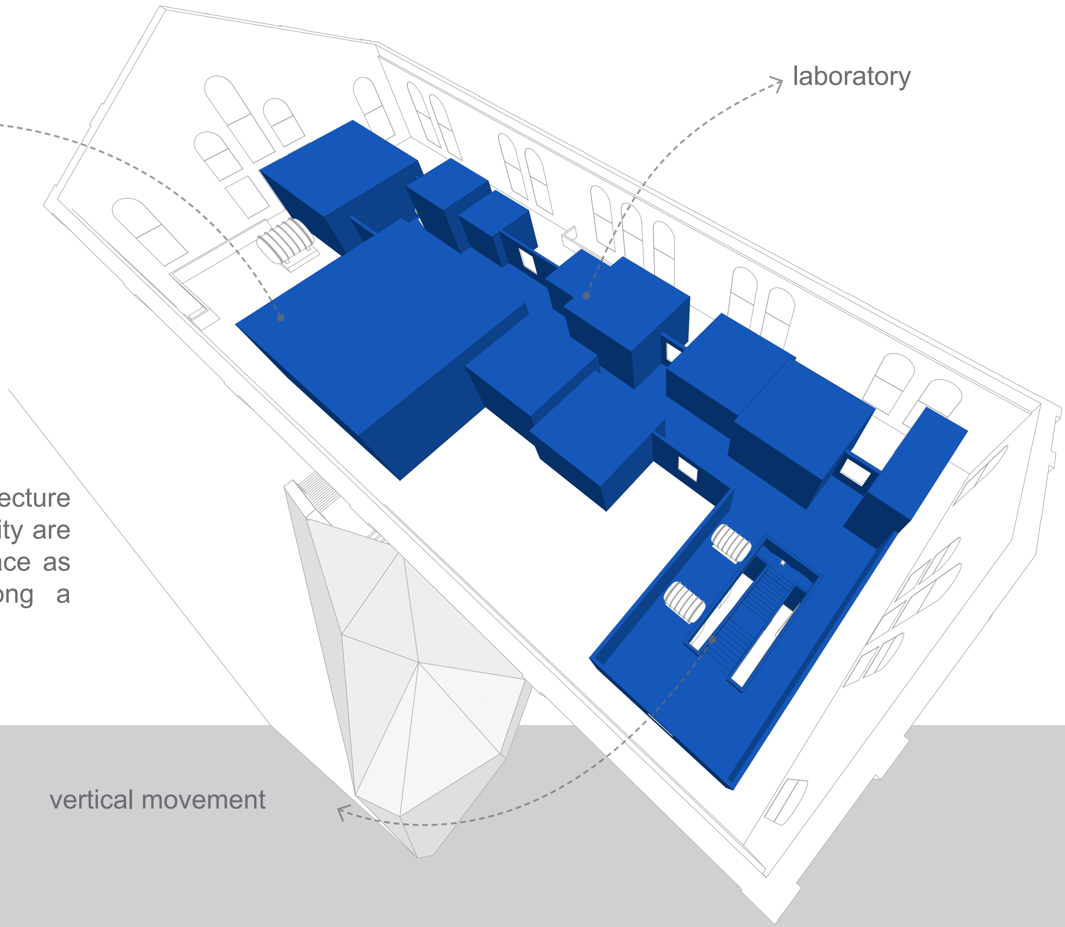


entrance point to the Meter House

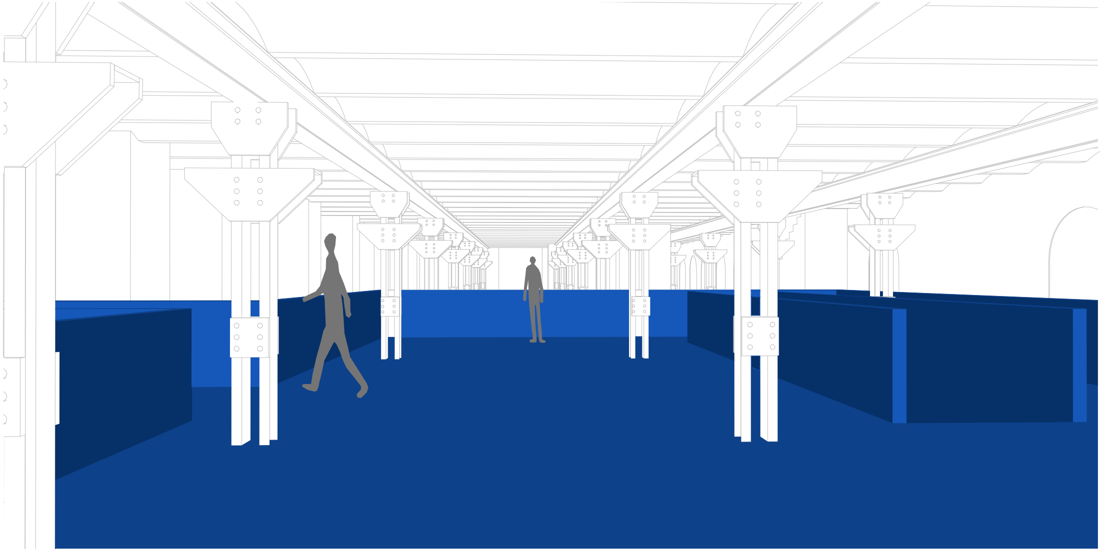

bridge leading to the reception area



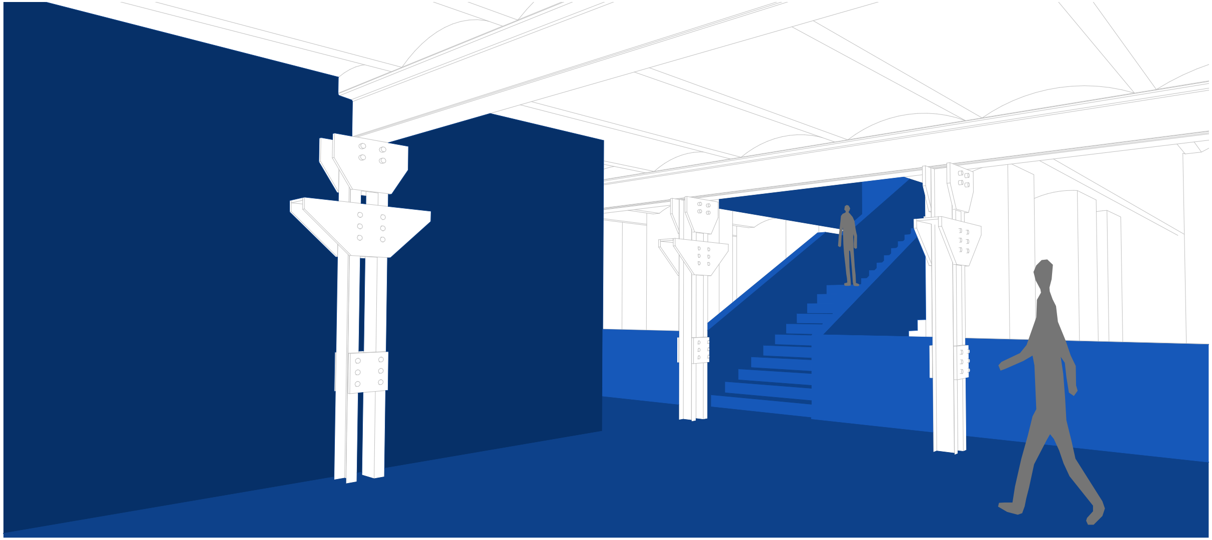
The exhibition space is divided into rooms by expansions and constrictions.



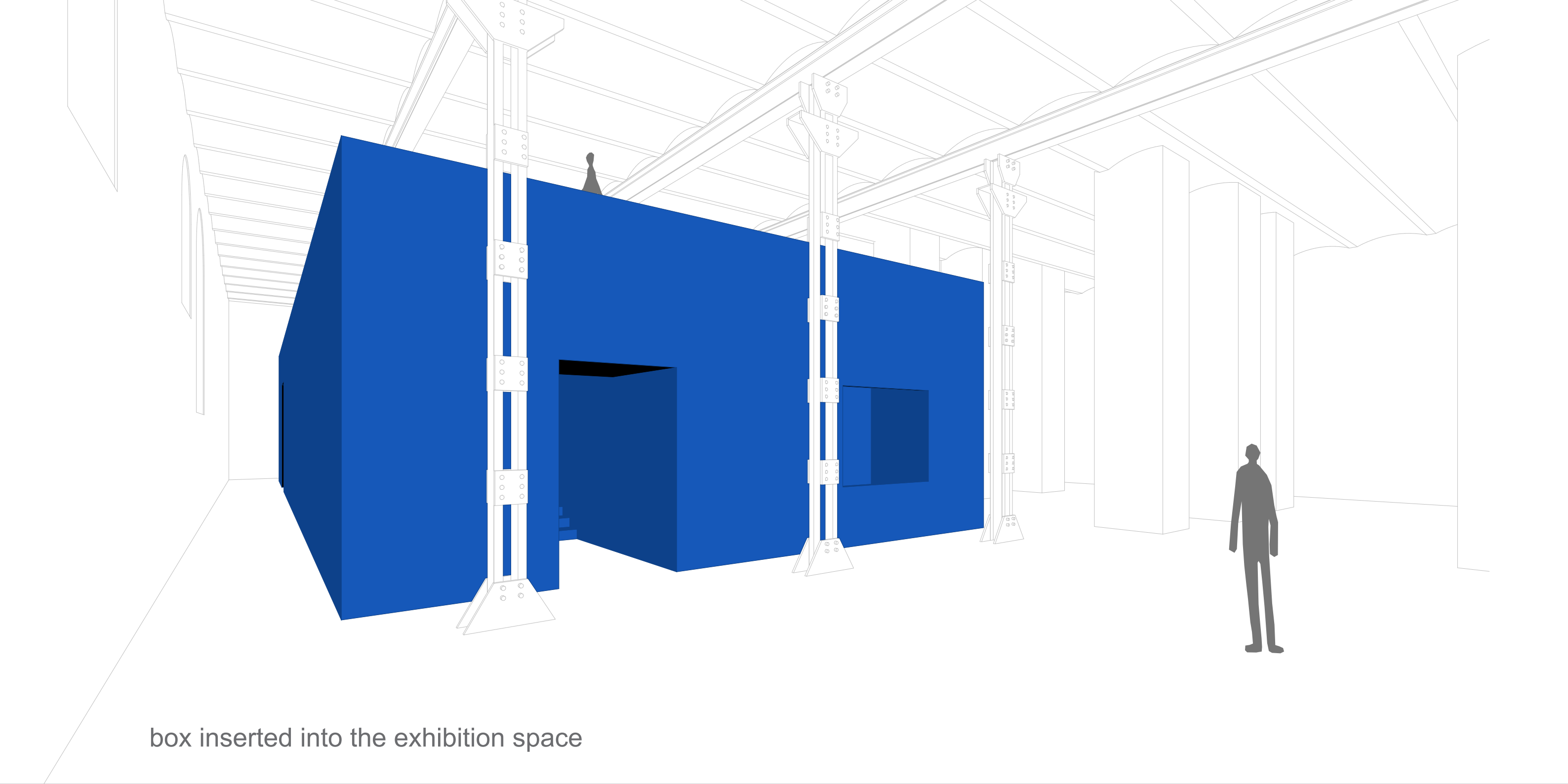
Research and lecture rooms of the university are inserted into the space as separate boxes along a central passageway.



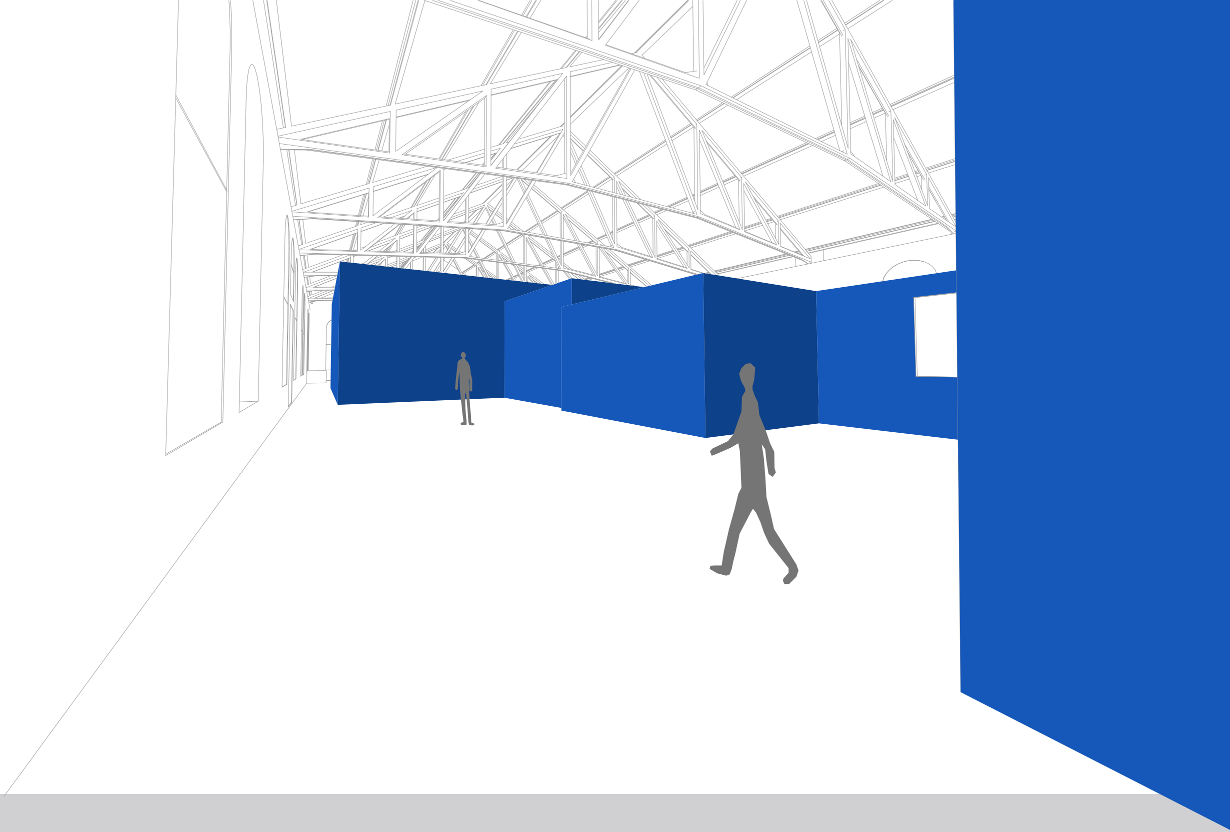
expansions of the exhibition space



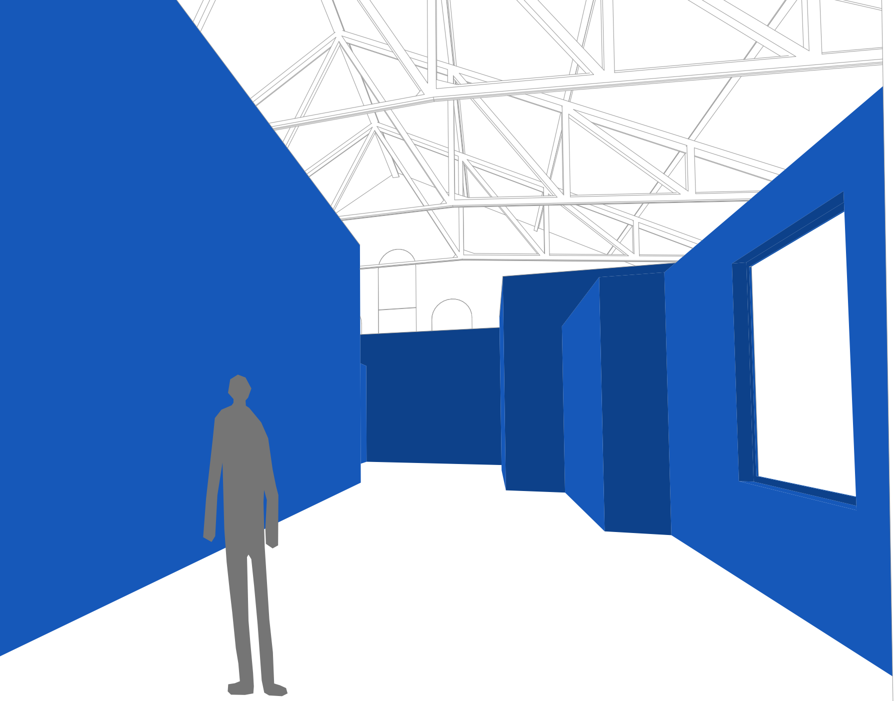
passageway of the university



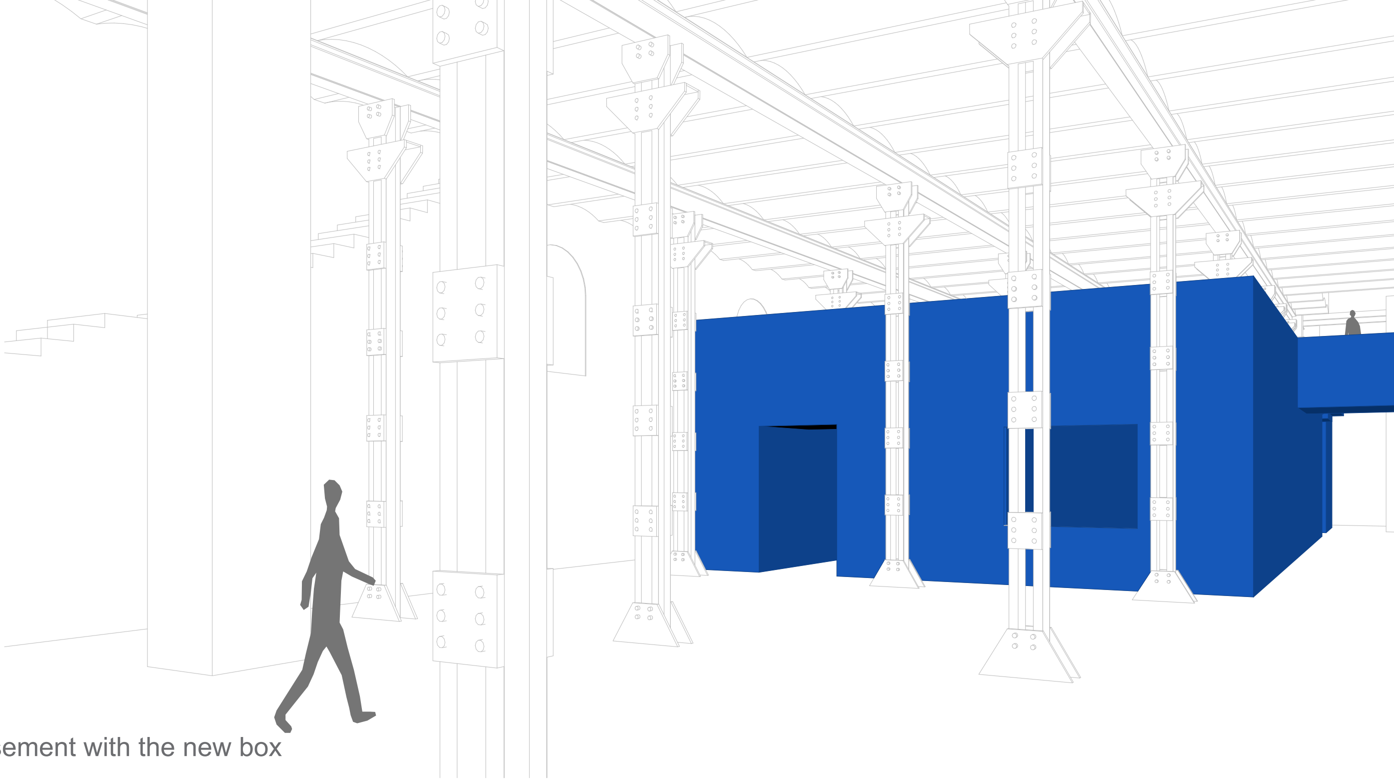
box inserted into the exhibition space



museum space



university passageway



basement with the new box

04

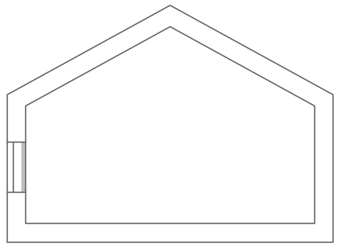
HVAC systems

Currently, the Meter House serves as a stone material deposit, which is not relevant within the scope of the ReFoMo project. Thus, for our case study we relied on the feasibility study made by BVV zrt. (10 September 2013)[16], that suggests the realization of a Contemporary Cultural and Communication Centre. We made our energy calculations based on the HVAC systems required for the use described in the feasibility study[17]. We compare every possible development according to this by means of energy-efficiency and cost evaluation.

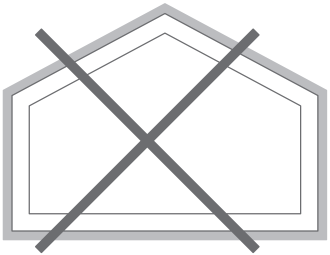
The goal of this study is to reduce the energy need as much as possible using active and passive elements taking into consideration the heritage protection directives. We investigated the possibilities for reducing the energy needs of the building and for possibilities of generation of energy.We chose HVAC systems that require the least visible mechanical (condensators etc.) and architectural (chimneys etc.) elements.

assumed normal operating conditions

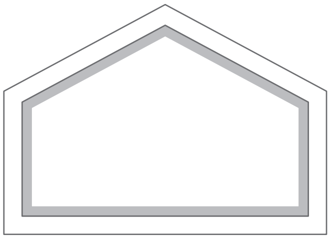
internal thermal insulation – moisture accumulation – structural damage



using additional thermal insulating glass



external thermal insulation



internal thermal isnulation

Heat loss is one of the main issues, that could be solved through an external thermal insulation, however, this is not allowed on listed historic buildings. This way, internal insulation is used, which can result in structural, aesthetical and health problems due to condensation on the inside, if not carried out properly.

One of the ways for reducing the building’s heating and cooling energy need is to improve thermal insulation of the structures. Considering this building, the most evident actions would be a thermal refurbishment of the outer walls, the roof and the windows, in accordance with heritage protection directives.

The existing external walls are made of small-size clay bricks of varying width with plaster finish on the inner side. The facade has a brickwork cladding, this way an external insulation was not an option. For this reason we suggested an internal insulation system (YTONG Multipor). We calculated the insulated wall’s heat transfer coefficient and in addition the vapor transfer calculation also had to be made taking into consideration the function and the use of the interior space. We suggest installing a 10cm thick layer of insulation (YTONG Multipor) on the inner surface of the wall, in this case the thickness of the insulation is depending on the result of the vapor transfer calculation. This way, better heat transfer coefficients can be achieved.

There will be curtain wall windows with undivided glazing attached to the restructured inner surface of the walls, thus preserving the original divisions of the windows. The glazing shall be equipped with heat resistant coating.

heating energy need: 944,5 MWh/a

cooling energy need: 378,6 MWh/a

External wall
$U_{existing}$=1,18W/m^{2}K,
U_{new}=0,38W/m^{2}K

internal thermal insulation

air humidity calculation!!

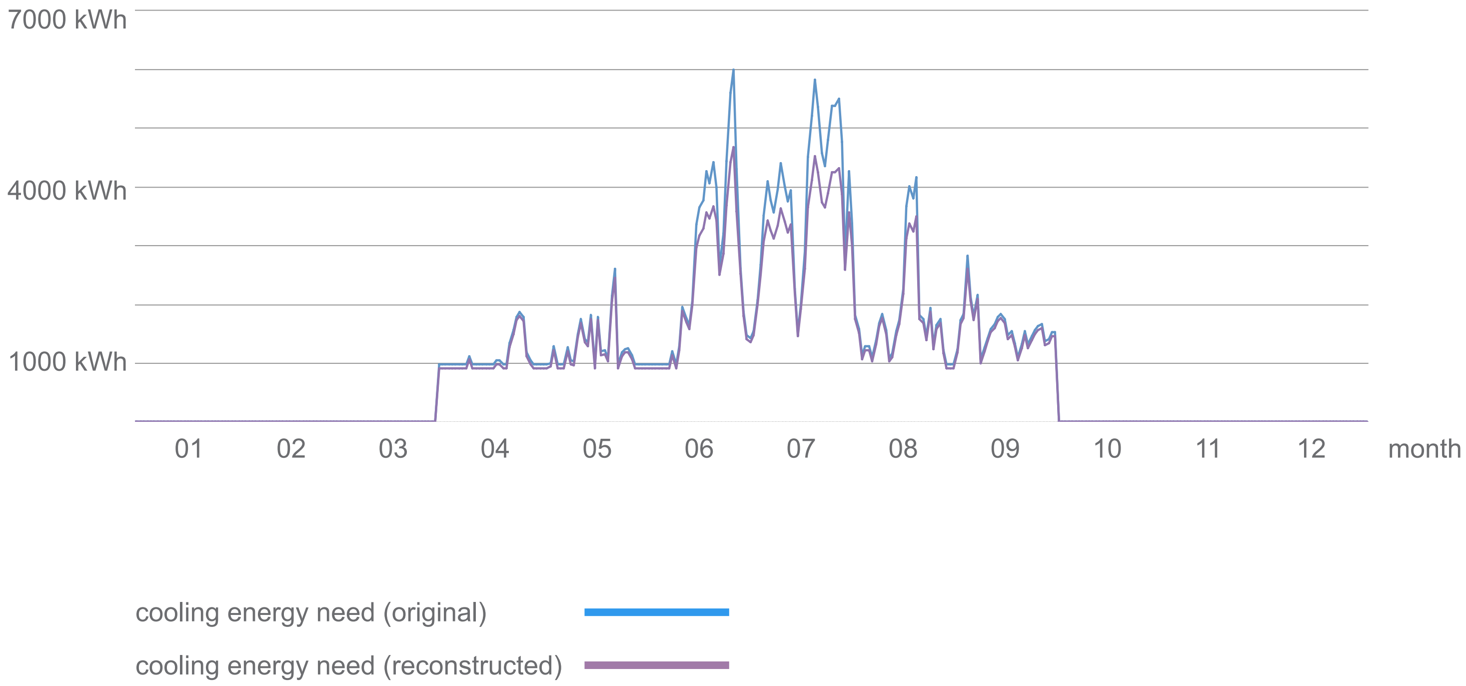
Window
$U_{existing}$=6,5W/m^{2}K
U_{new}=2,0W/m^{2}K

internal thermoglass

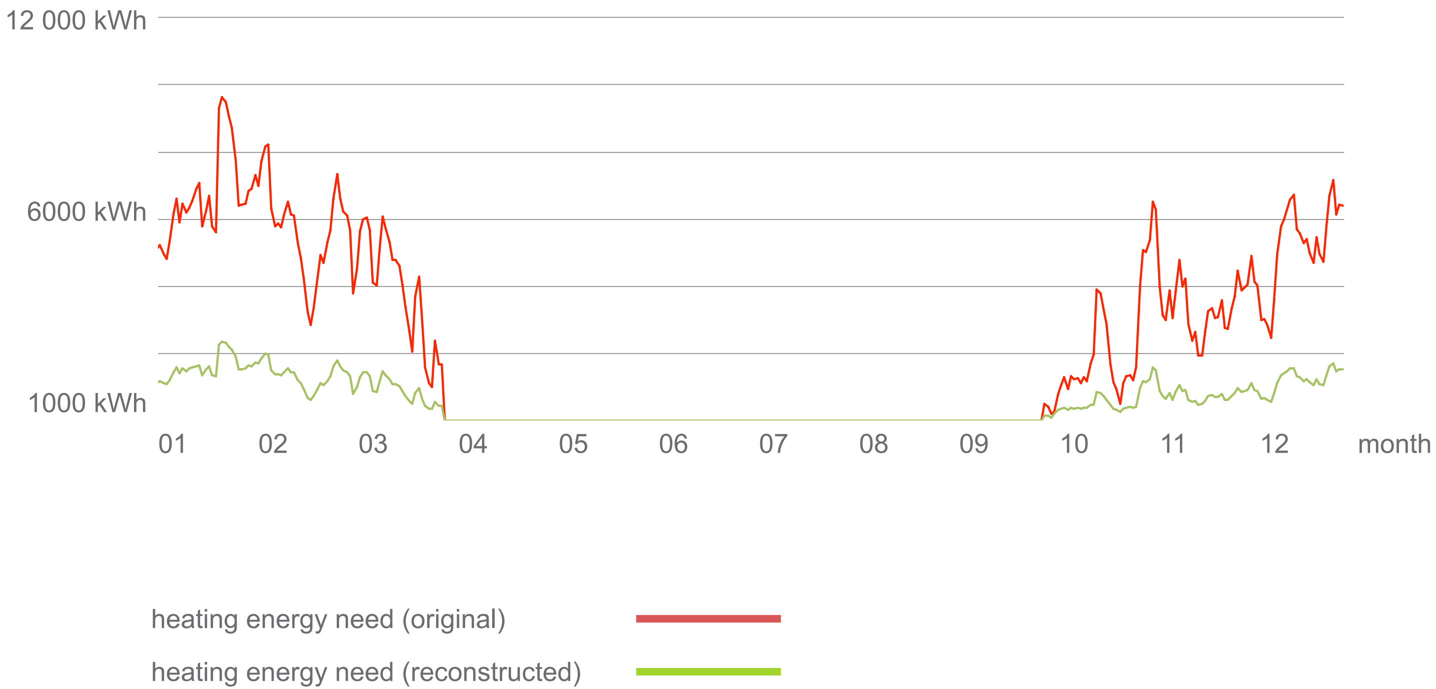
Roof
$U_{existing}$=2,21W/m^{2}K
U_{new}=0,1W/m^{2}K

thermal insulation

thermal management



7000 kWh
4000 kWh
1000 kWh
01
02
03
04
05
06
07
08
09
10
11
12
month
cooling energy need (original)
cooling energy need (reconstructed)

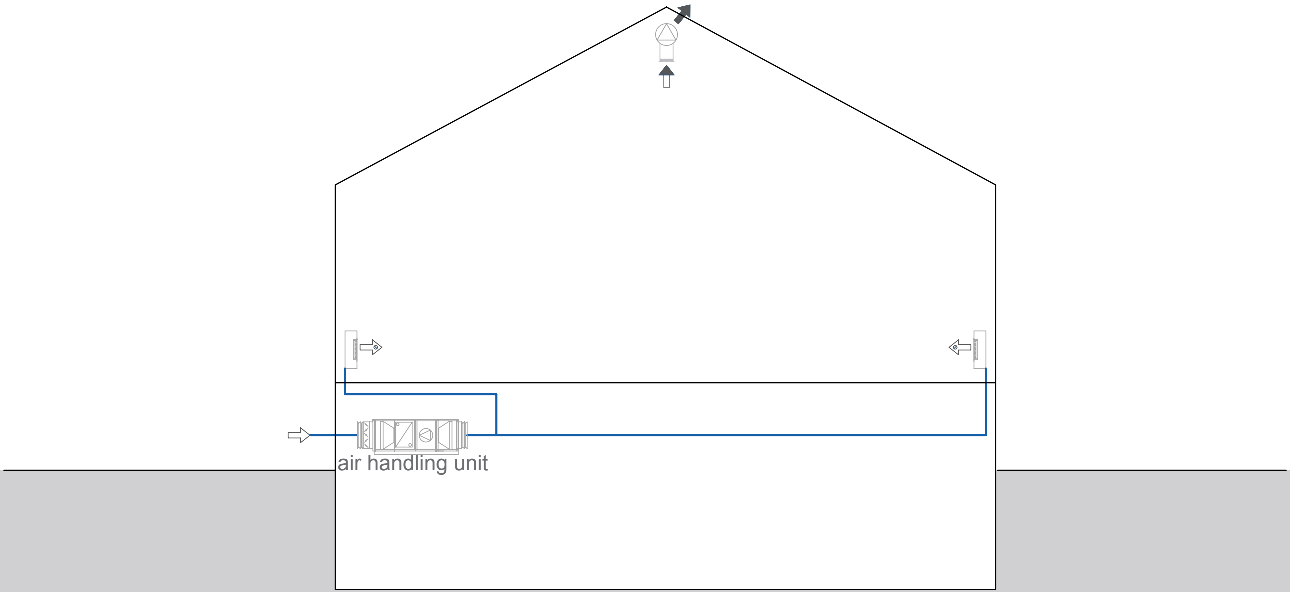

12 000 kWh
6000 kWh
1000 kWh
01
02
03
04
05
06
07
08
09
10
11
12
month
heating energy need (original)
heating energy need (reconstructed)

ventilation 19

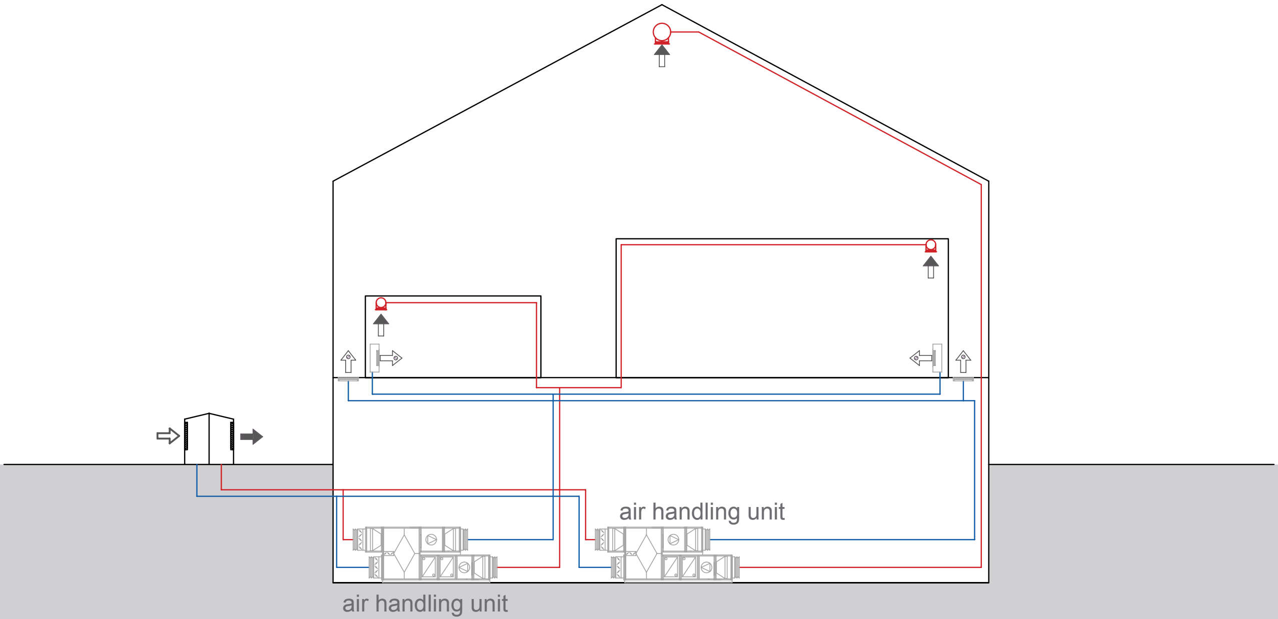
Due to the architectural design of the building the ventilation of the box shaped rooms has a low energy need because these rooms don’t have external surfaces but the internal heat gain is high so all year long only cooling is needed. Part of the cooling energy need during the winter is covered by free cooling, the other part is provided by high efficiency heat recovery by high temperature of exhausted air. So the energy need of the HVAC system would be greatly reduced due to the architectural design and the heat recovery.

The energy efficiency of the air handling units depending on the many parameters but based on the experiences to most significant is the heat recovery efficiency. Therefore high efficiency (>80%) cross flow heat exchangers shall be assembled to the units.

existing



new



heating and cooling

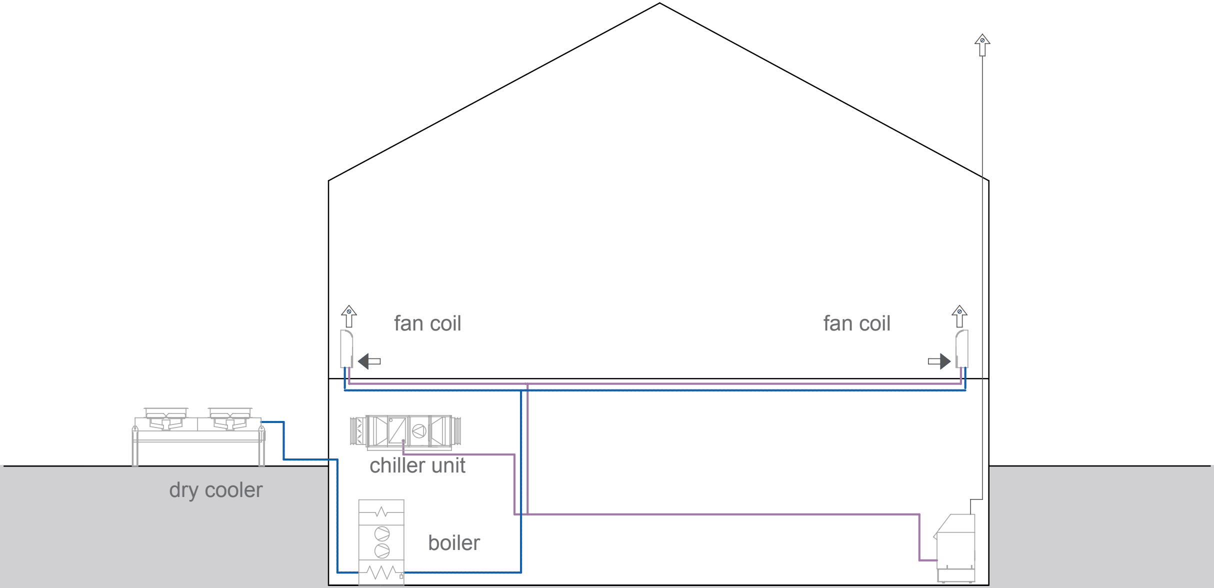
The heat recovery from waste water is not common yet but good working references are available. Wastewater is a cheap energy source continuously available in urban areas and production facilities. With appropriate technology, wastewater heat otherwise ending up as waste in the sewage system can be utilized. Utilizing wastewater heat doesn't affect the composition of wastewater, that is, conditions for cleaning or bio-energy production remain the same. Communal, household and industrial wastewater can all be used as an energy source. The temperature of communal wastewater falls in the range between 10°C and 20°C, while industrial wastewater can be even warmer than that. Their temperature doesn't sink below 10°C in winter either. Due to its virtually constant temperature, wastewater heat offers much better energy efficiency than soil heat or groundwater.

Typical values:

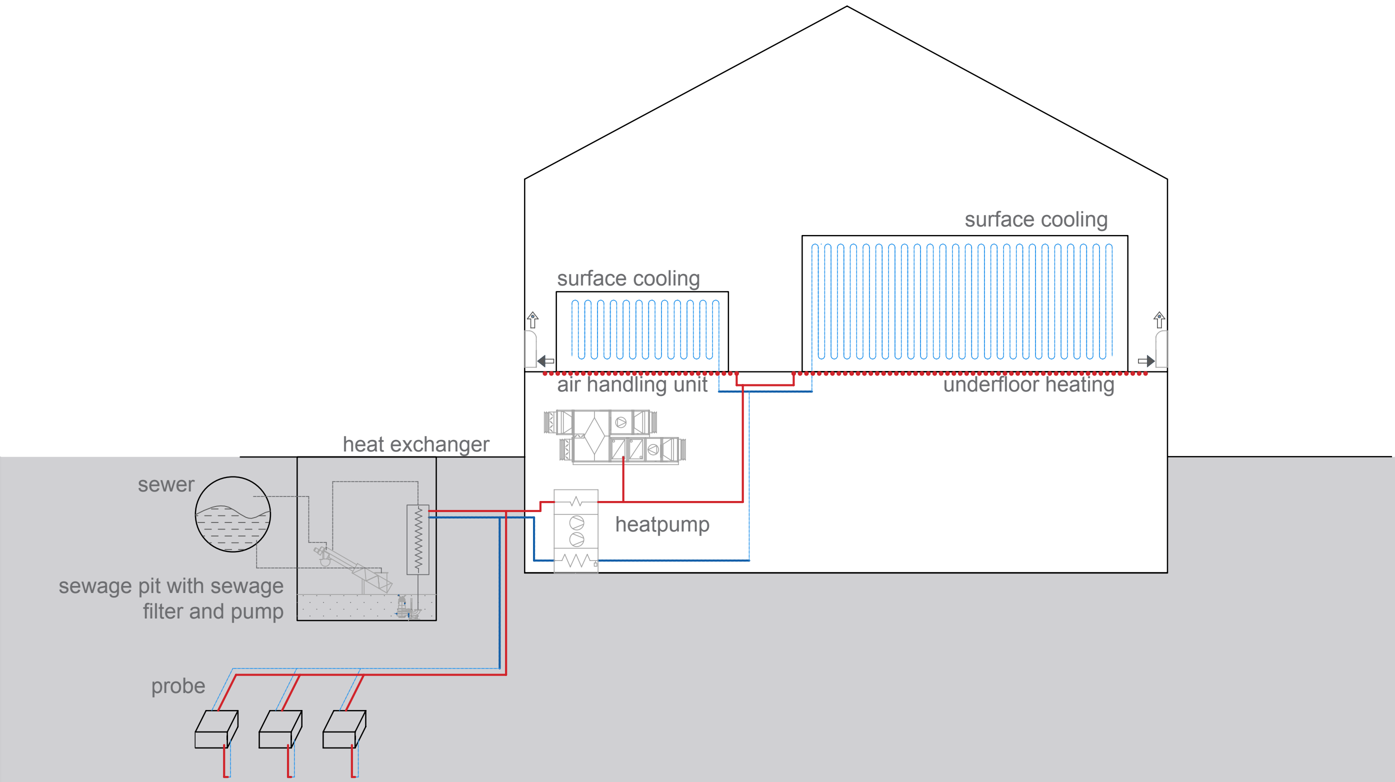
heating (COP): 5.0 – 6.5, with auxiliary energy: about 4.5

cooling (EER): 7.5 – 8.5, with auxiliary energy: about 6.5

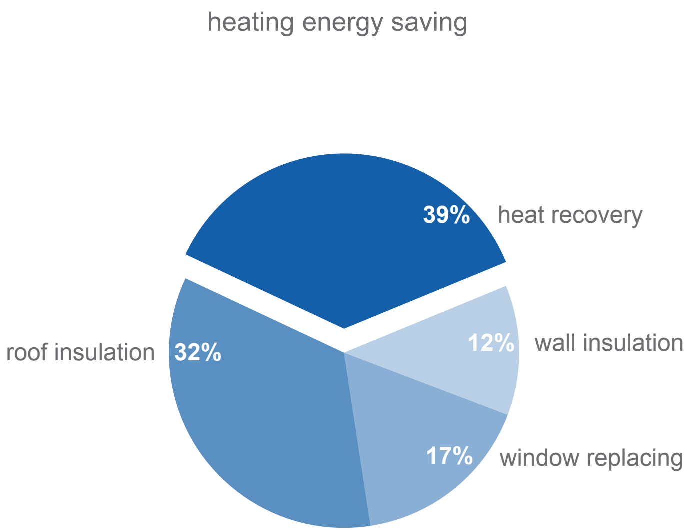
existing

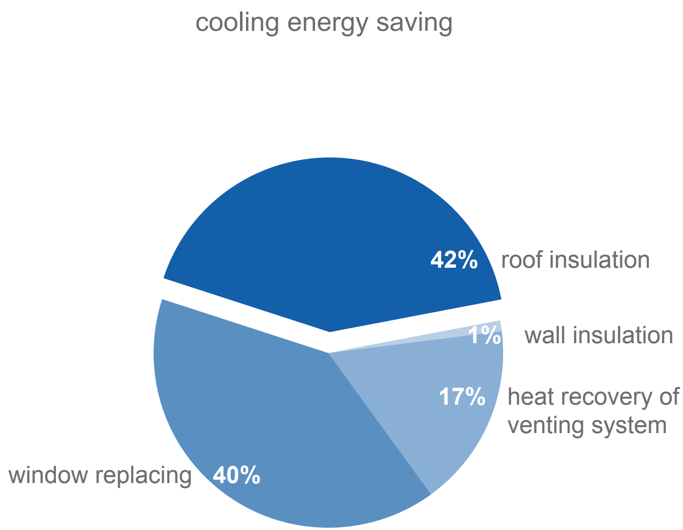


new



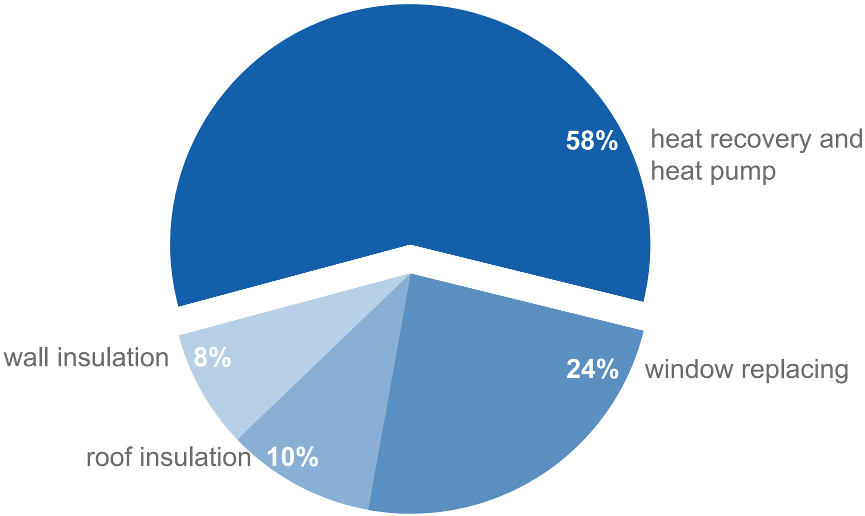
surface cooling
surface cooling
air handling unit
underfloor heating
heat exchanger
sewer
heatpump
sewage pit with sewage filter and pump
probe





energy saving

in the examination of payback time we subtract the costs of the issues which occur in case of a normal system from the initial costs, so the costs of the suggested activity:



initial costs

The refurbished building will use existing structures as an outer shell, providing the neccessary insulation within it. Thus the outer cladding and the layout of the openings will be preserved, the insulating structure will be built on the internal side. This will also accomodate curtain wall windows with undivided glazing, so the original division of the windows will remain the same. The glazing was considered assuming heat resistant coating. The characteristic truss structure of the roof visible form the inside will be preserved during the refurbishment, so the required insulation has to be installed on top of it. This way the roof will become higher, yet the inclination and roofing material will remain the same, so the outer appearence of the building will not be altered. The Meter House will receive a completely new, continuous layer of internal insulation, which, according to the atteched calculations will be responsible for most of the energy savings.

05

appendix

01 refomo
www.refomo.eu

02 climate-KIC
Climate-KIC is one of three Knowledge and Innovation Communities (KICs) created in 2010 by the European Institute of Innovation and Technology (EIT). Climate-KIC is based on cooperation between European research institutes, local governments and businesses leading innovation.

http://climate-kic.org

03 CO2-emission
94 % of CO2-emission comes from energy production and use. Buildings are responsible for 40 % of EU energy consumption.

04 organizational structure
Within the scope of ReFoMo, international KIC partners are cooperating.

International partners:

Province of Utrecht, The Netherlands (lead partner and main contact) The province of Utrecht takes the role as lead partner in the ReFoMo project and will be the main contact person. Together with other public and private investors, they areinvesting tens of millions of euro in the programme, and are seeking ways to maximize her return on investment.

https://www.provincie-utrecht.nl

ARCADIS Netherlands BV, The Netherlands (business partner) ARCADIS is an international company providing consultancy, design, engineering and management services in infrastructure, water, environment and buildings. They enhance mobility, sustainability and quality of life bycreating balance in the built and natural environment. In the REFOMO project they will help finding methods to deliver climate services into historical buildings in a sustainable way.

http://www.arcadis.com/

Utrecht University, Utrecht Sustainability Institue (UU-USI), The Netherlands (knowledge partner) - Consisting of more than 1.500 affiliated researchers, the Utrecht Sustainability Institute (USI) aims to find positive solutions to the increasing number of problems in the field of sustainability, such as climate change, energy dependence, scarcity of water and resources, explosive urbanization, and the social and economic tensions resulting from these developments. In this project USI provides its skills in knowledge dissemination in order to 1) collect, describe and visualize the lessons learned during the project and 2) disseminate these project results towards the market, public authorities and research communities by means of presentations, articles, social media and the organization of an international expert seminar.

http://www.uu.nl

UNIBO (Alma Mater Studiorum University of Bologna), **CIRI-CE** (Interdepartmental Centre for Applied Research on Buildings and Construction), Italy (knowledge partner) CIRI-EC of the University of Bologna promotes research co-operation and innovation within industries and small/medium enterprises by means of technological support, knowledge transfer and business development. It provides the appropriate tools and methods for implementing research results in commercial developments.

http://www.unibo.it

AIDICO Instituto Tecnológico de la Construction, Spain (knowledge partner) AIDICO works at new energy-saving strategies in buildings while they interact with their environment (passive systems). AIDICO is active in construction testing, diagnosis and monitoring of buildings. AIDICO has laboratories specialized in nanotechnology, testing building materials etc. and a certification department.

http://www.aidico.es/

Utrecht University - Energie, Milieu and Energiewetenschappen, The Netherlands (knowledge partner) is a research university spanning the entire academic spectrum in teaching and research. It explores investments and developments embracing sustainable cooperation and innovative changes.

http://www.uu.nl

Hungarian partners

NEGOS Zrt. (business partner) NEGOS is a strategic consultancy with international experience.It is involved in projects dealing with issues of social and climate change.

http://negos.hu

BVV Zrt. – Budapest City Planning and Rehabilitation LLC (knowledge partner) – a company established by the city of Budapest, performing the task of property management for the Óbuda Gasworks development territory. It is coordinating economical, technical, financial and legal activities. In 2013, they conducted a feasibility study regarding the Óbuda Gasworks site.

http://www.bpv3.hu

Minusplus (knowledge partner) – architecture office assigned by NEGOS zrt. to make this case study.

http://www.minusplus.hu

KIPTERV (knowledge partner) – engineering consultancy office assigned by Minusplus for the HVAC chapter of the study.

www.kipterv.hu

05 fortress

Utrecht, The Netherlands – Fort de Gagel and Fort aan de Klop
Partner: Province of Utrecht
The Nieuwe Hollandse Waterlinie consists of an area of 42 000 ha including more than 60 fortresses and several hundred built struc-

tures.

http://www.hollandsewaterlinie.nl
http://www.fortaandeklop.com

06 university

Bologna, Italy – Building of the Faculty of Engineering
Partner: UNIBO (Alma Mater Studiorum University of Bologna), CIRI-CE (Interdepartmental Centre for Applied Research on Buildings and Construction)
The building of the Bologna University was designed by Giuseppe Vaccaro between 1931 and 1935. The project aims to investigate the opportunities for the refurbishment of the building.

http://www.unibo.it/

07 gas propaganda

The gas campaign was launched in 1913 by the Hungarian National Society for Applied Arts through a competition for posters and postcards. The Gasworks popularized gas use by means of advertisement stamps, collection sheets, and training courses. The campaign gained momentum again after the war, when exhibitions, lecture series and courses were held in the auditorium of the Royal Hungarian Technology Institute. From 1929 on, the Royal Palace hosted demonstrations and cooking competitions as well.

08 location

The site is located on the edge of the central area of Budapest, right by the Danube. It is situated along the main North-South traffic route of the Buda riverbank, thus providing ideal accessibility required for a large project. Bus, commuter rail and railway lines intersect on the territory with road traffic, all which, together with the boat harbour, constitute the appropriate background for a possible intermodal hub. The factory site is approximately 72 hectares large, has a shape similar to a triangle, and covers the area to the south from the Újpest railroad bridge all the way down to the entrance of the Óbuda Island on the right side of the Danube.

09 Graphisoft Park

The Park was built by software development company Graphisoft in 1998 on a 160 ha greenfield lot on the Danube riverbank. Due to the continuous real estate development activity, there were office buildings built on the site, hosting mostly IT and biotechnology companies.

http://www.graphisoft.hu

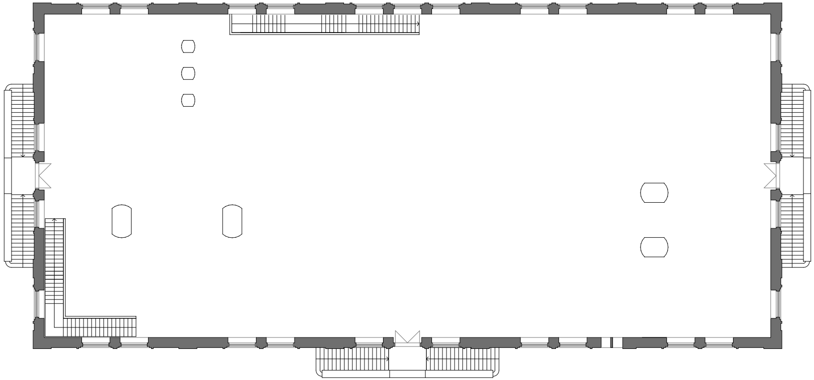
10 AIT – Aquincum Institute of Technology

An institution founded by Graphisoft president Gábor Bojár. It signed agreements with USA universities (with Princeton among them), which support the operation of the Institute with advice and constant monitoring. Also, most of the students are from the USA.

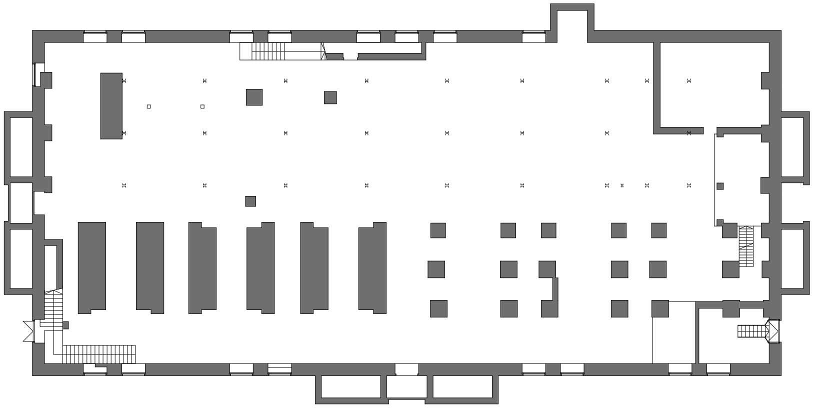
http://www.ait-budapest.com

	area (m^2)	use	flooring material	comment
1	1296	hall	concrete	in bad condition, significant amount of holes in the slab, existing equipment that's difficult to move
2	45,80	entrance	mosaic floor tiles	in medium condition
3	4,15	bathroom	floor tiles	in medium condition
4	1,40	toilet	floor tiles	in medium condition
5	25,89	gallery	concrete	in bad condition
6	7,26	storage	earth	in bad condition, accessible from the outside
7	7,26	storage	earth	in bad condition, accessible from the outside
8	1036,69	basement	earth	in bad condition, divided by columns, frequent presence of groundwater, traces of several reconstructions visible
9	50,21	storage	earth	in bad condition, without natural lighting
10	13,36	unknown	concrete	area 175 cm higher than the basement
11	20,33	switch room	concrete	accessible from the outside, it accomodates switch enclo-sures
∑	2508,45			

	visual assessment	indicator of condition
Loadbearing structure, supporting elements, slab	weak	30%
Roof structure, facade, wall bases, cladding	weak	30%
Waterproofing, drainage, bathroom heating elements	bad	20%
Windows and doors in the outer walls	bad	30%



existing gorund floor



existing basement

11 environmental remediation

In 2009, hazardous waste deposited in the gas container foundations was removed. This was only the first important step in the remediation of the territory. Beside the 2500 tons of purifier waste, there were 20700 tons of hazardous waste, 85 tons of liquid waste, and 300 tons of steel plates and other steel scrap plus 2000 m3 concrete debris from demolitions removed from the site.

12 existing condition

At the present, the building is not in use, it serves as storage for stone material. It covers an area of 1290 m2. Its structure is in good condition. Upon visual examination, it doesn't require significant reinforcement. The building was built using traditional structures corresponding to its age and use. It has a column grid loadbearing structure combining steel and brickwork, with a surbased vaults slab on steel beams. The roof has a truss structure with a slate covering, the facades are clad with two types of bricks (yellow and red). The foundation is presumably slab-on-grade structure. Windows are single paned with steel frames and arched vaults. Doors are made of wood with a solid panel design.

The basement has been having moisture issues several times in recent years, due to high levels of groundwater. Following the record-high flood in 2013, there has been a 8-10 cm deep layer of groundwater in the basement for weeks. The reuse will definitely require waterproofing.

13 dinamically developing area

The industrial territory remained absolutely untouched for twenty years after the shutdown. It was only in recent years that issues of heritage protection and maintenance have been dealt with. Software developer Graphisoft initiated the real estate development project of the southern part of the territory in 1998, resulting in office buildings being built that were successfully adapted to the existing monuments. Several buildings were renovated and transformed to accomodate new use. The directorial building, the workers' welfare premises, the police barrack and the emergency station were renovated and constantly expanding educational centres were made. Due to their strongly dilapidated condition, renovation of the water and tar towers became necessary even without utilization. The project started in the spring of 2013 and is expected to end by spring 2014. Buildings not under heritage protection were demolished.

14 hazards of contamination

In connection with the development and utilization of the building, BVV zrt. conducted research to explore the possible environmental hazards involved.

„In order to establishrisk assessment, we have had carried out

accredited analysis of internal air, building structure, ground and groundwater for organic and inorganic contaminating agents corresponding to the activities performed at the site previously. Numeric risk evaluation (RISC 5) based on the results showed values for carcinogenic and non-carcinogenic factors below threshold levels. The specialist made the following statements:
According to risk evaluation done with regard to the most sensible of affected groups (infant population), the maximum time allowed for children to stay in the basement of the Meter House is 7 hours/day and 120 times a year. Based on humane health risk analysis for workers as an affected group, there were no restrictions necessary. Considering the above, according to the available examination results the Meter House is suitable for community use in terms of humane health.
Health hazards concerning workers arising during soil removal for a possible reconstruction or outer waterproofing of the walls of the Meter House or building number 47 can be prevented or eliminated through the use of protective equipment (respiratory filter masks, clothing, gloves).
Soil removed along the outer side of the walls for external waterproofing can be filled back to its original place after completing the task.
Soil along the planned public utility track connecting the Meter House and the transformator building, as well as the Meter House and the water metering shaft can be removed to a depth of 1.5 meters, and filled back to its original place. Thus, in terms of environmental aspects, the building is suitable for development and utilization in accordance with the specified use.”
(Meter House – Contemporary Innovation and Cultiral Centre, Preliminary Feasibility Study)

16 Feasibility Study written by BVV zrt. (10 September 2013)

„... The utilization profile of the transition period is mostly identical with the final use, that is, a cultural entertainment centre capable of accomodating larger groups of people will be developed. Also, this building (i.e. the Meter House – the authors) is the first step in the process leading future investors and users towards the concept of innovation and R&D developments of the whole Gasworks site... We recommend the remodeling of the building be made in a way that allows the complete utilization of the basement... The windows of the basement are sufficient for this, but the space is higher than necessary. We propose the construction of an additional slab above the bottom to reduce room height, which will also significantly improve accessibility from ground level. As the terrain around the building is much lower than the ground floor, we can access in level a fully usable floor

15 list of rooms

basement

wind protection	10 m^2
cloakroom	20 m^2
toilets	25 m^2
information, museum shop	10 m^2
buffet, café	25+65 m^2
exhibition space	746 m^2
storage	20 m^2
building services systems/HVAC	78 m^2
passage way	105 m^2
	∑1104 m^2

half floor

arrival space	200 m^2
	∑200 m^2

ground floor

passage and social space	195 m^2
large lecture hall	138 m^2
small lecture room	60 m^2
lecturers’ room	15 m^2
laboratories, 5 pcs	150 m^2
toilets	25 m^2
exhibition space	570 m^2
	∑1153 m^2

without the need for subsiding. Following restoration, the lower level will become reception, distribution and service area. This way, toilets, building services rooms, but also storage and offices will be located here. The upper level will be remodeled preserving its undivided space. Accessing it from below i possible through the stairs and passages at both ends of the building. As an option, vertical access in the middle of the longer sides will be maintained. This will help to achieve better possibilities for dividing the upper floor. The large undivided space is suitable for larger events and also for creating much smaller section rooms.

Project description:

The goal is to create a contemporary cultural centre on international niveau. Contemporary event and exhibiton spaces are characterised by rather different ways of realization. The main elements of the project are community and exhibition space as well as education facilities and workshops. Among the centre's exhibitions there will be a media museum and several temporary exhibits changing in a frequent pace.

The exhibition will provide experiences and creative opportunities for vast social groups:

- education of children (age 10 to 16) - web and design
- youth art campus – collaboration with universities
- residency programs
- business cooperations and workshops (e.g. Graphisoft Park)
- artistic education of the physically disabled

...Visitor numbers: ... According to calculations by C3 centre, the Meter House can expect 300 to 500 people a day, which can increase to 1000 to 2000 people during temporary exhibitions. Workshops at the lower level could constantly accomodate further 50 to 100 people. Assuming frequent events during the transitory period, the tower complex would be able to accomodate 1000 to 3000 people per event.

Space utilization of the development: by means of mobile furniture and up to date folding screen systems, the 1300 m2 upper reception floor can be divided for use. The reception area with the cashier desk and the wardrobe can also accomodate a small museum shop. The neighbouring spaces could provide room for several exhibitions with different themes, where permanent and temporary areas could be separated.The lower floor, which is full featured and can be accessed directly, is the area for service activities. Besides adjacent storage rooms and workshops, a large capacity restaurant is also available. Furthermore, the office block with 270 m2 net area can be used not only by the management responsible for operating the museum, but also by BVV zrt, thus eliminating the company's rental costs... Provisional utilization of the tower complex is

possible either by regarding it as a separate building, or as connected temporary exhibition and event space. Once the environmental remediation is done, there can be an architectural element added, connecting the two buildings to be regarded as a whole."
(Contemporary Cultural and Communication Centre (C3)
- Feasibility Study -
10 September 2013)

17 assumed normal operating condition

Heating energy is provided by a normal gas boiler, the estimated efficiency factor of the heating system is ~80%. The heating consumers are panel heaters with thermostatic valves. The fresh air supply is ensured with air handling units which include only supply sections. For exhausting individual fan systems are installed. The ventillation systems are installed without heat recovery.The cooling energy is ensured by an external compact chiller unit; the 7/12°C fluid is circulated to the fan coil and air handling units. The estimated ESEER value of the cooling system is 2,8.

18 options

During the research process we investigated available HVAC options, with the conclusion that there are either no breakthrough solutions on the market yet, or their costs are too high under present Hungarian conditions.

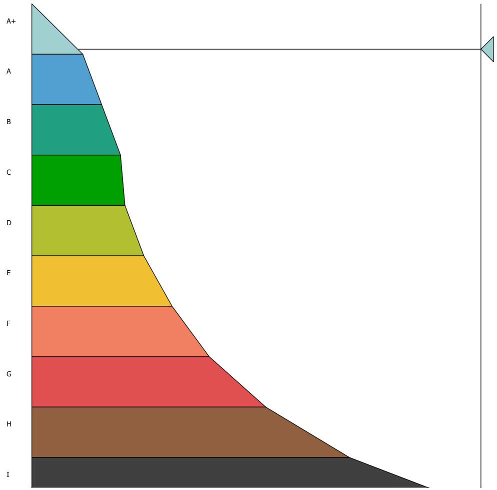
19 ventilation

With regard to the protection of the environment and sustainable development, the European Parliament and Council Directive 2010/31 EU was adopted on the basis of which the EN 13053 norm classifying air handling units was created and introduced. The energy efficiency of air handling units depends on many parameters but based on experience, heat recovery efficiency is the most significant.

21 calculations for the new condition

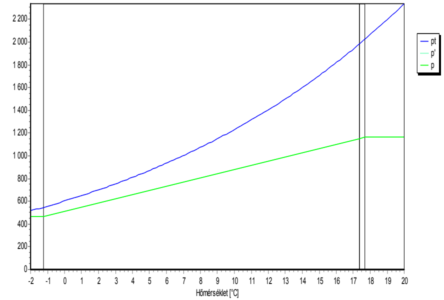
Energy Performance Calculation Summary

Specific primary energy need of the building:	207,2	kWh/m²a
Requirement value (base line):	414,7	kWh/m²a
The energy performance of the building related to the required value:	50,0	%
Energy performance level:	A+	(highly energy efficient)



STRUCTURES:

External Wall (insulated)



Type:	external wall	
Calculated coefficient of heat transmission:	0.29 W/m^2K	
Required value:	0.45 W/m^2K	

A calculated coefficient of heat transmission is ACCEPTABLE!

Coefficient of heat transmission modification part:	30 %	
Resultant coefficient of heat transmission:	0,38 W/m^2K	
Damping factor:	8119,36	
Delays:	2,4 h	
Specific weight:	1272 kg/m^2	
Specific thermal mass:	1 kg/m^2	
Surface air condition at -15 °C:	18,7 °C	54%
External air condition:	-2.0 °C	90%
Internal air condition:	20.0 °C	50%
External heat transfer coefficient:	24.00 W/m^2K	
Internal heat transfer coefficient:	8.00 W/m^2K	
Diffusion period:	180 day	

Layer name (from inside to outside)	No. -	d [cm]	λ [W/mK]	κ -	R [m^2K/W]	δ [g/msMPa]	Rv [m^2sMPa/g]	μ -	c [kJ/kgK]	ρ [kg/m^3]
small loam brick	1	72	0,72	-	1	0,033	21,818	-	0,88	1700
plaster	2	1,5	0,87	-	0,017241	0,024	0,625	-	0,92	1700
YTONG MULTIPOR	3	10	0,045	-	2,2222	-	1,62	3	0,85	115

Window (new)

Type:	window	
Coefficient of heat transmission:	2.00	W/m^2K
Required value:	2.00	W/m^2K

A calculated coefficient of heat transmission is ACCEPTABLE!

Glazing ratio:	95 %	

Door (new)

Type:	door	
Coefficient of heat transmission:	3.00	W/m^2K
Required value:	2.00	W/m^2K

A calculated coefficient of heat transmission is NOT ACCEPTABLE!

Glazing ratio:	60 %	

Floor

Type:	floor	
y size:	1.0	m
Calculated coefficient of heat transmission:	1.15	W/m^2K
Required value:	0.50	W/m^2K

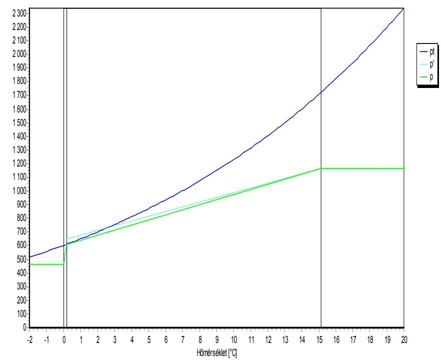
A calculated coefficient of heat transmission is NOT ACCEPTABLE!

Line coefficient of heat transmission:	0.60	W/mK
Damping factor:	55.03	
Delays:	14.0	h
Specific weight:	840	kg/m^2
Specific thermal mass:	493	kg/m^2
Floor heat-absorption factor:	1.768	$kJ/m^2Ks^{1/2}$
Floor classificaion:	cold	

Surface air condition at -15 °C: 13.3 °C 77%
External air condition: -2.0 °C 90%
Internal air condition: 20.0 °C 50%
External heat transfer coefficient: 0.00 W/m²K
Internal heat transfer coefficient: 6.00 W/m²K
Floor height: -1.4 m
Diffusion period: 180 day

Layer name (from outside)	No. -	d [cm]	λ [W/mK]	κ -	R [m²K/W]	δ [g/msMPa]	Rv [m²sMPa/g]	μ -	c [kJ/kgK]	ρ [kg/m³]
gravel filling	1	20	0,35	-	0,57143	0,072	2,7778	-	0,84	1800
concrete	2	20	1,55	-	0,12903	0,008	25	-	0,84	2400

Roof (new)
Type: roof
y size: 1.0 m
Calculated coefficient of heat transmission: 0,1 W/m²K
Required value: 0.25 W/m²K
A calculated coefficient of heat transmission is ACCEPTABLE!
Coefficient of heat transmission: 0,1 W/m²K
Damping factor: 540,21
Delays: 14,4 h
Specific weight: 89 kg/m²
Specific thermal mass: 1 kg/m²
Surface air condition at -15 °C: 19,6 °C 51%
External air condition: -2.0 °C 90%
Internal air condition: 20.0 °C 50%



External heat transfer coefficient: 24.00 W/m²K
Internal heat transfer coefficient: 10.00 W/m²K
Diffusion period: 180 day

Layer name (from outside)	No. -	d [cm]	λ [W/mK]	κ -	R [m²K/W]	δ [g/msMPa]	Rv [m²sMPa/g]	μ -	c [kJ/kgK]	ρ [kg/m³]
slate	1	0,5	1,4	-	0,0035714	0,01	0,5	-	0,92	2650
wood covering	2	4	0,13	-	0,30769	0,028	1,4286	-	2,51	400
mineral wool insulation	3	40	0,044	-	9,0909	0,13	3,0769	-	0,75	150

BOUNDING STRUCTURES: name	orientation	angle [°]	U [W/m²K]	A [m²]	Ψ [W/mK]	L [m]	AU*+LΨ [W/K]	$A_ü$ [m²]	Q_{sd} [W]	Q_{sd} [kWh/a]	$Q_{sdnyár}$ [W]
external wall	NE	vertical	0,381	269,0	-	-	102,5	-	-	-	-
window	NE	vertical	2	58,1	-	-	116,22	55,2	894	3312,9	3911
door	NE	vertical	2	10,9	-	-	21,755	6,5	106	391,7	462
external wall	SE	vertical	0,381	451,1	-	-	171,85	-	-	-	-
window	SE	vertical	2	140,8	-	-	281,68	133,8	2167	8029,1	12599
door	SE	vertical	2	7,1	-	-	14,235	4,3	69	256,3	402
external wall	SW	vertical	0,381	265,1	-	-	101,02	-	-	-	-
window	SW	vertical	2	62,0	-	-	123,98	58,9	954	3533,9	5433
door	SW	vertical	2	10,9	-	-	21,755	6,5	106	391,7	602
external wall	NW	vertical	0,381	454,3	-	-	173,09	-	-	-	-
window	NW	vertical	2	144,7	-	-	289,41	137,5	2227	8249,6	9655
roof	SE	30°-os	0,105	723,6	-	-	75,978	-	-	-	-
roof	NW	30°-os	0,105	723,6	-	-	75,978	-	-	-	-
floor			-	1295,0	0,6	160,0	96	-	-	-	-
basement wall			-	434,8	1,25	131,6	164,48	-	-	-	-

ε:	0.75	(radiation recovery factor)
A:	5051.0 m^2	(total bounding surface of the heated space)
V:	22814.2 m^3	(heated space volume)
A/V:	0.221 m^2/m^3	(surface-volume ratio)
$Q_{sd}+Q_{sid}$:	(24165 + 0) * 0,75 = 18124 kWh/a	(radiation heat gain)
ΣAU + ΣlΨ:	1829.9 W/K	

$q = [ΣAU + ΣlΨ - (Q_{sd} + Q_{sid})/72]/V = (7853,1 - 18124 / 72) / 22814,2$

q:	**0.069 W/m³K**	(calculated specific heat loss factor)
q_{max}:	**0.200 W/m³K**	(required specific heat loss factor)

The specific heat loss factor of the building is ACCEPTABLE!

Energy performance calculation

Building function: Other

A_N:	2590.5 m^2	(heated area)
n:	0.80 1/h	(av. natural ventilation rate during heating)
σ:	1.00	(intermittent operating factor)
$Q_{sd}+Q_{sid}$:	(6,52 + 0) * 0,75 = 4,89 kW	(solar heat gain)
q_b:	5.00 W/m^2	(av. internal heat gain)
$E_{vil,n}$:	50.00 kWh/m^2a	(annual net energy need for lighting)
q_{HMV}:	20.00 kWh/m^2a	(annual net energy need for domestic hot water)
$n_{nyár}$:	6.00 1/h	(natural ventilation rate during summer)
$Q_{sdnyár}$:	33,07 kW	(solar heat gain in summer)

Energy needs calculated from specific data

$Q_b = ΣA_N q_b$:	12952 W	(total of internal heat gains)
$ΣE_{vil,n} = ΣA_N E_{vil,n}$:	46629 kWh/a	(annual net energy need for lighting)
$Q_{HMV} = ΣA_N q_{HMV}$:	51810 kWh/a	(annual net energy need for domestic hot water)

$V_{átl} = \Sigma V_n$:	3.5 m^3/h	(av. ventilation air flow during heating)
$V_{LT} = \Sigma V_{nLT} * Z_{LT}/Z_F$:	13360.0 m^3/h	(ventilation air flow during operation period)
$V_{inf} = \Sigma Vn_{inf} * (1-Z_{LT}/Z_F)$:	0.0 m^3/h	(ventilation air flow during out of operation period)
$V_{dt} = \Sigma(V_{átl} + V_{LT}(1-\eta) + V_{inf})$:	4679,5 m^3/h	(air flow for the winter equilibrium temperature difference)
$V_{nyár} = \Sigma Vn_{nyár}$:	136884.9 m^3/h	(ventilation air flow during summer)

Calculation of the Annual net energy need for heating

$\Delta t_b = (Q_{sd} + Q_{sid} + Q_b) / (\Sigma AU + \Sigma l\Psi + 0{,}35V_{dt}) + 2$

$\Delta t_b = (4892 + 12952{,}5) / (1829{,}9 + 0{,}35 * 4679{,}52) + 2 = 7.1\ °C$

t_i:	20.0 °C	(av. internal temperature)
H:	73125 hK/a	(heating degree days)
Z_F:	4695 h/a	(annual heating hours)

$Q_F = H[V_q + 0{,}35\Sigma V_{inf,F}]\sigma - P_{LT,F}\text{-}Z_F - Z_F Q_b$

$Q_F = 125 * (22814{,}2 * 0{,}069 + 0{,}35 * 3{,}5) * 1 - -6216 * 4{,}695 - 4{,}695 * 12952{,}5 = 83{,}57$ MWh/a

$\mathbf{q_F}$**:**	**32,26 kWh/m²a**	(annual net energy need for heating)

112,7 MWh/a

$\mathbf{q_{LT,h}}$**:**	**43,52 kWh/m²a**	(annual net energy need for ventilation system)

Control the risk of overheating in summer

$\Delta t_{bnyár} = (Q_{sdnyár} + Q_b) / \Sigma AU + \Sigma l\Psi + 0{,}35V_{nyár})$

$\Delta t_{bnyár} = (33066 + 12952{,}5) / (1829{,}9 + 0{,}35 * 136885) = 0.9\ °C$

$\Delta t_{bnyármax}$:	3.0 °C	(the temperature difference from overheating)

The overheating in summer is acceptable.

Heating system

A_N:	2590.5 m^2	(the heated area belongs to the system)
q_f:	32,26 kWh/m^{2}a	(annual net energy need for heating)

Heat pump with geothermal source, heating medium temp. 55/45°C

e_f:	2,50	(electricity, primer energy conversion factor)
C_k:	0,27	(boiler efficiency)
$q_{k,v}$:	0.00 kWh/m^{2}a	(auxiliary energy need)

Two-pipe heating system with central control device

$q_{f,h}$:	3,30 kWh/m^{2}a	(the specific energy loss of the control accuracy)

The distribution system is installed in the heated space, heating system temp. 55/45°C

$q_{f,v}$:	1,20 kWh/m^{2}a	(the specific energy loss for the distribution)

Constant speed pump. temp. gradient 10 K

E_{FSz}:	0,46 kWh/m^{2}a	(the specific energy loss for the circulation)

Energy loss of buffering 55/45°C

$q_{f,t}$:	0.00 kWh/m^{2}a	(the specific energy loss of buffering and the auxiliary energy loss)
E_{FT}:	0.07 kWh/m^{2}a	

$E_F = (q_f + q_{f,h} + q_{f,v} + q_{f,t})\Sigma (C_k \alpha_k e_f) + (E_{FSz} + E_{FT} + q_{k,v})e_v$

$\mathbf{E_F}$ = (32,26 + 3,3 + 1,2 + 0) * 0,675 + (0,46 + 0,07 + 0) * 2,5 = **26.14 kWh/m²a**

Domestic hot water making

A_N:	2590.5 m^2	(the area belongs to the system)
q_{HMV}:	20.00 kWh/m^2a	(annual specific net energy need for domestic hot water)

Heat pump with geothermal source, heating medium temp. 55/45°C

e_{HMV}:	2,50	(electricity, primer energy conversion factor)
C_k:	0,26	(the heater efficiency)
E_k:	0.00 kWh/m^2a	(auxiliary energy need)

The distribution system is installed in the heated space, without circulation system

$q_{HMV,v}$:	10.00 %	(the specific energy loss for distribution)
E_C:	0.00 kWh/m^2a	(the specific energy loss circulation)

The electric heater installed in the heated space

$q_{HMV,t}$:	7.00 %	(the specific energy loss for the storage)

$E_{HMV} = q_{HMV}(1 + q_{HMV,v}/100 + q_{HMV,}t/100)\ \Sigma(C_k \alpha_k e_{HMV}) + (E_C + E_k)e_v$

$\mathbf{E_{HMV}}$ = 20 * (1 + 0,1 + 0,07) * 0,65 + (0 + 0) * 2,5 = **15.21 kWh/m2a**

Ventilation

A_{LT}:	1000.0 m^2	(the area belongs to the system)
n_{LT}:	1.36 1/h	(ventilation rate during operation period)
n_{inf}:	0.00 1/h	(ventilation rate during out of operation)
$V_{LT} = V_{nLT}$:	12000.0 m^3/h	(air supply during operation period)
η_r:	65.0 %	(efficiency of heat recovery)
Z_{LTr}/Z_F:	0.000	(operation period (only heat recovery, no heating))
t_{bef}:	20.0 °C	(the temperature of supplied air)
Z_{LTbef}/Z_F:	0.400	(operation rate (with heating))

$Q_{LT,h} = 0{,}35V_{LT}(1 - \eta_r)(t_{bef} - 4)Z_{LTbef}/Z_F{*}Z_F$

$Q_{LT,h}$ = 0,35 * 12000 * (1 - 0,65) * (20 - 4) * 0,4 * 4,695 = **44,17 MWh/a**

$q_{LT,h}$:	44,17 kWh/m²a	(annual net energy need for ventilation)

Heat pump with geothermal source, heating medium temp. 55/45°C

e_{LT}:	2,50	(electricity, primer energy conversion factor)
C_k:	1.15	(heat pump efficiency)
$E_{LT,k}$:	0.00 kWh/m²a	(auxiliary energy need)

air suplly temperature is above 20 °C, central control system

$f_{LT,sz}$:	10.00 %	(the specific energy loss of the control accuracy)
V_{LT}:	12000.0 m³/h	(the air supply voume)
Δp_{LT}:	500 Pa	(the static pressure loss)
η_{vent}:	55.0 %	(the fan efficiency)
$Z_{a,LT}$:	3650 h	(annual operation time of the ventilation)

$E_{vent} = V_{LT}\Delta p_{LT}/3600/\eta_{vent}Z_{a,LT}/1000$

E_{vent} = 12000 * 500 / 3600 / 0,55 * 3650 / 1000 = 11061 kWh/a

$E_{LT} = (q_{LT,n}(1 + f_{LT,sz}) + Q_{LT,v}/A_N)\ \Sigma C_k \alpha_k e_{LT} + [(E_{vent} + E_{LT,s})/A_N + E_{LT,k}Z_{LT}/_{ZF}]e_v$

E_{LT} = (44,17 * (1 + 0,1) + 0 / 1000) * 0,675 + ((11061 + 0) / 1000 + 0 * 0,4) * 2,5 = **60.45 kWh/m²a**

Ventilation

A_{LT}:	1000.0 m²	(the area belongs to the system)
n_{LT}:	1.68 1/h	(ventilation rate during operation period)
n_{inf}:	0.00 1/h	(ventilation rate during out of operation)
$V_{LT} = V_{nLT}$:	14800.0 m³/h	(air supply during operation period)
η_r:	65.0 %	(efficiency of heat recovery)

Z_{LTr}/Z_F:	0.000	(operation period (only heat recovery, no heating))
t_{bef}:	17.0 °C	(the temperature of supplied air)
Z_{LTbef}/Z_F:	0.400	(operation rate (with heating))

$Q_{LT,h} = 0,35V_{LT}(1 - \eta_r)(t_{bef} - 4)Z_{LTbef}/Z_F{*}Z_F$

$Q_{LT,h}$ = 0,35 * 14800 * (1 - 0,65) * (17 - 4) * 0,4 * 4,695 = 44,26 MWh/a

$q_{LT,h}$:	**44,26 kWh/m²a**	(annual net energy need for ventilation)

Heat pump with geothermal source, heating medium temp. 55/45°C

e_{LT}:	2,50	(electricity, primer energy conversion factor)
C_k:	1.15	(heat pump efficiency)
$E_{LT,k}$:	0.00 kWh/m²a	(auxiliary energy need)

Air suplly temperature is below 20 °C, central control system

$f_{LT,sz}$:	0.00 %	(the specific energy loss of the control accuracy)
V_{LT}:	14800.0 m³/h	(the air supply voume)
Δp_{LT}:	500 Pa	(the static pressure loss)
η_{vent}:	50.0 %	(the fan efficiency)
$Z_{a,LT}$:	1878 h	(annual operation time of the ventilation)

$E_{vent} = V_{LT}\Delta p_{LT}/3600/\eta_{vent}Z_{a,LT}/1000$

E_{vent} = 14800 * 500 / 3600 / 0,5 * 1878 / 1000 = 7720,7 kWh/a

$E_{LT} = (q_{LT,n}(1 + f_{LT,sz}) + Q_{LT,v}/A_N)\ \Sigma C_k \alpha_k e_L + [(E_{vent} + E_{LT,s})/A_N + E_{LT,k}Z_{LT}/Z_F]e_v$

E_{LT} = (44,26 * (1 + 0) + 0 / 1000) * 0,675 + ((7720,7 + 0) / 1000 + 0 * 0,4) * 2,5 = **49.18 kWh/m²a**

Ventilation

A_{LT}:	590.0 m^2	(the area belongs to the system)
n_{LT}:	1.27 1/h	(ventilation rate during operation period)
n_{inf}:	0.00 1/h	(ventilation rate during out of operation)
$V_{LT} = V_{nLT}$:	6600.0 m^3/h	(air supply during operation period)
η_r:	65.0 %	(efficiency of heat recovery)
Z_{LTr}/Z_F:	0.000	(operation period (only heat recovery, no heating))
t_{bef}:	20.0 °C	(the temperature of supplied air)
Z_{LTbef}/Z_F:	0.400	(operation rate (with heating))

$Q_{LT,h} = 0{,}35VLT(1 - \eta_r)(t_{bef} - 4)Z_{LTbef}/Z_F{*}Z_F$

$Q_{LT,h} = 0{,}35 * 6600 * (1 - 0{,}65) * (20 - 4) * 0{,}4 * 4{,}695 = 24{,}29$ MWh/a

$\mathbf{q_{LT,h}}$:	**41,18 kWh/m2a**	(annual net energy need for ventilation)

Heat pump with geothermal source, heating medium temp. 55/45°C

e_{LT}:	2,50	(electricity, primer energy conversion factor)
C_k:	1.15	(heat pump efficiency)
$E_{LT,k}$:	0.00 kWh/m^2a	(auxiliary energy need)

Air suplly temperature is above 20 °C, central control system

$f_{LT,sz}$:	10.00 %	(the specific energy loss of the control accuracy)
V_{LT}:	6600.0 m^3/h	(the air supply voume)
Δp_{LT}:	500 Pa	(the static pressure loss)
η_{vent}:	50.0 %	(the fan efficiency)
$Z_{a,LT}$:	1878 h	(annual operation time of the ventilation)

$E_{vent} = V_{LT}\Delta p_{LT}/3600/\eta_{vent}Z_{a,LT}/1000$

E_{vent} = 6600 * 500 / 3600 / 0,5 * 1878 / 1000 = 3443 kWh/a

$E_{LT} = (q_{LT,n}(1 + f_{LT,sz}) + Q_{LT,v}/A_N)\ \Sigma C_k \alpha_k e_L + [(E_{vent} + E_{LT,s})/A_N + E_{LT,k}Z_{LT}/Z_F]e_v$

E_{LT} = (41,18 * (1 + 0,1) + 0 / 590) * 0,675 + ((3443 + 0) / 590 + 0 * 0,4) * 2,5 = **45.16 kWh/m²a**

Cooling system

$A_{hű}$:	2590.5 m²	(the area belongs to the system)
$Q_{hű,n}$:	3,32E5 kWh/a	(the annual net energy need for cooling)
$Z_{hű}$:	1800 h	(the time period of cooling)
$V_{hű}$:	0.0 m³/h	(the air supply voume)

Chiller unit with compressor (split) EER=2,5

e_f:	2.50	(electricity, primer energy conversion factor)
C_k:	0.20	(chiller efficiency)
$q_{k,v}$:	0.00 kWh/m²a	(auxiliary energy need)
$\Delta p_{hű}$:	500 Pa	(the static pressure loss)
η_{vent}:	70.0 %	(the fan efficiency)

$E_{vent} = V_{LT}\Delta p_{LT}/3600/\eta_{vent}Z_{a,LT}/1000$

E_{vent} = 0 * 500 / 3600 / 0,7 * 1800 / 1000 = 0 kWh/a

Central control system

$f_{hű,sz}$:	10.00 %	(the specific energy loss of the control accuracy)

$E_{hű} = (Q_{hü,n}(1 + f_{hű,sz)} + Q_{hű,v})/A_N * \Sigma C_k \alpha_k e_{hû} + (E_{vent} + E_{hű,s} + Q_{hű,k}Z_{hű})e_{v/}A_N$

$E_{hű}$ = (332000 * (1 + 0,1) + 0) / 2591 * 0,5 + (0 + 0 + 0 * 1800) / 2591 * 2,5 = **70.49 kWh/m²a**

Lighting system

A_N: 2590.5 m^2 (the area belongs to the system)

υ: 0.95 (correction factor)

$E_{vil} = (\Sigma E_{vil,n}/A_N)\ \upsilon e_v$

E_{vil} = 18 * 0,95 * 2,5 = **42,75 kWh/m²a**

The total energy need of the building

$(\Sigma A_{LT,i} * E_{LT,i})/A_N$ = (1000,0 m^2 * 228,27 kWh/m^2a + 1000,0 m^2 * 207,01 kWh/m^2a + 590,0 m2 * 205,42 kWh/m^2a)/2590,5 m2 = 214,81 kWh/m^2a

$E_P = E_F + E_{HMV} + E_{vil} + E_{LT} + E_{hű} + E{+-}$ = 254,92 + 58 + 59,375 + 214,81 + 157,11 + 0

E_P: 207,18 kWh/m²a (the calculated specific total energy need)

E_{Pmax}: 414,72 kWh/m²a (the permitted specific total energy need)

Estimated annual CO_2 emissions: 78,36 t/a

The calculation is prepared in accordance with 7/2006. TNM decree and the 7/2006. (IV. 6.) BM decree.

bibliography

Az Óbudai Gázgyár története, Dr. Gulyásné Gömöri Anikó, Dr. Balogh András, Vadas Ferenc, Fővárosi Gázművek Rt., Budapest, 2004

Fiókgázgyárak Budapesten, Dr Gulyásné Gömöri Anikó, Dr. Balogh András, Vadas Ferenc, Fővárosi Gázművek Rt., Budapest, 2001

Az első gázgyár, Dr Gulyásné Gömöri Anikó, Dr. Balogh András, Vadas Ferenc, Fővárosi Gázművek Rt., Budapest, 1999

Fővárosi gázművek 1856-1945 I. Kötet, Dr. Vida Miklós, Gömöri Géza, Fővárosi Gázművek, 1982

Fővárosi gázművek 1945-1965 II. Kötet, Gömöri Géza, Mihók Béla, Berek János, Bánki László, Fővárosi Gázművek, 1982

Fővárosi gázművek 1966-1991 III. Kötet, Dr. Szűcs Miklós, Nagy Bíró Sándor, Fővárosi Gázművek, 1991

Fővárosi gázművek 1992-2006 IV. Kötet, Czoch Árpád, Csallóközi Zoltán, Rékasi Balázs, Dr Vasanits Dezső, Blaháné Kerecsényi Judit, Kertész Péter, Palasik Márton, Fővárosi Gázművek, 2006

A fővárosi gázszolgáltatás 150 éve, Dr Balogh András, Dr. Gulyásné Gömöri Anikó, Vadas Ferenc, Budapest, 2006

bibliography

webpages

http://hgd.hu/hu/epuletenergetikai-direktiva-epbd

http://lasdbudapestet.blogspot.hu/2013/10/obudai-gazgyar.html

http://hvg.hu/itthon/20110623_megmentik_a_gazgyarat

http://hvg.hu/kultura/20130517_obudai_gazgyari_lakotelep_riport

http://www.vgfszaklap.hu/lapszamok/2011/januar-februar/az-óbudai-gázgyár-története-i

http://www.vgfszaklap.hu/lapszamok/2011/marcius/az-óbudai-gázgyár-

http://obuda.hu/hirek/gyarbol-egyetem/története-ii

http://tablet.magyarnarancs.hu/belpol/az_obudai_gazgyar_projekt_-_piszkos_foldek-65583?pageId=39

http://www.agt.bme.hu/tantargyak/bsc/bmeeoafasi4/BMEEOAFASI4_ea_05.pdf

http://www.vati.hu/files/sharedUploads/docs/FVR/FVR_2008_2.pdf

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