A2PBEER – Affordable and Adaptable Public Buildings through Energy Efficient Retrofitting

acciona Construction

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G.A. NMP2-SE-2013-609060

SEVENTH FRAMEWORK PROGRAMME

A2PBEER
AFFORDABLE AND ADAPTABLE PUBLIC BUILDINGS THROUGH ENERGY EFFICIENT RETROFITTING

SUSTAINABLE PLACES 2017
June 28 – 30, 2017
MIDDLESBROUGH, UK

Project Overview.

Building and energy solutions to apply an "Affordable and Adaptable Public Building through Energy Efficiency retrofitting"

- Develop innovative technologies
- Develop a systemic energy retrofitting methodology for Public buildings
- Demonstrate and validate the methodology of retrofitting and use of the developed kits at three demonstration sites.
- Replicability validated further with virtual sites.
- Implement and exploit a training programme to provide training across Europe.
- www.a2pbeer.eu

Technologies.

- Building Envelope
- Reversible Window
- Smart Lighting
- Smart Dual Thermal Substation

Building Envelope

- External super insulated façade retrofitting system
- Internal super insulated façade retrofitting system

Vacuum Insulation Panel (VIP)

Using a VIP core material of **fumed silica** (thermal conductivity **0.023 W/m.K**) and placed in a **thin metalized polymer laminate** (providing vacuum, air and vapour tightness) and reduces its thermal conductivity to **0.005W/m.K**.

VIP protected by ASFALTEX ASFAPLUS FV 20:

Bituminous vapour barrier roll with a ***glassfibre*** felt **reinforcement and plastic**, adhered to both sides of VIP panel.

The Application

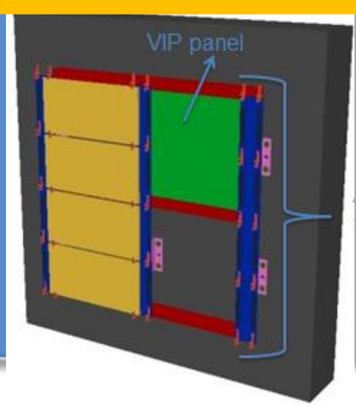
EXTERNAL FACADE

INTERNAL FAÇADE

A2PBEER: Integration of VIP in Facades Systems

- Excellent thermal properties, thermal conductivity **λ=0,005W/mK**
- The system is easy to install and customized to different building requirements
- The insulation thickness lower in comparison to other systems (**30mm instead of 200mm**)

- T profiles
- **Cladding**

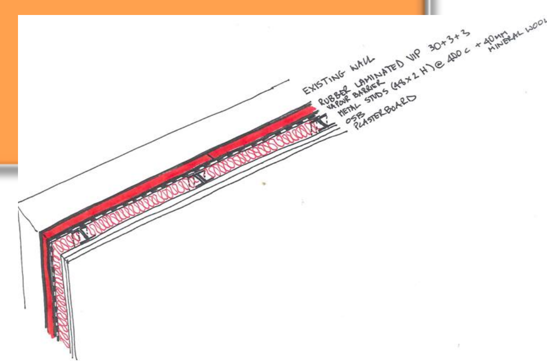


aluminium vertical profiles

- Standardized 46 C **metal studs**

- 9mm OSB board to be used behind the plasterboard

- **Plasterboard** (15mm)



Reversible Window

- **Main issue of existing low emissivity windows:** low e coating is either on the outer (max. solar gain, desirable in winter) or the inner side (min. solar gain, desirable in summer)

- **Breakthrough:** to develop a reversible window, so that users can rotate the sash from *winter* to *summer* position and vice versa to change the position of low e coating to select the right configuration.

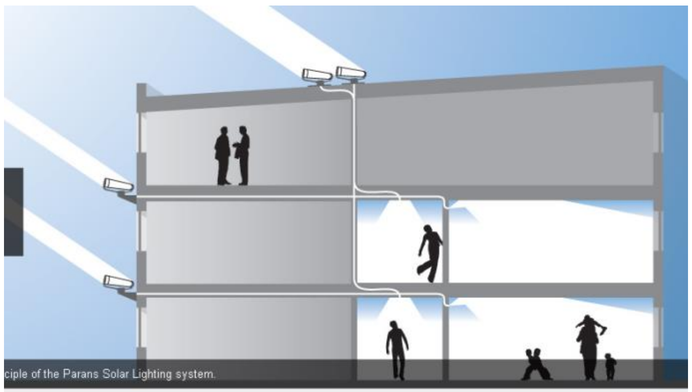
Prototype

Innovative window concept based on the idea of reversing sash in vertical or horizontal positions through the central axis.

- Prototype dimensions 900x1400mm
- Wooden profiles thickness of 90mm.

DUE TO POSSIBLE PATENT APPLICATION NO TECHNICAL DETAILS AND DRAWINGS CAN BE SHARED

Smart Lighting

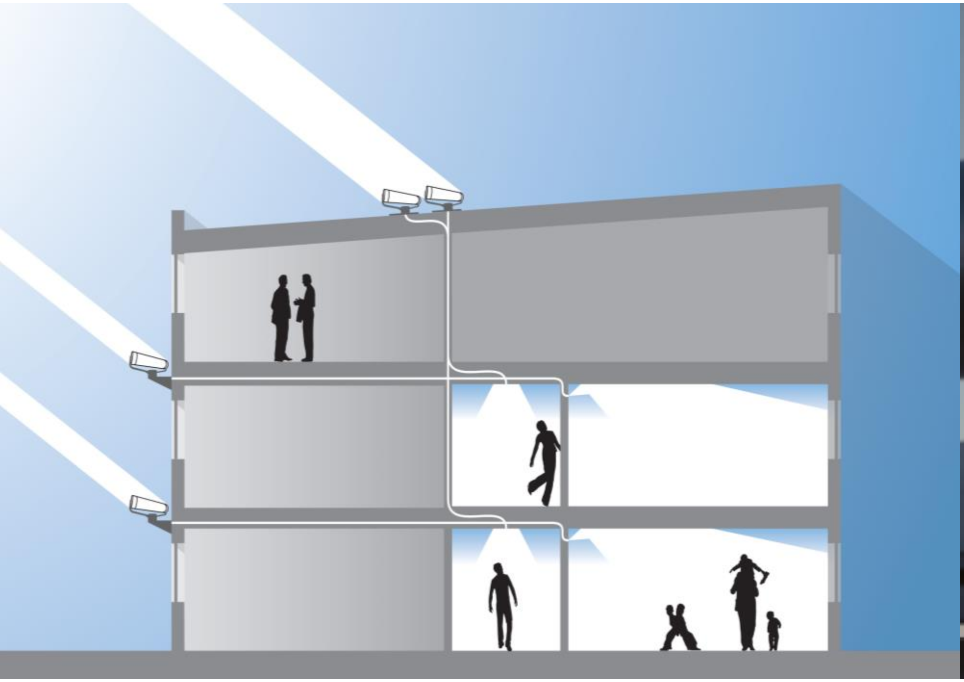


Main Components:

Sunlight collector and a fiber optic system

Hybrid luminaires with LED and diffusers

Controllers: presence detector and light intensity



- Let the sun shine where it never did before, through the flexibility of fiber optic cables
- A solution that makes you less dependent on windows and their position
- Not affected by the location of the sun, the smart receiver follows the sunlight

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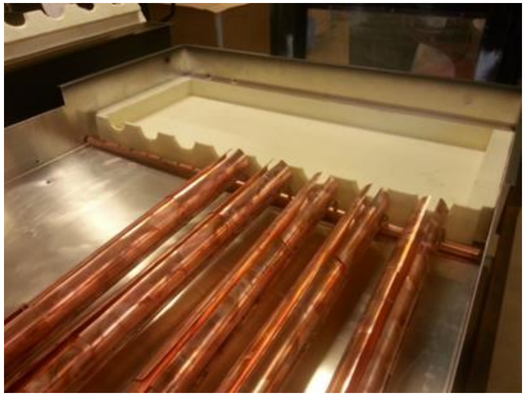
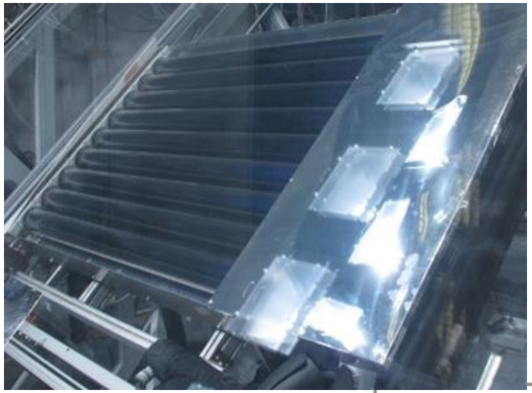
Smart Dual Thermal Network.

- **Dual Thermal Sub-Station**



To maximise efficiency a dual thermal approach to install absorption/ adsorption machines at building level and solar thermal systems with short term storage.

- **Solar Collector System**



A solar collector with combined heating, cooling and energy storage, delivering twice as much energy compared to today's state-of-the-art solar collectors.

Retrofitting Strategies.

- To identify and collect existing data for the update of the Public Buildings and Districts in Europe
- To identify and evaluate EU national policies on legislation related to energy efficiency, environment and cultural heritage
- To analyse the different existing & innovative strategies and technologies at building and district scale
- To analyse the best international retrofitting practices
- To assess the Socio-economic impact of the Public sector retrofitting.

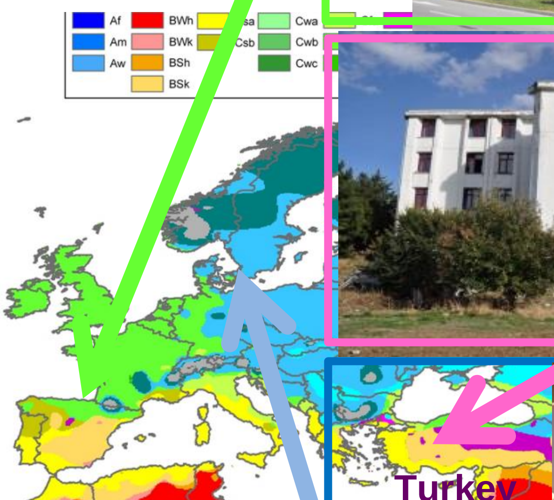
System final installation (real scalevalidation)

Demosites: 3 buildings with different uses and climate

1

Spain (Bilbao)

Office building in University Campus



2

Students dormitory in educational Complex

Turkey (Ankara)

3

Technological museum in mixed uses complex

Sweden (Malmö)

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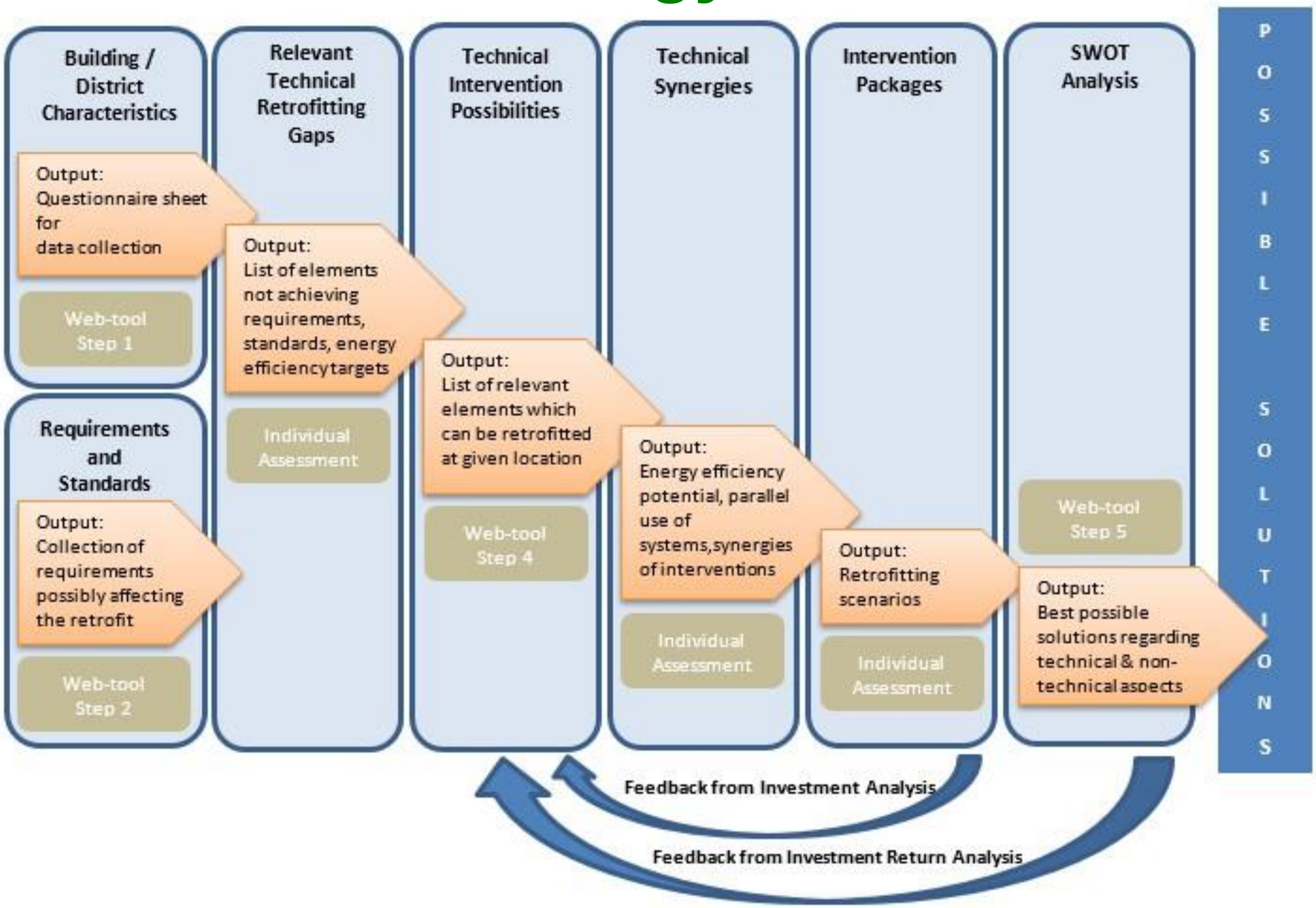
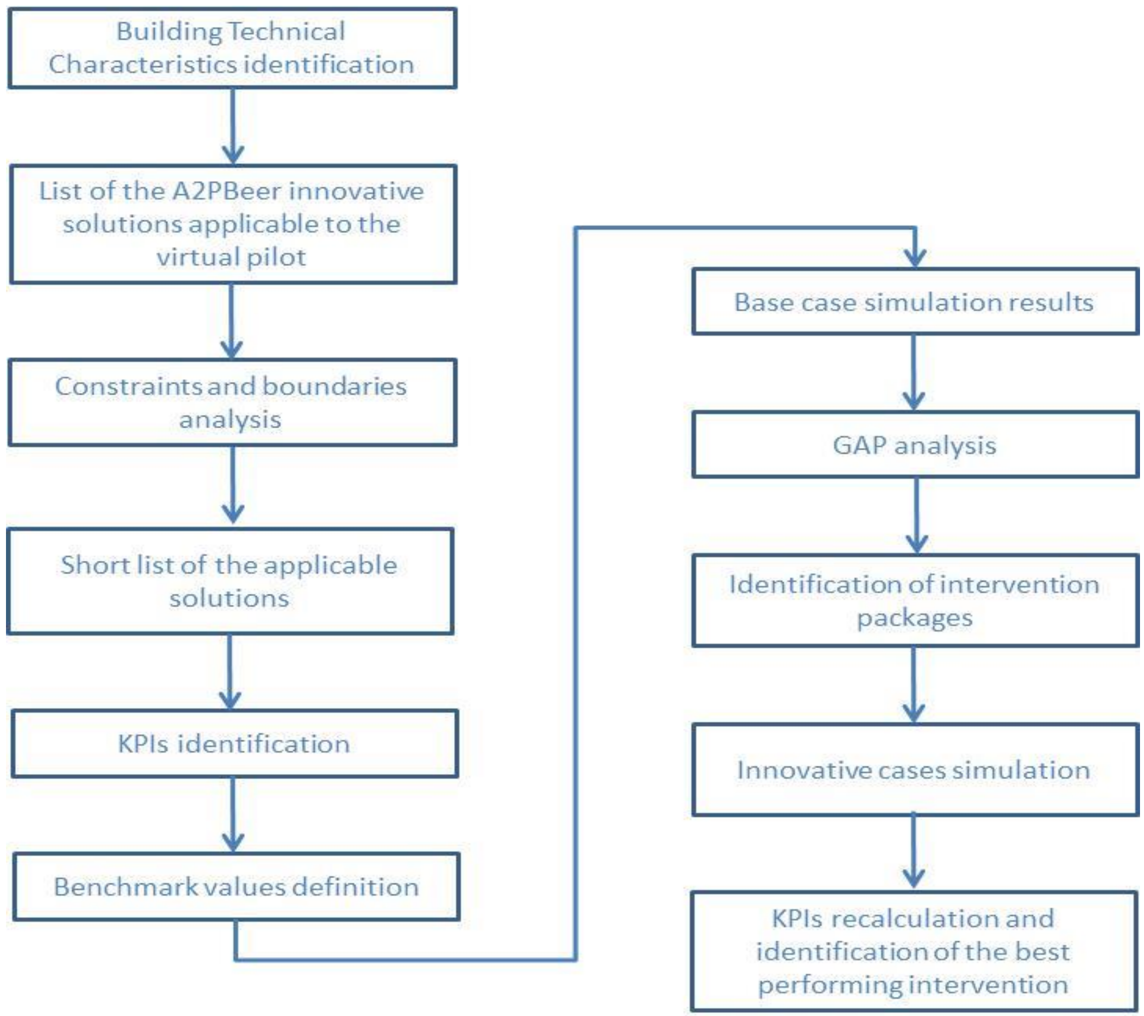
A2PBEER Methodology



A2PBEER Methodology



Replication in close district hospital in Italy, virtual pilot 1

Evaluate and validate the applicability of the retrofitting methodology and the deployment of the innovative solutions developed in the frame of the project on the main Hospital of Genova - Italian virtual pilot.

Hospital Description

Building Description 1

- Inaugurated in 1979
- Surface: ~ 54000 m^2 . is about 30% of the total surface of the entire hospital complex
- Available recovery bed: max 900
- Building height: 50m
- Building length: 180m
- 15 floors (3 underground), with several hospital wards including also critical care and ER, surgery rooms and radiology exams rooms

Building Description 2

- Electric power produced by two stations, each of about 1.3MW. The building is also equipped with hot water delivered via a district heating system, a steam line used to produce both heating and cooling

Description of the main results

- Different intervention packages are proposed and evaluated after the technologies analysis; the best retrofitting intervention is then identified in accordance with the different KPIs used to evaluate the performance.
- The A2PBEER External super –insulated façade retrofitting system perfectly match the need pointed out. In fact the super insulated façade system allows to increase the thermal resistance of the wall of more than 4 m^2K/W (south façade) and more than 3.5 m^2K/W (north façade), allowing both façades to reach an U value lower than **0.25 W/m^2K**

Description of the main results

- The smart window kit developed in A2PBEER project has an U value (U_w) of 1.4 W/m^{2}K, about 40 % lower than the benchmark value. Moreover, the A2PBEER smart window allows to optimize the energy gain during heating and cooling season. In fact thanks to the reversibility through the horizontal central axis of the window and its solar control glazing, the energy gain through the window can be reduced or increased depending on the climatic conditions
- The smart dimming system of the smart lighting kit is not suitable for this building, but using LED decreases the energy demand for lighting.

Description of the main results

- Intervention package 1:
  - VIP, SMART windows, LED system
- Intervention package 2:
  - VIP, LED system
- Intervention package 3:
  - Windows and LED system
- Intervention package 4:
  - Windows and VIP

KPIs	AS-IS scenario values	Retrofitted model Values			
		package 1	package 2	package 3	package 4
Energy Balance					
Mean global heat transfer coefficient [W/m²K]	2.74	1.44	1.99	2.19	1.44
Energy need for heating [kWh/m³y]	45.93	44.66	47.98	42.84	39.73
Energy need for cooling [kWh/m³y]	23.84	14.98	16.39	23.23	16.38
Building energy use					
LENI [kWh/m²y]	54.02	11.86	11.86	11.86	54.02
Energy cost					
PBP	-	14.5 years	10 years	9.3 years	27.4 years

Description of the main results

- The analysis carried out on Italian virtual pilot demonstrates the potentiality of the selected A2PBEER solutions in terms of energy savings and returns of the investment needed.
- With respect PBP KPI the best solution is the intervention package 3 in which lighting system is renovated and windows are substituted.
- Good results in terms of energy savings and PBP are achievable also with intervention package 1 in which all the intervention proposed are applied.
- With reference to the particular climate of Genova with high winter temperatures and very big solar energy contribution during the whole year and to the surfaces affected by the interventions the substitution of the windows is the more suitable solution to apply from a thermal energy point of view.
- The application of the renovated lighting system is decisive to reduce the electricity consumption and make economically reasonable the renovation process.

Replication in open district library in Norway, virtual pilot 2

Evaluate and validate the applicability of the retrofitting methodology and the deployment of the innovative solutions developed in the frame of the project on a cultural heritage library in Oslo - Norwegian virtual pilot.

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Building Description 1

- The Deichman library on Schous plass is a single building located in an urban area of Oslo close to the city centre. It is situated in a small plaza with a park surrounding the building. It was built in 1912 – 1914 and the architect was August Nielsen. It is in the style of nordic Neo-Baroque and consists of a basement, ground floor and first floor covering a total of 1030 m^2. The building is protected as architectural cultural heritage.

Building Description 2

- Open district library
- Built in 1914
- Heated gross area: 860 m^2
- Plastered brick walls
- Old wooden windows with double glazing
- Refurbished roof early 1990s

Description of the main results

		ACTUAL CONDITIONS				NATIONAL BUILDING CODE (KPIs)
		Basement	Principal	Attic	TOTAL	Total
	Final Energy demand [kWh/m²yr]	No Heated	292,55	173,63	233,09	175,00
	Ratio Thermal Power [W/m²]*	No Heated	65,43	39,30	52,36	
U-Value	External Wall	1,20	1,00	1,00	----	0,22
	Roof	----	----	0,20	----	0,18
	Floor	1,00	1,00	1,00	----	0,18
	Window	----	2,50	2,50	----	1,20
	Door	----	2,40	----	----	1,20

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Description of the main results

- Cultural heritage constraints:
    - Building aesthetics are preserved
    - Elements on the rooftop shall be designed with a low profile and not be visible from the street level
    - Windows must have the same appearance from the outside after interventions

Description of the main results

To examine the effects of the different intervention scenarios, five simulation scenarios are developed:

1. Changing windows
2. Insulating slabs
3. Insulation of opaque façade
4. Insulation of opaque façade and slabs
5. Total retrofitting of windows, opaque façade and slabs

Description of the main results

1. **Scenario 1** involves changing the existing windows to the A2PBEER SMART window system using a triple argon filled glazing resulting in a U-value of 0,8 W/m²K, with a g-value in summer (may – sep) of 0,45 and a g-value in winter (oct – apr) of 0,55.
2. **Scenario 2** involves adding insulation to the internal slabs to prevent heat losses to the non-climatised zone and the ground. The slabs are insulated with the A2PBEER VIP panels to an U-value of 0,14 W/m²K
3. **Scenario 3** involves adding A2PBEER VIP insulation panels to the inside of the opaque facade resulting in a U-value of 0,14 W/m²K.
4. **Scenario 4** combines 2 and 3
5. **Scenario 5** combines 1, 2, and 3

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		Final Energy Demand [kWh/m²yr]	Ratio Thermal Power [W/m²]*	Saving final energy demand	Saving ratio thermal demand
	Actual Conditions	233,09	52,36	100%	100%
RETROFITTING	Windows	218,29	49,42	6,35%	5,62%
	Insulation Floors	223,62	51,14	4,06%	2,32%
	Insulation Façades	177,52	41,24	23,84%	21,25%
	Insulation Façades + Floors	177,50	41,20	23,85%	21,31%
	Total Actions	160,40	37,73	31,19%	27,95%

Description of the main results

- This shows that insulation of the opaque facades is the single intervention that gives the largest energy savings. This would also be the most cost-effective. However, this would result in cold downdrafts from the windows rendering large areas unsuitable for occupancy. Therefore applying **scenario 5** will be the optimal scenario considering user comfort.

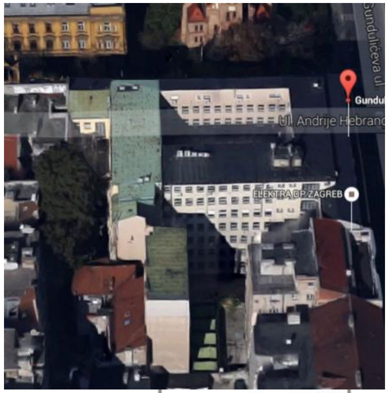
- **Scenario 5** is also the only scenario that satisfies the national building code in regards the final energy demand. This results in energy savings of **31%** from the existing situation.

Replication in open district office building in Croatia, virtual pilot 3

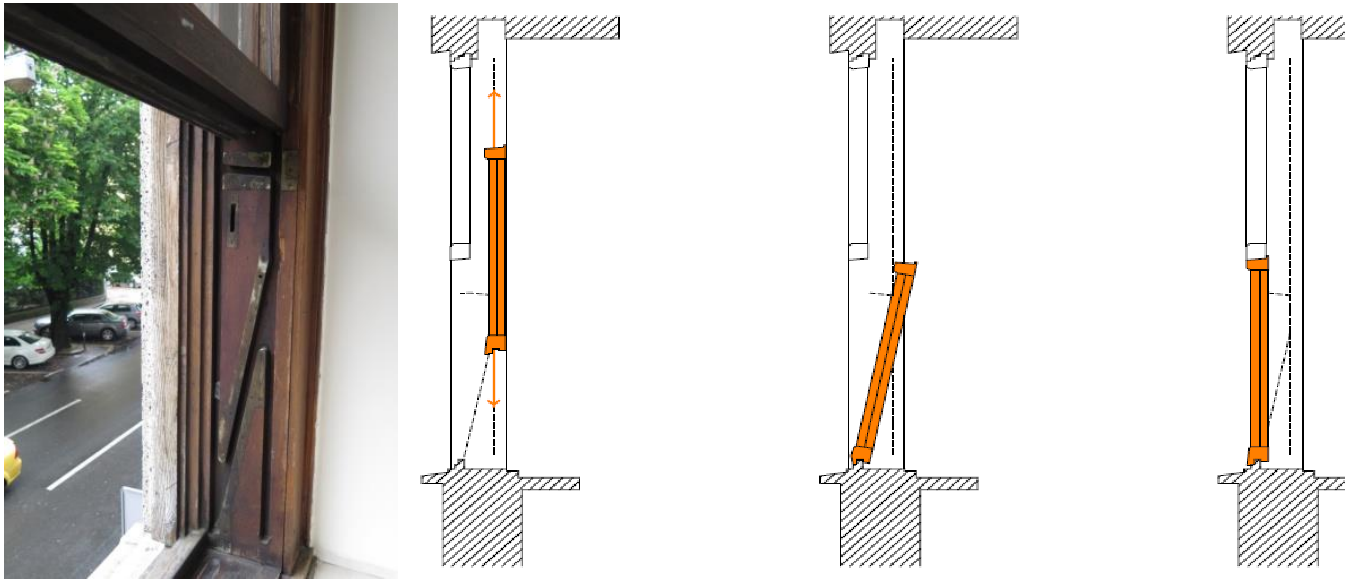
Evaluate and validate the applicability of the retrofitting methodology and the deployment of the innovative solutions developed in the frame of the project in a Croatian citizen services office – Croatian virtual pilot

Building Description 1

- Office building located on Gunduliceva street nº32, an open district area in the city centre of Zagreb, Croatia
- Cultural heritage monument
- Built in 1934 by architect Juraj Denzler
- Total gross area of the building is 12.242 sqm through basement and 7 stories above grade



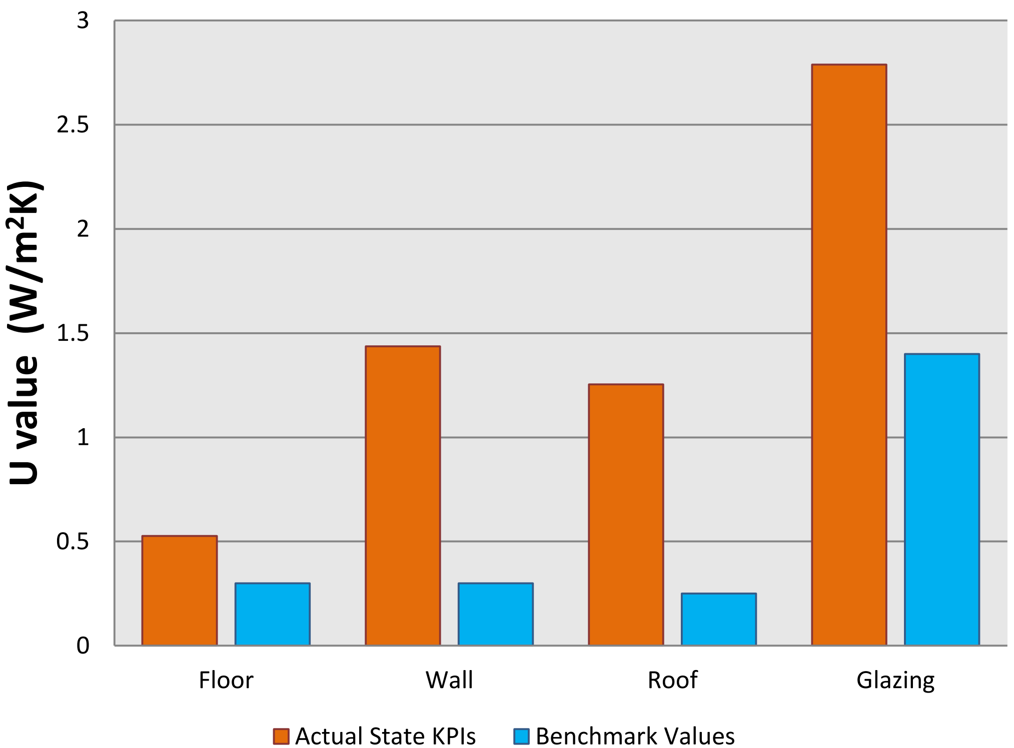
Building Description 2

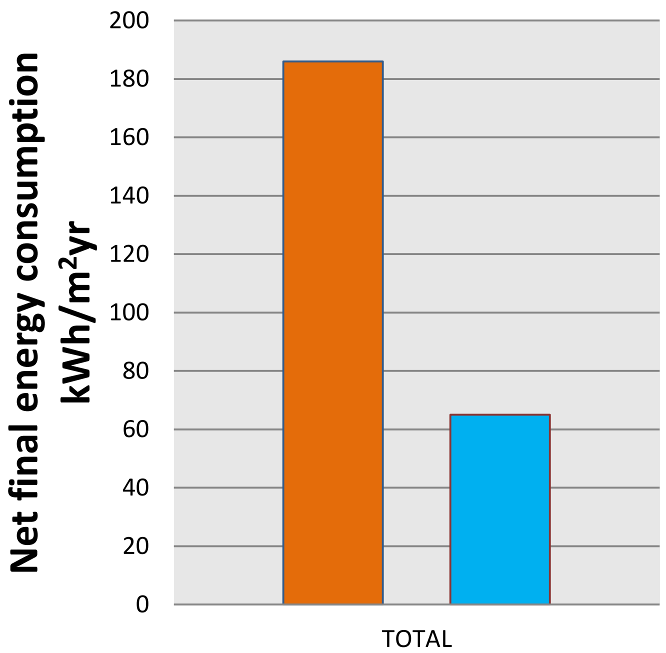


Building Description 3

- The following aspects can be highlighted:
  - Space-heating is the main energy use for the case study
  - The courtyard where are the booths for general public attention is the largest node of energy use in the building, for heating and cooling, in terms of global and specific values.
  - For heating period, north and south orientations have the largest energy demands. Despite in specific values the building seems to be regularly distributed. So zones between basement and ground floor, also 5th floor and Attic shall be well insulated.
  - As expected cooling loads rises proportionally to the building height due to the increased solar availability. An interesting case of study is the western zone on the 5th floor, where loads are unusually bigger than the rest of spaces in the same floor.

Description of the main results



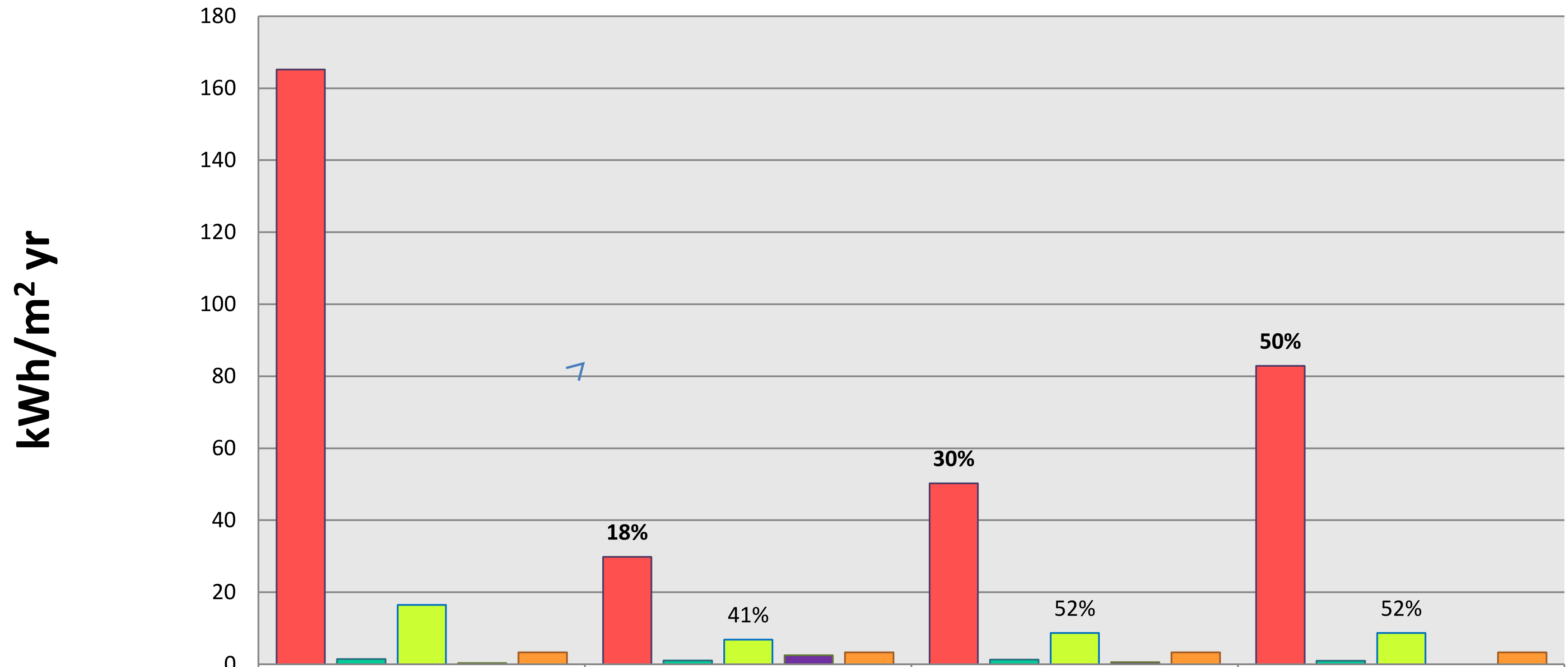


Description of the main results

Constraints due to cultural heritage:

- Building aesthetics must be preserved with special attention to the façades looking the main streets. External intervention on those façades will not be acceptable and elements on the rooftop shall be designed with a low profile.
- Windows located in the north and east façades are also protected by the cultural heritage association, they are patented and specially protected. The only acceptable options are (1) an interior intervention, (2) a substitution with replicated models or (3) dedicated substitution of the panes or glazing units.
- The burden of massive elements such as AHU, accumulation tanks and other heavy equipment is not going to be allowed on the rooftop due to its structural condition and aesthetic preservation.

Comparation of final energy consumption



	Actual State	Scenario 1	Scenario 2	Scenario 3
Heating (Natural Gas)	165.21	29.81	50.24	82.85
Cooling (Electricity)	1.45	1.01	1.26	0.95
Lighting	16.47	6.83	8.66	8.66
Auxilliary energy	0.30	2.51	0.54	0.00
DHW (Electricity)	3.31	3.31	3.31	3.31

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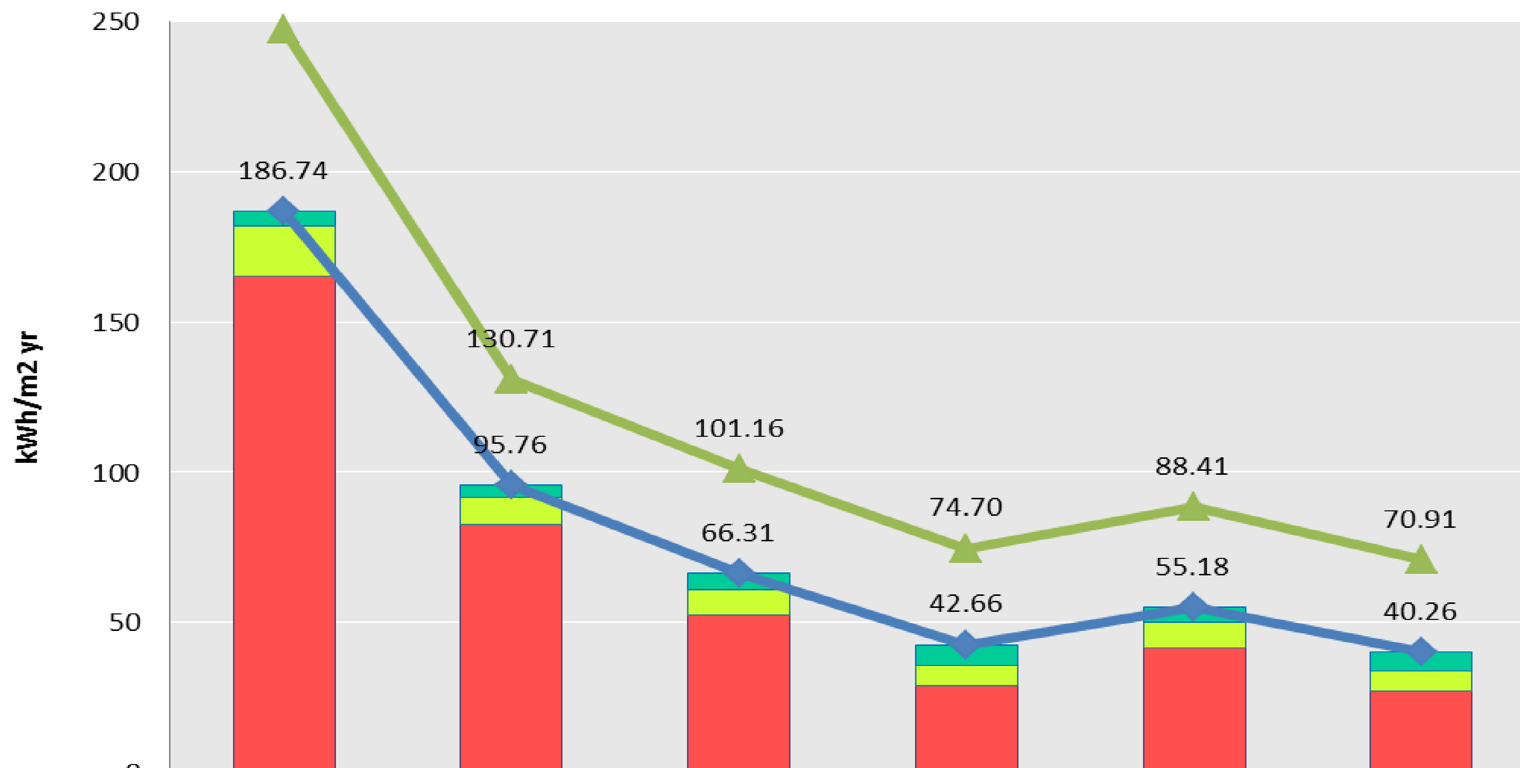
Comparation of final energy consumption



	Baseline	Scenario 3	Scenario 2	Scenario 1	Optimal	[A2PBEER] BEST
Electricity	5.05	4.26	5.41	6.83	5.07	6.26
Lighting	16.47	8.66	8.66	6.83	8.66	6.83
Heating Use (Natural Gas)	165.21	82.85	52.24	29.00	41.45	27.17
Total (FE)	186.74	95.76	66.31	42.66	55.18	40.26
Total (PE)	247.26	130.71	101.16	74.70	88.41	70.91

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Description of the main results

- *Scenario 1* is the most challenging compared to scenario 2 and 3, regarding the integration of technically feasible passive and active systems considering the buildings cultural heritage limitations
- *Optimal* represents the solutions which provide the minimum energy performance/investment cost ratio.
- *A2PBEER best*: represents the scenario with no economical nor technical limitations, and in which the A2PBEER technological solutions use has been maximized

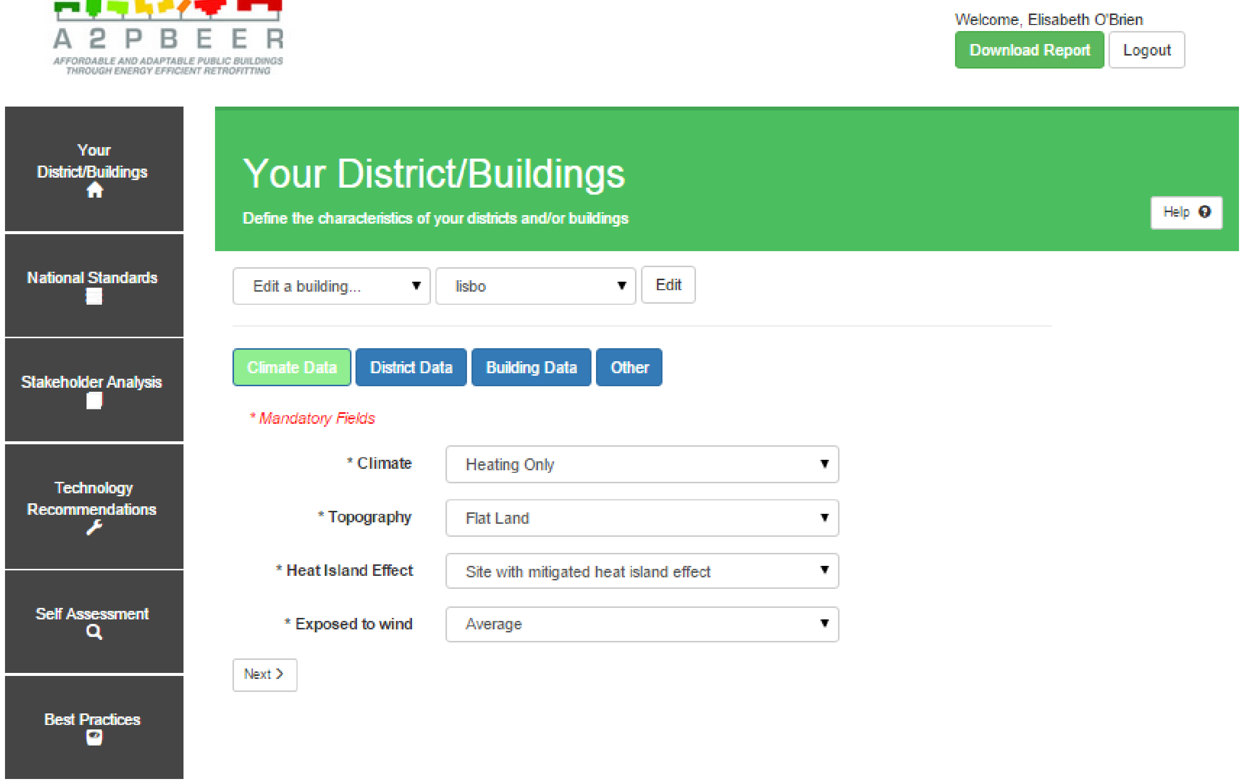
Description of the main results

- Refurbishment on opaque elements, new windows or modification of actual windows, new luminaries and addition of control systems for lighting, air handling units and an installation of renewable energy source have been analysed
- Many constrains for energy retrofitting: The cultural heritage protection, the poor compactness and its deterioration process.
- Deep retrofitting actions focused on passive elements on the building can be cost effective and can lead to energy cuts **between 59 and 70%** (referred to Primary energy) **compared to preintervention status** for the Optimal and most challenging Scenario 1, with **payback periods** between **11 and 18 year depending of the energy price scenario** considered.

Support Guide Toolkit

- Tool developed for assessing best retrofitting plan

  http://retrofit.a2pbeer.eu



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Thank you for attention!

FURTHER INFORMATION ON : www.a2pbeer.eu

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