BRICKER

ENERGY REDUCTION IN PUBLIC BUILDING STOCK

Total Renovation Strategies for Energy Reduction in Public Building Stock

Final report

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Integration of technologies for energy-efficient solutions in the renovation of public buildings

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0 Project Public Summary.

The BRICKER project had the initial objective of demonstrating a package of technological solutions for the renovation of public buildings in Europe. In the proposal presented to the European Commission in 2012, ambitious objectives were set in line with what was recommended by the Commission in the call made to unlock the renovation of the European Public Building stock.

Today, 6 years later, **the BRICKER project has ended with relative success with respect to what was planned then, considering the adversities and limitations encountered when moving along a path full of uncertainties due to the complexity of the European public sector**, and given the peculiarity of the managerial issues related to an innovation project integrated by 19 partners from all over Europe.

The proposed solution entailed the development of passive and active technologies, to be implemented in all three demonstration buildings located in Spain, Turkey and Belgium. In this executive summary we will review these 5 facets of the project (passive, active and the demos) trying to highlight the learnings and the main results.

Regarding **passive technologies**, we have 3 developed systems. The first, the windows with integrated ventilation system developed by Partner GREENCOM, which have been satisfactorily developed in time and specifications. Today, the owner of the technology has a strategic plan to sell units throughout Europe in the coming years. The second passive technology has been developed and demonstrated by ACCIONA; these are the panels of PIR foam with embedded Phase Change Material (PCM) to insulate and increase the thermal inertia of the ceilings in which it is installed. This technology has been developed in collaboration with PURINOVA, and the first known installation of 600 square meters has been installed in a real and functioning building, in our Belgian demonstrator. The solution has great market potential, although perhaps the public sector is not the best to expand its commercialization. The third passive technology, also coordinated by ACCIONA, has been the development of a ventilated façade based on recycled concrete, which has been successfully installed in the ACCIONA Test Cell in Seville (Spain) as the fire protection law in Turkey was modified (the original idea was to install the façade in Turkey). It is true that this technology has been shown on a smaller scale than the initial one (approximately 10% of the initial size), but this is a lesson learned, since the legislation changed during the Project progress, and this can certainly happen to other similar initiatives.

Regarding **active technologies**, two solutions have been the main developments undertaken during the project; A cogeneration system developed by Partner RANK, and the parabolic trough solar collectors developed by Partner SOLTIGUA. Regarding the first, the objectives initially set have not been 100% achieved, but technology has made a qualitative step forward in terms of its potential for market penetration, as shown by the number of units sold by RANK in the UK in the final months of the Project. The machine developed by RANK has met the requirements indicated initially in terms of electrical and thermal power (around 90 and 400kW respectively), with a performance of 17% compared to 20% goal initially set. Certainly, these data sticks to the initial plan, and especially the unit developed is competitive in the cogeneration market, since several units have been delivered in other projects at the end of BRICKER.

As for the parabolic trough solar collectors developed by SOLTIGUA, the initial challenges have been satisfactorily fulfilled, given the circumstances: It is worth mentioning the fact that the Spanish demonstrator building left the Project, and this was the building in which the design for roof integration was going to be demonstrated, although it was not possible. However, all the solar developments of the project has been deployed in the demonstrator building in Turkey, and we are proud to have installed a solar field of almost 1.5MW thermal in a unique project in Turkey, if not the only one. The efficiency and operation parameters of the solar field are still being checked by operation, but the initial data obtained during the commissioning phase in early 2018 indicate that they are within the framework of the objectives initially marked.

In the facet of the **demonstration**, the first thing that should be noted is that the project began with three demonstration buildings, and has ended with two (and with an extension of 6 months granted by the European Commission for the Consortium to complete the works). This is one of the most important lessons learned; Public buildings should be an example of efficiency and sustainability, but they are perhaps not ideal to set an example of innovative technologies. We infer this for two reasons; the first is that innovative technologies are sometimes in the line of legality, because regulation usually does not contemplate them, and this weighs down on the public entity to be able to implement them in their buildings. And on the other hand, public authorities must launch public competitions to select the candidate to provide and install the novel technologies, and this procedure is slow, and sometimes not practical when it comes to innovative technologies, not very mature, and therefore with a business model not competitive when it comes to being chosen by price (high in the case of novel technologies) and technical specifications (uncertain for the novelty of the solutions).

The **Belgian building** is the headquarters of the school of engineers of Liege. It is a multi-block building, with a triangular floor plan and 50 years old, which renovation has been a success in the passive and the active sides. Two of the building blocks of the building, I and VI, have undergone a drastic aesthetic change as the envelope has been completely renovated; facades, roofs and windows. At whole building level, the reduction of the heating demand due to the installation of the passive BRICKER renovation packages is around 16% (all blocks). In this regards, the higher energy saving has been reached for Block VI, where the renovation packages lead to a -68% in term of the heating demand, while for Block I the reduction is around 39%. The reduction of the heat supplied to terminals is reduced accordingly. Concerning the 22 aerating window units installed, significant improvement on the comfort conditions has been observed. The aerating window contribute to reduce the discomfort due to the high temperatures in the zones, in particular when the overheating is not too severe. The PCMS show little advantages, as their impact on such an old building is low compared to the insulation and the new windows installation.

In relation to the active systems, a 1,5MW thermal power biomass boiler has been installed, together with an ORC unit (estimated 90kW electric and 400kW thermal). The reduction of primary energy demand, and consequently CO_2 emissions, was one of the most important objectives to fulfil by the BRICKER system. In this perspective, the proposed control strategy consisted in replacing the operation of existing gas boilers with more environmental friendly biomass boilers. The full heating season has not been covered in the duration of the Project. However, the system has been commissioned and started, and its capacity has proven to be in line with the expected outcomes. By this, transient simulation shows that this strategy leads to the following results: Reduction of primary energy of 56% with respect to the existing reference case and analogous CO_2 reduction; Electricity consumption slightly increases (+2.3%) with respect to the reference scenario, but this value is covered up to 60% on an yearly basis through the electricity generated by the ORC; In terms of yearly operation costs, the BRICKER system is not showing any significant improvement compared to the renovated building scenario supplied through the existing gas boilers.

Finally, the other building renovated, the **Turkish Adnan Menderes University Hospital**, is another multi block-building, where only Block A has been renovated (out of 4 blocks). During the course of the BRICKER evolution, new blocks have been built in the campus, but we have considered the impacts at the initial level (Blocks A, B and D) level. In relation to the passive implementations, Block A has been insulated (roof and façades) and the reduction of heating and cooling demands due to the installation of the passive BRICKER renovation packages is around 15% and 11.5%, respectively for the whole sanitary district (A, B and D blocks together). In relation to the active systems, due to the withdrawal of the Spanish demonstrator in the last period of the Project, the solar collectors and the ORC from the Spanish demo were sent and installed in Turkey. There is also an adsorption unit to produce solar cooling on site in the frame of BRICKER acquisitions. With all these in place, around 1,5MW thermal solar power and two ORC units were placed and commissioned in the hospital, in the city of Aydin. The Turkish partners have provided numbers in relation to their expected final energy savings, once the system fully operative, and these show that the electricity savings will be around 17% and the natural gas savings will raise up to 75%.

In relation to the **economic indicators for the demonstrators**, and considering the Spanish demonstrator as a “virtual one”, for which we only count on simulations, the following outcomes can be highlighted: Although the positive values in terms of energy and environmental KPIs, the financial indicators bring different conclusions for the different demo-sites. Through the effort made on calculating the expectable market prices of the project prototypes, paybacks of the BRICKER system in replication scenarios as the Belgium and Turkish demo sites are expected to be reduced in 2 years (for passive interventions) and 3 years (for both active and passive technologies). In the case of Turkey, the investment on the passive interventions will be quickly recovered, with a payback of 2 years. In the case of the Belgian demo-site, as the passive interventions were more complex, which required of higher investment, a payback of 19 years is calculated. The total interventions, as active solutions are based on technologies less mature than those technologies used for the passive interventions, have associated larger paybacks: 24 for Belgium, 11 for Turkey and more than 30 years for Spain (over lifecycle of the systems, which discourages the investment for the Spanish demo site, in cost-effectiveness terms). From these indicators, diverse conclusions and recommendations for replication are extracted. The bigger the baseline energy consumption of the building and the bigger free renewable source (solar) exploited, the biggest the economic savings in absolute terms. This combined with the fact that the more yearly operating hours a cogeneration or tri-generation system is run, the largest its cost effectiveness, the convenience of BRICKER intervention for scenarios with almost permanent thermal and electrical demands arise. In this sense, high consuming buildings as the Turkish (hospital) and Belgium (faculty) demo sites, would save annually over 140.000€ and 75.000€ respectively, while in the Spanish demo site (offices) the savings would be around 7.000€. These differences in orders of magnitude in the savings have a direct impact on the payback periods.

Finally, the **benchmarking of the BRICKER technologies** with similar technologies show that the BRICKER concept can be compared to conventional technologies in terms of cost-effective reduction of primary energy and CO_2 emissions. This shows that the BRICKER technologies are a suitable approach to achieve the objectives of the EU in terms of energy efficiency, integration of renewable energies in buildings and spreading of nearly-Zero Energy Buildings.

1 WP1: Project Management.

1.1 Task 1.1. Governance structure, communication flow and methods (ACCIONA).

1.1.1 Amendment #1. Requested on 20th of February 2014.

In period 1, the Project Coordinator requested an amendment to the Grant Agreement due to the substitution of one of the demonstration Partners, which did not access to the Grant Agreement due to economic problems.

Main objectives remain for the new Turkish Demo, although a delay (estimated 4 months) was foreseen due to the negotiation and integration of the new Partner in February 2014.

Modifications with respect to the DoW:

WP2: Task 2.1. Scope change in task 2.1. of the DoW.

Due to the research works performed in the different activities and tasks during the first year of project execution, there has been a scope deviation from the content of work in relation to the work described in the Description of Work, *Task 2.1. Design and development of a sustainable and innovating ventilated façade for the Turkish demo*.

As this change is a consequence of manufacturing and testing of prototypes and the goal of the Project in the Turkish demonstration site has not suffered significant deviations, it has been considered that another Amendment to the Grant Agreement would not be necessary, although this change is reported to the European Commission in this email and in other supporting documentation to come in the following weeks, to confirm this position.

The change consists on the following:

- The original material selected for the façade, called Green Cast and developed by ACCIONA, has been replaced for an alternative lightweight polymer-concrete based on recycled materials.
- The reasons that justify this change are the following;

  - ✓ The Green Cast was tested in the ACCIONA facilities in Spain, and it was demonstrated that it does not meet the seismic and wind load requirements of the REAL demo site in Turkey. Despite the fact Green Cast's mechanical properties can be definitely enhanced; BRICKER approach and timing do not permit to do it. Therefore, with these results on the table, ACCIONA carried out a market study to search for innovative, sustainable and adequate material to be implemented in the Turkish demonstration Hospital, with the warrantee of safety during installation, operation and life-time of the solution and trying to keep the scope of the targets established
  - ✓ Also the Turkish regulation for seismic and wind load requirements was analysed to make the selection of this alternative material, as there two parameters are quite limiting in relation to the materials that can be used in this country.
  - ✓ The final solution derives from a ready-to-market lightweight polymer-concrete which base composition has been modified pursuing the BRICKER goal to develop an innovative, sustainable and lightweight ventilated façade. The product proposed is

made of crushed marble, recycled crushed glass, low-density aggregate and polyester resin with recycled PET. The material's manufacturer is a Spanish company with a long experience in plastic and ceramic manufacturing in the building sector both for envelope and indoor applications and adaptable to market and client demands.

This change has been sent to the PTA with a request for revision/approval of the proposed changes.

On October 1st, 2104, our intention is to launch the purchase order of the materials to the manufacturer: As the delivery period after confirming the purchase is long (2-3 months) and we are willing to deliver the material by ship to Turkey (2-3 weeks plus border protocols), we would like to start with this purchase order with the intention of avoiding Christmas period and future delays in the project execution.

WP2: Task 2.3. Work Package 2 changes in the aerating systems.

Deliverable D.2.10 changes its dissemination level from PUBLIC to RESTRICTED as is contains confidential information from the ventilation system manufacturer, partner GREENCOM.

The number of aerating systems to be installed in the real demo changes from 15 to 22, keeping the same budge, due to the window size. More information can be found in the Deliverable D.2.10.

WP3: Task 3.3. Deliverable D.3.12 postponed from Month 18 to Month 21.

D.3.12. Novel solar prototype fields developed and manufactured, due in month 18, has been postponed to month 21. The PTA accepted this relocation in an email on January 2nd 2015. The reason for this change is that the building owners will not need the collectors on site until the subcontractors start the execution works to install the BRICKER system, and this will not happen until the end of the summer 2015.

WP3: Task 3.3. Turkish solar field is ground mounted rather than roof mounted.

Justification included in the report D.3.13.

WP6: New list of deliverables for Work Package 6.

As recommended by the PTA (Mr. Cousin) during the Kick-off meeting, the 6 deliverables of WP6 related to the exploitation and replication reports for M18, 36 and 48 (total **six** documents) will be merged to **three** reports covering exploitation and replication, due in months 18, 36, 48 with specific sections, so there will be three instead of six deliverable reports. This way, the new deliverables for Work Package 6 are:

- D.6.1.7 and D.6.18. → D.6.17.
- D.6.32. and D.6.33. → D.6.32.
- D.6.39. and D.6.40. → D.6.39.

1.1.2 Amendment #2 requested on August 30th 2016.

At the end of Period 2, it begins to be clear that the delay in the renovation works of the demonstrators in general is going to cause a strong impact on the post-monitoring campaign compromised in the DoW.

In June of 2016, the PC establishes contact with the PO, Ms. Planchon, and upon her request, the PO prepares a pre-amendment request document (attached to the present as an annex) explaining the delays and presenting impacts and contingency plans to absorb/minimise the deviations. The PO informs the PC that there are budgetary deviations (minimal) related to subcontracting of transport costs and other minor PMs allocations, and the PO explains that an email with an explanation is enough for her to approve those minor changes. This email will be prepared once all the Form C´s from all 18 Partners are reviewed and approved by the PC which will be not later than November 30th 2016.

The review meeting to show progress related to the 2nd Project Period is to take place in Brussels on the 8th and 9th of November 2016. The PO has confirmed their assistance, whereas the PTA has not.

The 30th of August, the PO sends via e-mail the official letter of Amendment request, including JUST the PROJECT EXTENSION, in view of an easier administrative process for the Amendment not to interfere the 2nd Periodic Payment, due 60 days after the 30th of September of 2016. The letter is also sent via postal service, but there is no evidence in Brussels that is has reached the Administrative Service, and after another conversation, the letter is sent again on October 21st.

At the date when this report is being finished, November 4th 2016, ACCIONA does not have any official answer from the EC regarding the Amendment request.

1.1.3 Amendment #3.

In Period 3, the amendment 2 requested on August 30th 2016 is approved, and to execute it, together with the termination of the Spanish Partner, which is unable to fulfil their commitments in the demonstration works, a new amendment is requested to transfer the rights from the original government to the new elected one (see section 81.1.).

Finally, the last version of the DoW was approved on September 26th 2017, and this was the final document shared and used to coordinate the elaboration of the compromised works.

1.2 Task 1.2. Overall coordination (ACCIONA).

1.2.1 General Progress.

The Project Team has generally worked efficiently and with a good performance. Considering the great focus that the Team has to make on the demonstration works, most of the activities are carried out by the demonstration Partners (the building owners and the local engineering and technologic Partners) together with the Technology Providers of the Consortium (namely SOLTIGUA, RANK, ACCIONA and GREENCOM).

The only exception is the delay caused by the public nature of the demonstration buildings. Due to a variety of political, administrative and bureaucratic reasons, all demonstration activities have been delayed to a point which does not allow the post monitoring of the two remaining demonstration sites. This situation is reported to the PO and there is an agreement to focus on the execution of works with the goal to leave all technologies installed on the buildings by the end of the Project. The monitoring is therefore reported via simulations and with coefficients and assumptions presented by the building owners, which are the ones who better know their climate, building, regulation and operation strategies.

In the case of Turkey, the coup attempt of July 2016 had a direct impact on the project technical and budgetary situation. The Educational profile of the Turkish partners was an added problem, as this collective suffered the negative effects of the political instability during those days. However, the Turkish Partners reacted in a positive way, and works were compressed to the limit, considering that the technologies coming from the Spanish demonstrator (a solar field and an ORC) were decided to be installed in Aydin in September 2017, not before as the Amendment was not approved.

As for the Belgian demo, problems were not of the same nature, and delays were related to the management of the subcontractors hired for the active system installation. This isa really ambitious renovation, and although all tenders went well in execution, the active system was delayed. However, works were finished on time. On the contrary, the heating system installed was not fully operative and serving the building for a long period, due to the fact that it was finished in the Spring of 2018, just in the period when the heating seasons ends in Belgium This had also an impact on the post-monitoring works in this demonstrator.

1.2.2 Deliverables.

All deliverables have been submitted to the EC and have been approved by the PTA and the PO. All of them are available at the SESAM reporting system of the European Commission.

1.2.3 Meetings.

Work progress is reported by WP Leaders every six months. There is no need to report personnel justifications (Time sheets), but works execution.

Most of the important face to face meetings and some of the teleconferences are listed in the following tables.

Place	Date	Purpose	Assistants	Report
Madrid (Spain)	9-11/Oct/2013	Kick Off	All Partners	Minutes available
Cáceres (Spain)	Feb/2013	Monitoring	CEM,GEX, ACC	Report available
Cáceres (Spain)	Nov /2013	Data collection	CEM, GEX	Report available
Lieje (Belgium)	19/Nov/2013	Data collection	SPB, PUR	Report available
Italy	Nov/2013	Visit Soltigua facilities	FBK, EUR, ACC, SOL	No
Lieje (Belgium)	Nov/2013	Data collection	SPB, GRE	Report available
Seville (Spain)	Jan/2014	Visit ACCIONA facilities	ACC, FBK, EUR	No
Liege (Belgium	March 2014	Steering Committee 1	SC Partners	Yes
Working Sessions Cáceres Demo	March to August	WP3+WP5 works	CEM+GEX+ACC+TEC+CAR	Yes
Visit to Turkish Demo	May 2014	WP2+3+5 works	ACC+EUR+TEC+DEU+ADU+ONU	Yes
Visit to Cáceres	September 2014	Demo Works	ACCIONA+GOBEX	Report available
General Assembly Cáceres	October 2014	GA	All Partners	Minutes available
Technical Meeting Sevilla	November 2014	WP5 Tenders	GEX+CEM+ACC	Notes available

List of relevant meetings first Period.

Place	Date	Purpose	Assistants	Report
Italy. Visit to SOLTIGUA Premises	June 2015	Technical work	ONU, OZU, ADU	Report available
SC Teleconference	June 2015	Managerial	SC Members	Minutes available
Turkish demo telco	September 2016	Technical works	AC, ADU, OZU, ONU	Minutes available
ACCIONA visits GEX	September 2016	Managerial	ACC, GEX	Minutes available
ACCIONA internal meeting Madrid	June 2016	Technical works	ACC team	Report available
GA Liege	September 2015	Technical and Managerial	All Partners	Minutes available
ACC visits SPB	March 2016	Technical works	ACC, SPB	Report available
ACC and CEM	March 2016	Technical works around Spanish demo	ACC, CEM	Reports available

Place	Date	Purpose	Assistants	Report
SEZ in ACC	April 2016	Technical works	SEZ (E.H) and ACC	Minutes available
SC Seville	September 2016	Technical and managerial	SC Members	Minutes available
ACC internal progress meeting	September 2016	Technical and managerial	ACC team	Minutes available
WP6 Workshop Madrid	June 2016	Exploitation Workshop	SEZ (Leads), ACC, CEM, TEC, GRE, PUR	Report available
ACC visits RNK	September 2016	Technical progress	ACC, RNK	Report available
ACC visits SPB	October 2016	Technical progress	ACC, SPB, ULG, GRE	Minutes available
Review Meeting Period 2 Brussels	November 2016	Technical and financial reporting	ALL PARTNERS	-

List of relevant meetings Second Period.

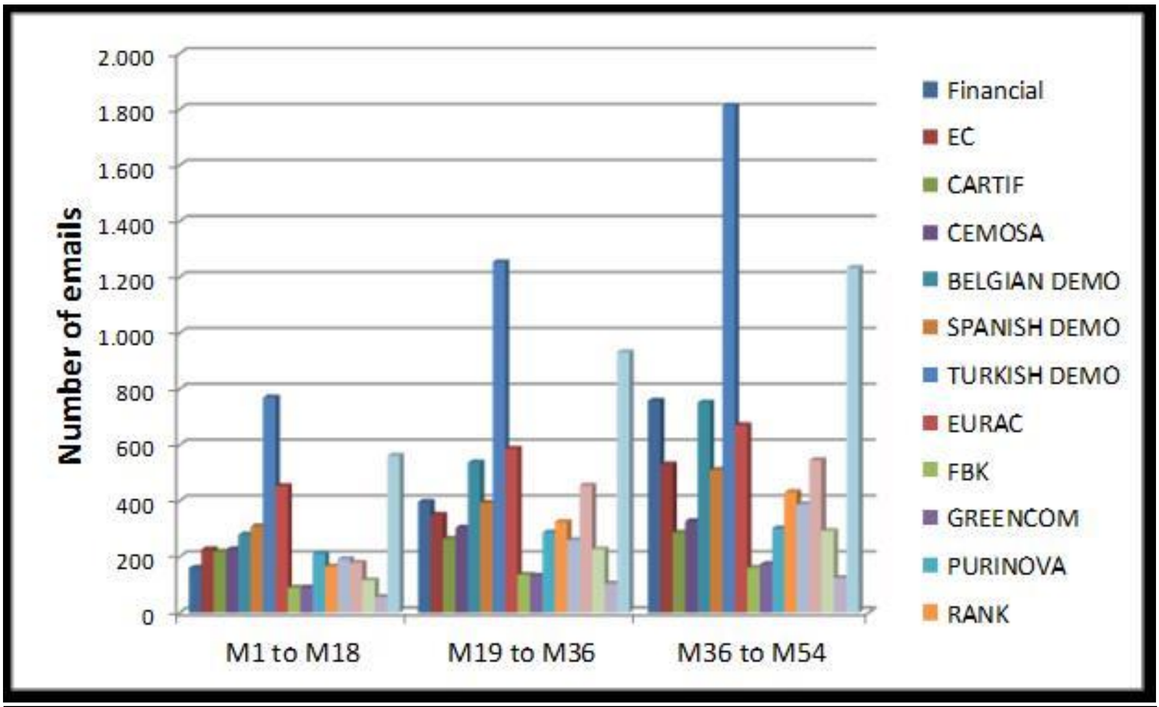
Place	Date	Purpose	Assistants	Report
Mérida (Spain)	March 2017	Negotiations for continuation	GEX+ACCIONA	Report available
Seville (Spain)	February 2017	Technical progress	ACCIONA+CEMOSA+GEX	Minutes available
Telco	May 2017	Steering Committee	SC Members	Minutes available
Aydin (Turkey)	November 2017	Technical visit	Turkish Partners + ACCIONA	Minutes available
Aydin (Turkey)	December 2017	Technical visit	Turkish Partners + ACCIONA	Report available
Brussels (Belgium)	March 2018	Final Technical Meeting	Partners+PO+PTA	Minutes available

List of relevant meetings Third Period.

In parallel to all the meetings listed above, there have been a number of teleconferences among Partners where the PC has not participated, and also many other day-to-day teleconferences and informal technical meeting which have not been recorded, but must be highlighted.

1.2.4 Communications

The Project communications were monitored since the beginning, and in the Project Coordinator records, the following number of emails were present, the day before the final technical meeting, March 19th 2018.



1.3 Project closure.

After the final technical Meeting in Brussels, organized during the 20th of March 2018, the final actions to be taken consist on the economic and financial reporting to the European Commission. These works will be done during the 60 days available for such purposed.

As for the technical reporting, the final report will be delivered based on this deliverable, which has the same structure as the one proposed by the EC services to report the final status of the project once this terminated.

From the Coordination, we must thank all Partners, the EC Officer and supporting staff, and the 2 PTAs assigned to BRICKER for their fruitful collaboration and valuable feedback received during such long period of collaboration. Without them, it would have not been possible to Coordinate such a large team during such a long period of time and with such number of problems. Today we can say we faced all of them successfully.

2 Work Package 2; Envelope retrofitting solutions for demand reduction.

2.1 Task 2.1. Design and development of a light weight ventilated façade (ACCIONA).

In P3, the façade, which was initially designed in P1 for the Turkish demonstrator, was finally installed in Spain. This modification occurred due to the legal framework modification in Turkey, where the fires resistance regulation was modified to a more restrictive one in the summer of 2016, leaving the recycled material the façade was made of, put of the legal status in Turkey. As a contingency plan, a small portion of the entire façade was installed in Spain.

General status;

- In P1, all the design phase was complete.
- In P2, the general production and quality check was performed.
- In P3 the selected prototype was installed in Spain.

All in all, after the modification of the fire resistance regulation in Turkey, the ventilated façade developed by ACCIONA for the Turkish demonstrator had to be relocated and installed in Spain.

In WP5 there is a description of the works done so far for the testing of the solution developed.

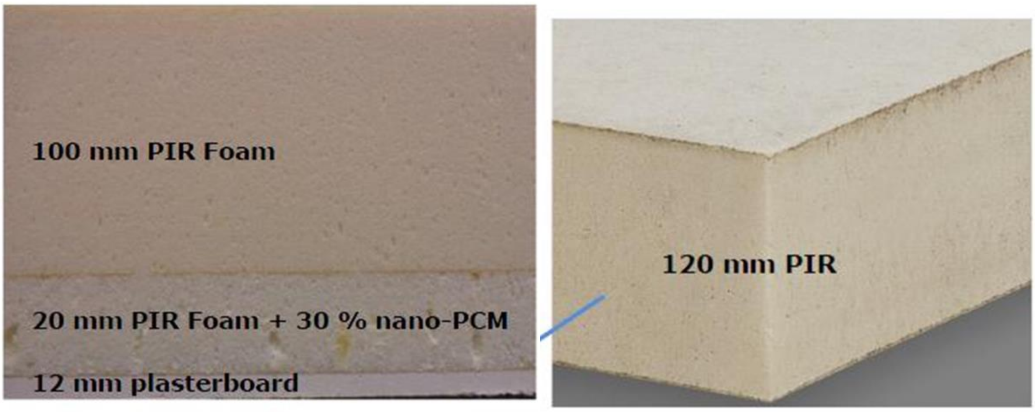
2.2 Task 2.2. Development of novel insulation materials with embedded PCMs to improve thermal inertia of the building envelope (PURINOVA).

Partial progress items:

- In P1, all the design phase was complete.
- In P2, the general production and quality check was performed.
- In P3 the selected prototype was installed in the Belgian demonstration.

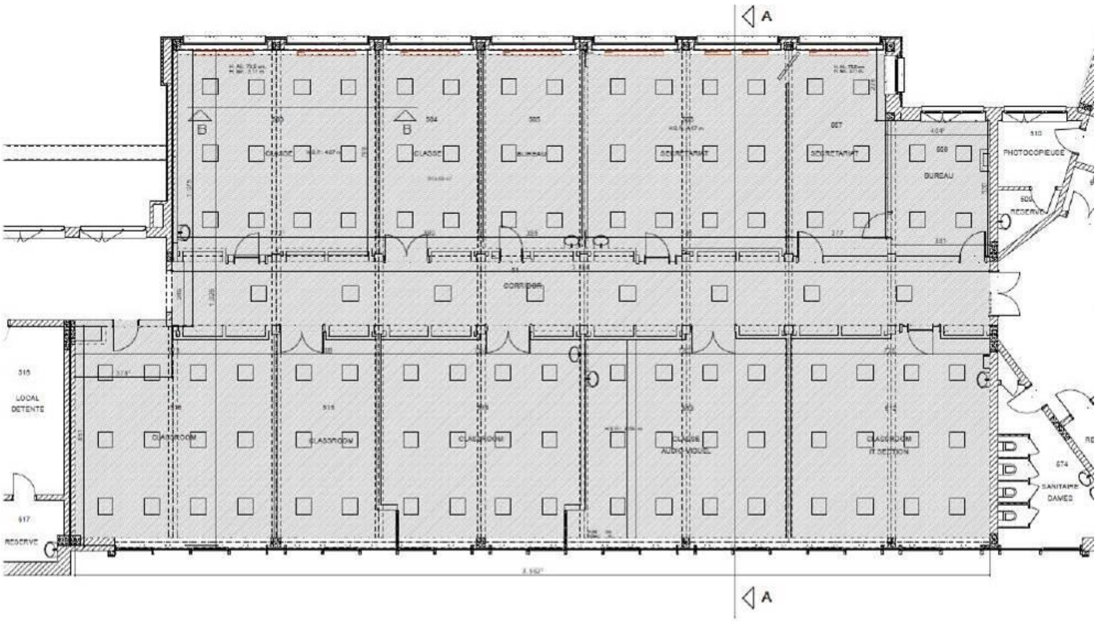
Works within WP2 concluded with the delivery of the modules from the PURINOVA premises in Poland to the demonstration building in Liege.

First of all, some mock-ups were manufactured to assess the integration of the PCM microcapsules in the PIR foam. In the figure below there is a presentation of those first trials, which were used to prepare the final manufacturing process which had to produce the whole surface to insulate.



Selected solution for the exterior insulation (right) and the internal insulation with embedded PCM (left).

During the evolution of works, the local architects from the Province of Liege developed the detailed integration project together with an architect from PURINOVA. The final design for the internal insulation in block 6 is shown below. The insulation was to be done internally on the ceilings of the rooms selected.



Floor plan for the PCM installation.

May 2016 - Dismantling of the ceilings for the PCM-based installation

May 2016 – Reception of Purinova's panels

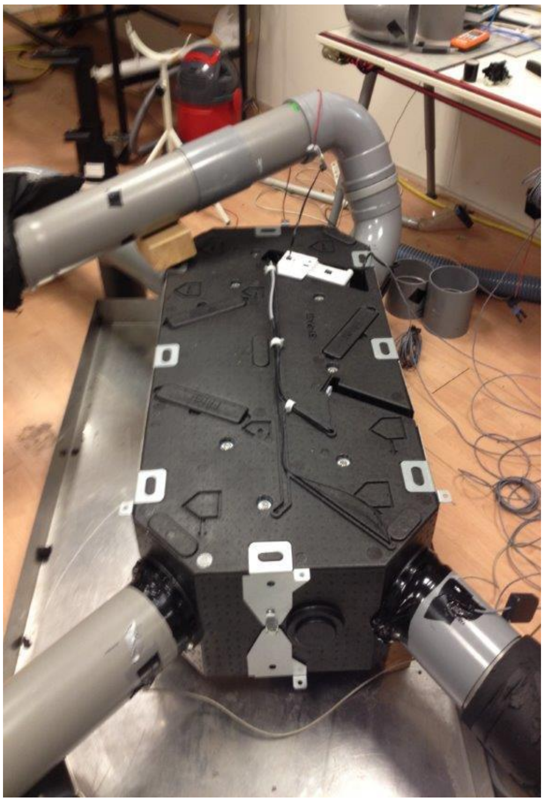
In the Work Package 5 section there is a description of works done so far in the demonstration building, for the installation of the panels and for the monitoring of the indoor conditions of the rooms selected. The installation was carried out by a local company subcontracted by the local BRICKER Partner SPB and the monitoring works were responsibility of ACCIONA.

2.3 Task 2.3. Development of smart and high performance aerating windows (GREENCOM).

Partial progress items:

- At the termination of the second period (October 2016), the GREENCOM double flow ventilation systems (22 units) was under installation in the identified classroom according to the plan :
    - Classroom 105 (max capacity 30 students), Block #6, schoolyard side, Level+1, 4 units.
    - Laboratory 293 (max capacity 15 students), Block #6, schoolyard side and back façade, Level +2, 8 units.
    - Auditorium 428 (max capacity 80 students), Block #1, schoolyard side, 8 units
    - Office 316 (max capacity 2 persons), Block #6, schoolyard side, Level +3, 2 units.
- Works done within the third period were;
    - Termination of the installation and starts-up of the units.
    - Monitoring and comparison between classrooms with and without smart aerating windows. Presentation of the result as a study case.

In the picture below there is a unit ready to be installed. In the corresponding Work Package 5 there are representative pictures of the installation works and the final look of the system, totally integrated in the classrooms.



GREENCOM aerating system prototype ready to be installed.

3 Work Package 3: Zero emissions energy production technologies.

3.1 Task 3.1. Technical requirements and specifications of the Cogeneration prototype and its components (RNK).

3.1.1 Selection of the working fluid (RNK).

Regarding the working fluid selection, special attention was paid to the security properties, as toxicity, flammability, thermal stability and environmental properties.

Seven different refrigerants (R134a, R245fa, SES36, R1234yf, R1234ze(Z), R1233zd, R1336mzz) were investigated, being other options like Toluene, OMTS and hydrocarbons discarded for the application due to toxicity and flammability issues.

Fluid	Toxicity/Flammability	GWP	ODP	Tcrit (ºC)	Pcrit (bar)	Tmax (ºC)
R134a	1000/Non-flammable	1300	0	101	40.59	<200
R245fa	300/Non-flammable	950	0	154	36.51	250
R1234yf	500/Low-flammability	4	0	94.7	33.82	<200
R1234ze(Z)	500/Non-flammable	1	0	150	35.30	<200
R1233zd	300/Non-flammable	1	~0	165.6	35.71	200
R1336mzz	500/Non-flammable	2	0	171.3	29	250
SES36	1000/Non-flammable(*)	3710	0	177.55	28.49	190

ORC´s refrigerant alternatives considered.

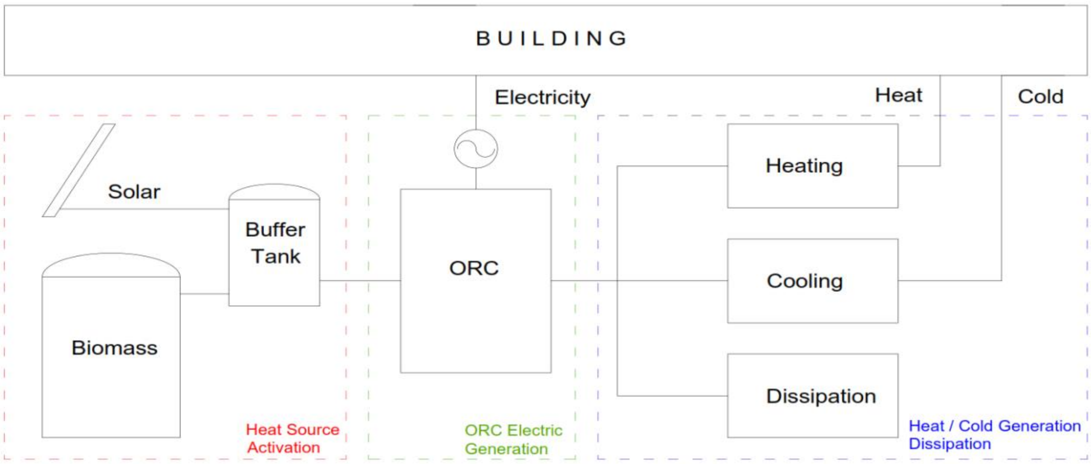
Finally, **R245fa was selected as the best commercially available option (low toxicity, non-flammable)**, with a good theoretical expected performance in generation and cogeneration modes (maximum temperature of 250ºC).

HFO-1336mzz would be another option, with promising results, but it is no still commercially available.

3.1.2 Technical requirements of the equipment (RNK).

Heat transfer fluid chosen for the high temperature loop (outside the ORC) was thermal oil, **Terminol SP**.

The possibility of using steam as heat transfer fluid was rejected due to the high pressures required. The following figure shows different production modes considered for the estimations of the thermal parameters, like the expected performance in partial loads (linearity decrease) with the selected working fluid.



General layout for definition of requirements.

3.1.3 Selection of the thermodynamic cycle (software works) (RNK).

Attending to the ORC configuration, the adoption of a recuperative heat exchanger was considered, due to the high temperature of the heat source compared with the critical temperature of the working fluid selected, having to work with high superheat degree.

The possibility of working in transcritical conditions was studied and rejected due to the increase on the pump consumption that reduces the net efficiency of the cycle.

Finally, the best configuration wass the use of a recuperative heat exchanger in subcritical conditions.

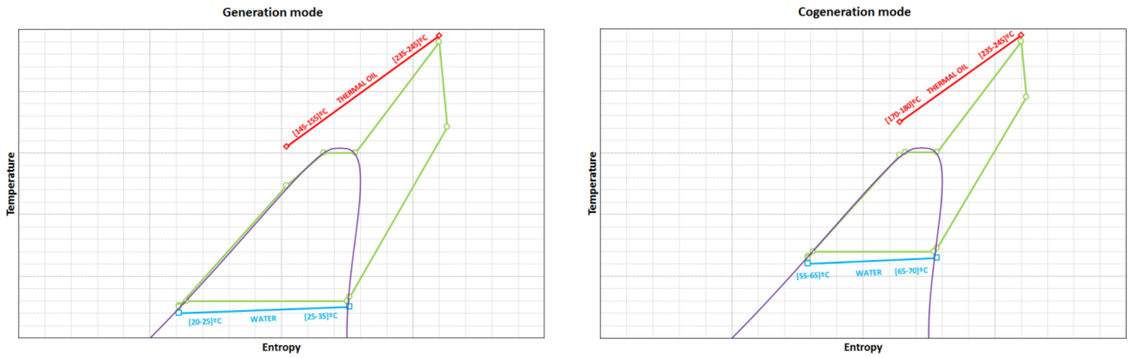
3.1.4 Operation points optimization (software works) (RNK).

With the working fluid and the configuration selected, the last step in the optimization of the ORC module was the operation points´ selection.

Parameters like the evaporating pressure and superheating have high influence in the cycle efficiency and a previous optimization of these parameters help in the selection of the components of the ORC module in order to improve the performance of the system.

As result of the optimization process, the evaporating pressure, the superheating degree and the regenerator efficiency was obtained for addressing the system design.

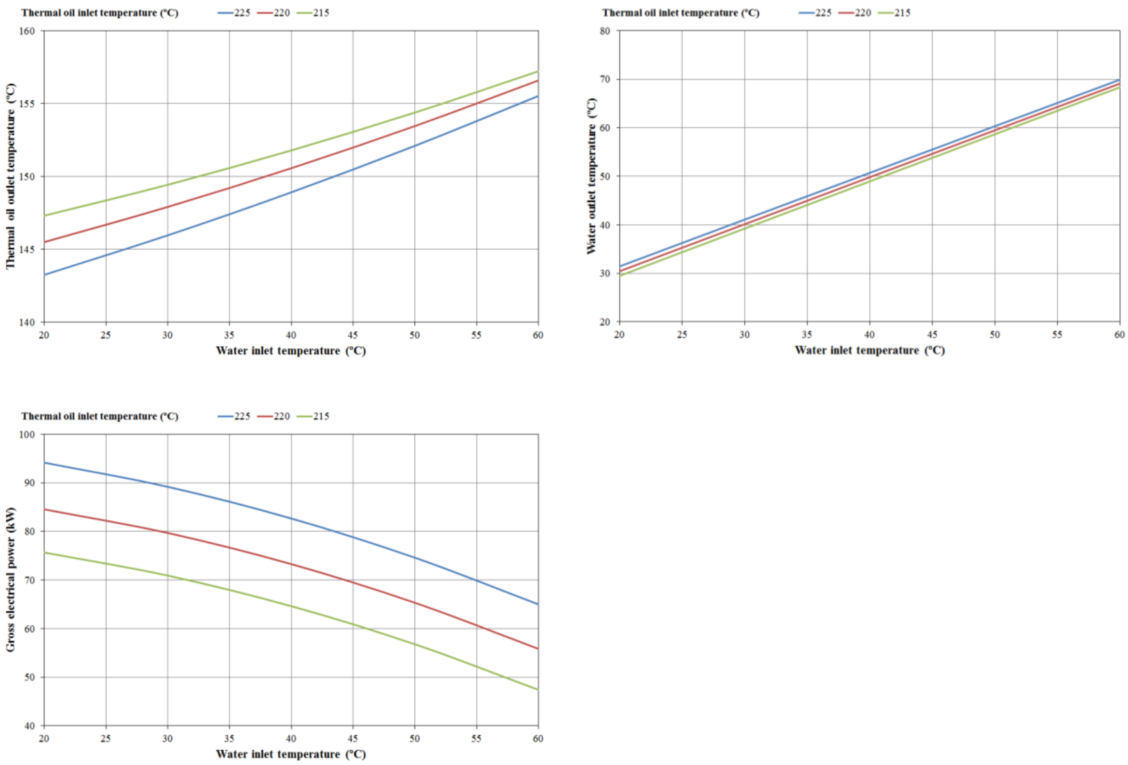
Expected Rated Performance: Once the expander prototype developed and the technology of the rest of components selected. (task 3.2), the operation points was recalculated, obtaining the expected rated performance (uncertainty ±15%)



Optimized operation points.

<u>Expected partial load performance</u>: The control stablished for the cogeneration prototype was based on maintaining the secondary fluids flow rates and varying the secondary fluids temperatures. In this way, the ORC performance results on smooth dynamic behaviour, based on previous experience.

Therefore, in the following, the expected partial load behaviour when the inlet temperatures of thermal oil (Therminol SP) and water are changed are presented in terms of thermal oil thermal power, water thermal power, gross electrical power, thermal oil outlet temperature and water outlet temperature. The expected performance presents an uncertainty of ±15%.



Partial load behaviour.

3.2 Task 3.2. Design, construction, test and optimization of the Cogeneration prototypes (RNK).

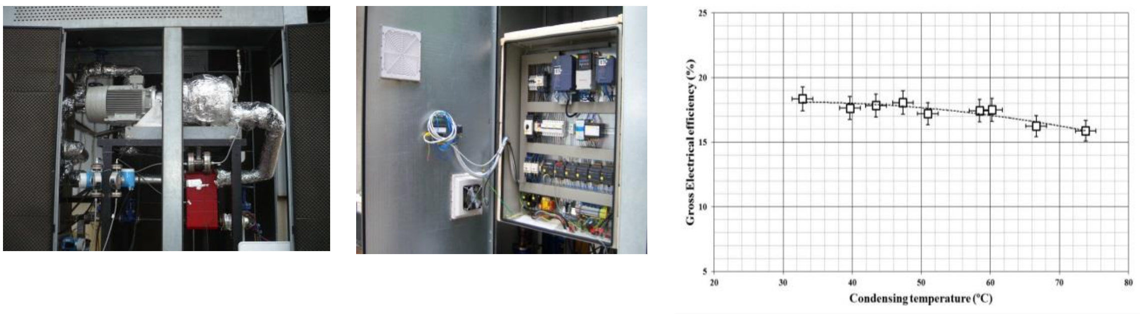
3.2.1 Scaled prototype.

Once the working fluid and the cycle configuration were defined, the first step for the prototype design was to address the expander design.

The expander technology selected to meet the prototype requirements was analysed, and, finally, a volumetric expander proposed. So, based on the power requirements and the operation points, two proposed expander prototypes were obtained.

Simulation and first expander prototype

The expected performance for both expander prototypes were experimentally tested in the test bench constructed ad-hoc for the expander tests. Thermal and electrical power were been down to meet the disposal thermal power on the test bench, with a 1:3 scale. The test bench allowed experimentally characterize the expander prototypes.



Control cabinet, ORC test bench and test results.

Partial experimental tests were carried out with the expander prototypes mounted in the 1:3 scale ORC prototype, obtaining results using both expander designs. Finally, the expander prototype was designed according to the second proposal, optimizing the cogeneration mode (mode with maximum overall efficiency) and the feasibility of the ORC system, avoiding the disadvantages of the other design.

3.2.2 Real scale unit.

Regarding the pump system, the technology provider (Rank) developed a special design for the ORC pump in order to meet the design requirements based on a rotative volumetric technology. Regarding to the heat exchangers, attending to the technical requirements, compact heat exchangers were selected for the 3 real scale ORC prototypes (allowing this compact heat exchangers temperatures up to 225ºC and 40 bar of working pressure). Specifically, brazed plate heat exchangers customized to achieve the required characteristics of the application were selected.

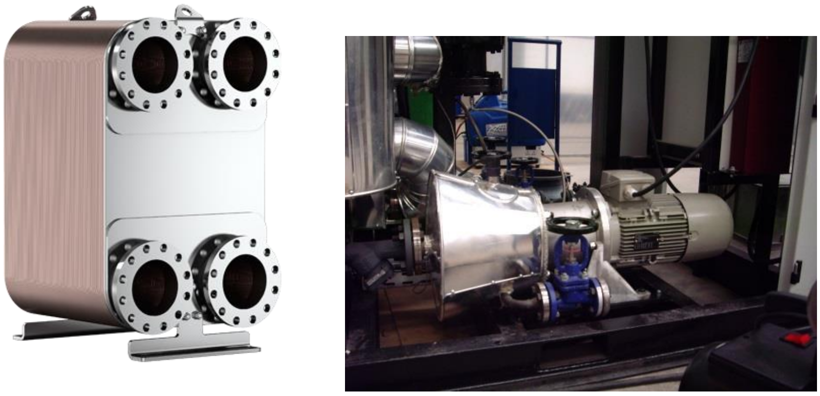


Figure 3.6: Heat Exchangers and pump prototype.

With all the components selected, the 3 real scale ORC prototypes layout were determined, based on the know-how of the technology provider (Rank). So, the first ORC prototype (to be installed in Liege demo site) has been assembled. After the design modifications for the real scale components, pre-commissioning tests and the experimental campaign were carried out.

Figure 3.7: Liege ORC unit ready to be shipped.

All documents regarding to installation, commissioning, operation and maintenance were developed. So the Safety analysis to the machine was assessed in order to do the CE Declaration of Conformity.

Although this fact was already mentioned at the 3.21 deliverable, it must be highlighted the importance of operating temperatures in the efficiencies of the ORC prototypes. The initial targets for the efficiencies were 21% and 18% for generation and cogeneration mode respectively, with heat source inlet temperature of 270ºC. This temperature was limited to a final value of 225ºC, as it was explained within at 3.21 deliverable. After selecting R245fa as the best working fluid (with low toxicity, non-flammable, technical feasible), the temperature was limited to 240ºC in order to work bellow its maximum allowable temperature, following the manufacturer advice in order to avoid risk of degradation of the organic fluid. After continuous operating of the scaled prototype in the test bench, the allowable temperature was reduced to 225ºC in order to maximize the life of the components, as some degradation was observed above that temperature. On the other side, the expander prototype was designed optimizing the cogeneration mode in order to maximize the overall efficiency of the system and the feasibility of the future product in market. This fact and the reduction of the activation temperatures have resulted on final efficiencies near 17% and 14% for generation mode and cogeneration mode, respectively, lower than the initial targets but better than those theoretically expected in previous reports. However, the resulting ORC prototype is associated with a future product in the market with greater technical and economic feasibility.

Finally, the other two real scale ORC prototypes, to be installed in Turkey and Spain, were assembled.

Turkey and Spain ORC units assembly process.

The unit for Turkish demo site was ready to install pump and expander and finished in Period 2. After this test shall be done in order to check all parameters. Spanish ORC was assembled 8 weeks later, which is October 2016.

3.2.3 Manufacturing of the real scale units.

In relation to the three ORC units, all of them were manufactured and shipped to Liege and Turkey.

It needs to be mentioned that the original plan to send one unit for each of the three demonstration buildings was modified after the termination of the Spanish demonstration , in September 2017. The contingency plan prepared allocated two units in Turkey and one unit, as in the original plan, in Liege. The fact that two unites were sent to Turkey is due to the large energy demand of the hospital, which allows the integration of a second unit, together with another solar field (See section related to Task 3.4.).

In the following pictures there is a presentation of the ORC unit from Liege, ready to be shipped, and the 2 units already placed in the Turkish demonstrator, were a warehouse was built for the BRICKER purpose.

Liege ORC unit ready to be shipped.

All documents regarding to installation, commissioning, operation and maintenance were developed, the economic analysis of the operation and maintenance and the replication plans from RANK to sell ORC units in the coming years are ready, and placed in the corresponding deliverables.

February 2018– The 2 cogeneration units from Partner RANK are placed in the BRICKER Warehouse.

3.3 Task 3.3. Design and construction of the new collector fields for easy roof installation and operation at temperatures up to 300°C (SOL).

3.3.1 PTC development by design (SOL).

During period 1, specifications were listed, and boundary conditions identified. In period 2, developments included 3 main activities:

1. Collector modelling,
2. Development of new receiver, and
3. Shift from on board control panels to control units

Within activity #.1, Soltigua's modelling techniques were validated with a TRNSYS model done together by Eurac. During this activity there was a synergy with the H2020 project FLEXYNETS, started in summer 2015, in which both Eurac and Soltigua are active.

Within activity #.2, several options were considered to optimize the modular not evacuated receiver within the operating temperature range of the developed ORC cogeneration units.

First, a higher attention was given to the optical and thermal properties of the absorber and of the glass tube. In this respect, also by exploiting a synergy with the work of EU FP7 project FRESH NRG, we studied new SolGel coatings for not evacuated receiver tubes. The new coatings could provide a performance increase of the optical transmittance of the outer glass tube from approximately 92% to around 97%. Unfortunately, to be exploited, these coatings would require to set-up a dedicated pilot coating line, whose cost is not supported by the current volumes foreseen for the technology.

A second line of improvement was to adopt flangeless receiver tubes, so to reduce the thermal losses provided by the collector flanges. This solution could also decrease by a small amount the cost of the collectors. After careful analysis it was however decided that such solution, which would require some degree of on-site welding, is more suited for large, ground based installations, in which a turn-key solar solution provider can manage directly the welding and the overall solar construction. In the spirit of exploiting public tenders with local suppliers, it was judged better to adopt a welding free modular receiver solution, with flanges to connect the different parts of the receiver tube.

Activity #.3 was born taking into account two elements. On one side, the delay of the demo projects forced Soltigua to delay the acquisition of the control panels, to avoid the risk of damage and/or theft. On the other side, this extra time could be used to optimise the control system by shifting from on board PLC-driver control panels to fully standardized electronic control units, which would be simpler to install and more cost competitive. This activity started towards the end of P2 and continued until Month 42.

3.3.2 Prototype development by testing (SOL).

Main focus of testing is the verification of the collector with particular reference to the receiver tubes and the control panels and units.

This makes also possible to validate the performance foreseen by current modelling which simulates it by using an efficiency curve based on EN 12975 standards.

Testing took place mostly on a dedicated full blown outdoor loop which can test the tubes in real conditions while mounted on a collector: testing activities were run in parallel to the actual operation of the demo field, to optimise activities and compare results.

3.3.3 Manufacturing of the Turkish solar field (SOL).

Activities continued to both execute the manufacturing of the prototypes and on setting up a system for effective procurement and manufacturing, also in view of future industrial exploitation after the end of the project.

This included consolidating the supply base by asking – whenever possible/meaningful – more than one offer as a way to ensure effective use of public money.

Also, the introduction of an MRP (Material Requirement Planning) was initiated to further reduce cost, lead time and inventory to favour the future exploitation of the technology.

Despite the lack of precise timing for the demos, mirrors were bought for both the Turkish and the Spanish demo, in order to take advantage of scale economies (an important factor which will be taken into account for future exploitation plans). Ordering of last components (control panels/units) is being aligned to expected shipment dates so to avoid too long storage time, which may have lead to risk of theft and/or product deterioration/damage.

As indicated before, this challenge was transformed into an opportunity by the initiated development of a new control unit, which reduced the cost of the on board control panels.

3.4 Task 3.4. Development of optimized structures to connect and integrate the solar collectors´ structure in different building roof configurations (ONU).

3.4.1 Structure for the Turkish solar field (ONU).

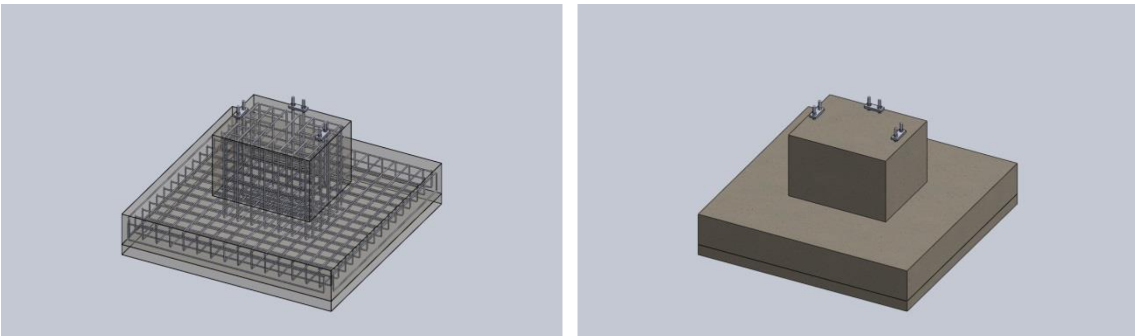
As the solar field was to be placed on the ground in an empty site, foundation project were to be carried out for the panels and anchorage system. Alternative installations were studied simultaneously.

Anchor plate first design was complete. The anchorage system for each support was designed in accordance with the details provided by Partner SOLTIGUA. The software PROFIS Anchor 2 provided by HILTI was used to design the whole anchorage system. The analyses were ruled by Guideline for European Technical Approval of Metal Anchors for Use in Concrete (ETAG 001-05). The design was also in compliance with the Turkish National Code for Reinforced Concrete Structures.

Due to a recent change in the placement of the solar field, the best possible layout with support from Partner SOLTIGUA was identified. However, our efforts to find the best possible ground anchorage system were not significantly effected by this change.

The advantages of this design are:

- Using much less concrete, in comparison to single block foundation.
- 60cm height from the ground minimizes the ground effects such as grass, dirt, flood, without increasing the cost much.



3D view of the anchorage solution

Considering the installation of the collectors over the foundations, a gusset column, as a constructive means, was envisaged and designed to ensure an adequate thickness for the embedment depth of anchors, and to avoid unforeseen problems due to levelling the ground.

All anchor plates were specified with 2ϕ22 holes. The software offers solutions with respect to the anchor types produced by HILTI. Among various anchor types, HIT HY-200+HIS-RN M16 with a diameter of 16 mm hold out all the support forces within varying Load/Capacity ratios. Required embedment depth for the anchor is 170 mm and the anchor were mounted by means of a mortar after a sufficient auger drill is provided.

WORKS DONE IN PERIOD 2:

→ Selecting best layout for the new solar field (ONU & OZU & SOL)

→ Verification and finalizing design of the anchorages (ONU & OZU & SOL).

→ Preparation of the specification for the subcontractor (ONU).

3.4.2 Structure for the Spanish solar field (CEM).

Works were completed in P1. There is a technical report which conclusions are listed herein below.

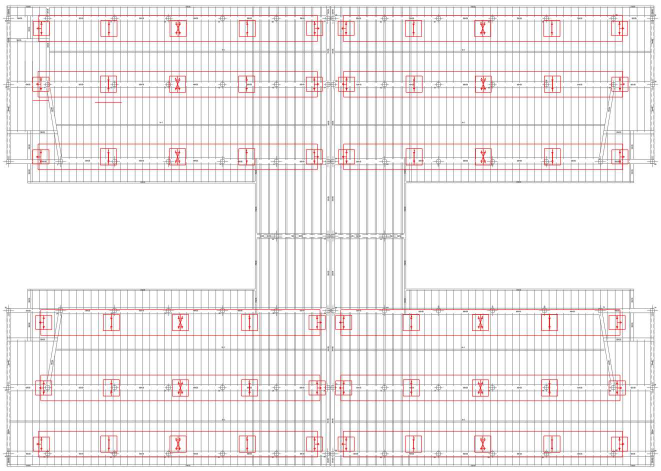
The report elaborated for CEMOSA is divided in three phases:

1. Obtain the wind pressure, and the forces transmitted to the foundations and anchor plates from the calculated wind pressure
2. Design of the anchor plates and the bases of support
3. Checking of the structural behaviour of the roof with the new loads

The results obtained after to apply the detailed computation process described in the report are:

- The wind pressure for each PTMx-24 system is 1859 N/m^2.
- Three types of concrete foundations (1, 2 or 3) have been defined for each group of anchor plate (A, B, C or D) of solar collectors. All foundation types have the same dimensions (150 x 150 x 25 cm) and the same frame (mesh upper and lower steel diameter ϕ12 mm each 20cm).
- The execution of these foundations needs to remove the elements of the cover on the roof. The water proofing layer and thermal isolation will be replaced properly after to construct the new concrete foundations.

The location of foundations and the type are described in the attached plan:



Collectors location (red) on the Spanish roof.

Finally, the behaviour of the different structural elements of the floor to the new situation of loads is verified.

As an outcome of these works, it is to be highlighted that this demonstration was not renovated due to the withdrawal of the Spanish Partner Junta de Extremadura un Period 3, as it is explained in Work Packages 1 and 5 sections.

3.5 Task 3.5. Control and hydraulic systems of the solar field adaptation to provide optimal temperature and flow conditions to the system (FBK).

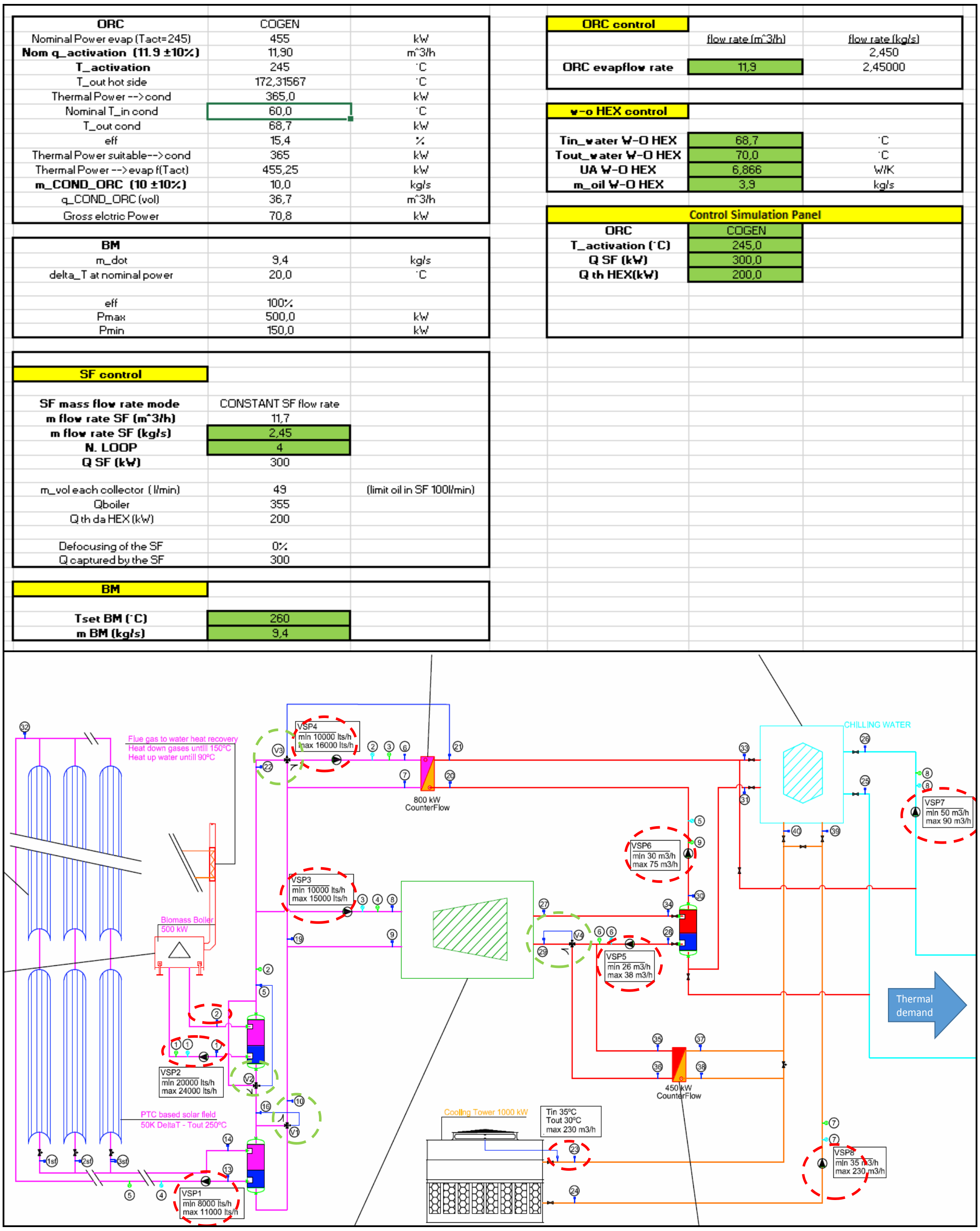
3.5.1 Specification.

After collecting data on SOLAR, BIOMASS, ORC and CHILLER from partners (SOL, RANK, CARTIF) the active plant layout and control strategies was analysed and a solution is presented, taking into account the energy constraints, annual working hours and technology constrains.

A file collecting the specification was created and updated collaboratively by the partners involved in WP3. This document was very important in order to have a common ground of discussion for the all partners involved (it is currently maintained by FBK and ACCIONA).

3.5.2 Development.

Layout Configurations for the Spanish, Belgian and Turkish demo sites were defined and analysed with an energetic level trough stationary lumped models. The flow charts for Spain, Turkey and Belgium were realized according to the systems constraints and peculiar sites characteristics.



ORC	COGEN	
Nominal Power evap (Tact=245)	455	kW
Nom q_activation (11.9 ±10%)	11,90	m^3/h
T_activation	245	°C
T_out hot side	172,31567	°C
Thermal Power -->cond	365,0	kW
Nominal T_in cond	60,0	°C
T_out cond	68,7	kW
eff	15,4	%
Thermal Power suitable-->cond	365	kW
Thermal Power -->evap f(Tact)	455,25	kW
m_COND_ORC (10 ±10%)	10,0	kg/s
q_COND_ORC (vol)	36,7	m^3/h
Gross elctric Power	70,8	kW

BM		
m_dot	9,4	kg/s
delta_T at nominal power	20,0	°C
eff	100%	
Pmax	500,0	kW
Pmin	150,0	kW

SF control		
SF mass flow rate mode	CONSTANT SF flow rate	
m flow rate SF (m^3/h)	11,7	
m flow rate SF (kg/s)	2,45	
N. LOOP	4	
Q SF (kW)	300	
m_vol each collector (l/min)	49	(limit oil in SF 100l/min)
Qboiler	355	
Q th da HEX (kW)	200	
Defocusing of the SF	0%	
Q captured by the SF	300	

BM	
Tset BM (°C)	260
m BM (kg/s)	9,4

ORC control	flow rate (m^3/h)	flow rate (kg/s)
		2,450
ORC evapflow rate	11,9	2,45000

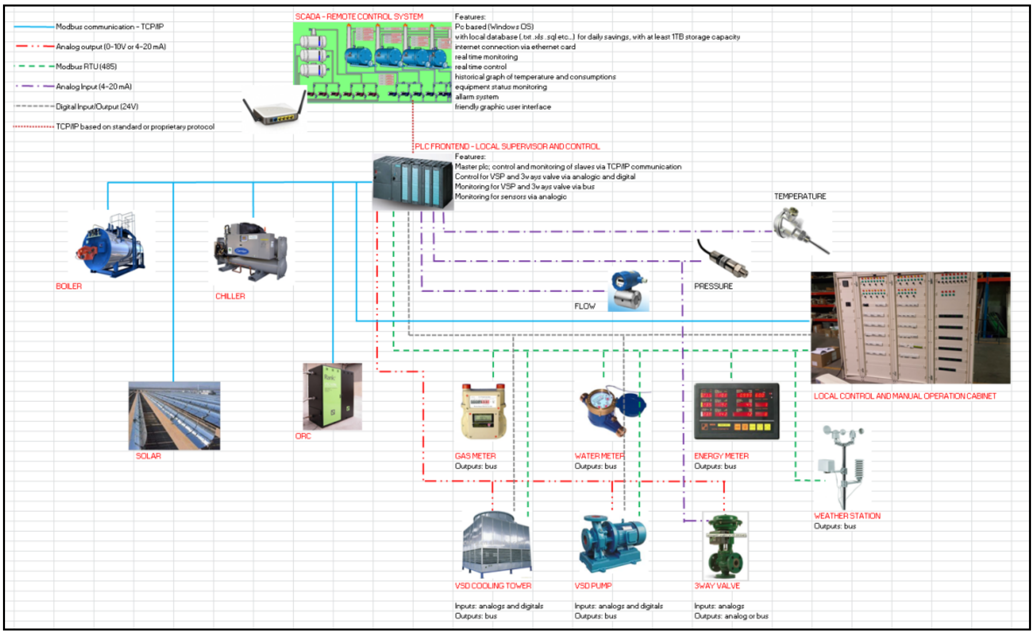
w-o HEX control		
Tin_water W-O HEX	68,7	°C
Tout_water W-O HEX	70,0	°C
UA W-O HEX	6,866	W/K
m_oil W-O HEX	3,9	kg/s

Control Simulation Panel	
ORC	COGEN
T_activation (°C)	245,0
Q SF (kW)	300,0
Q th HEX(kW)	200,0

Example for the BoP (Balance of Plant) tool developed for the three demo site. This tool allows to calculate the energetic state of each component in system given different values of solar irradiation and load demand. The control components put in place are highlighted in the red and green boxes.

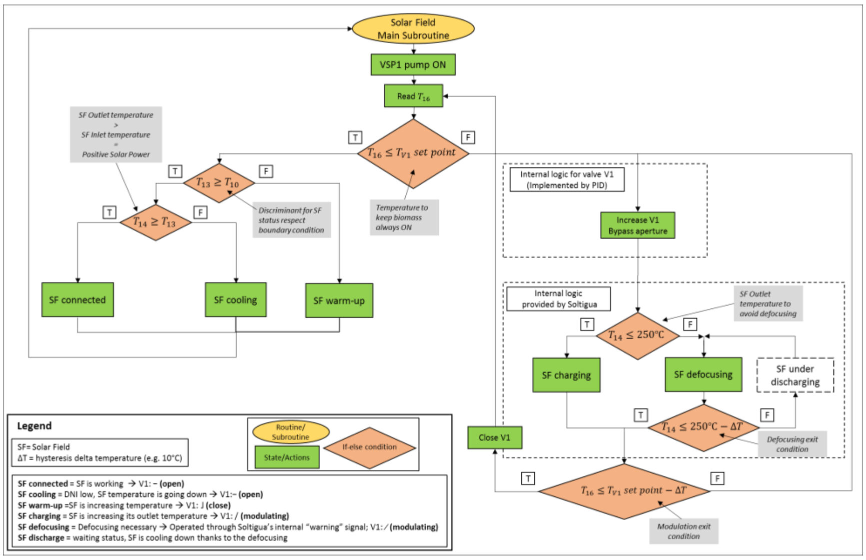
General requirements for the diathermic oil circuit, based on previous FBK experience have been distributed through an internal report to the three demos owner (Spain, Turkey, Belgium).

Control requirements for the cogenerative plants have been finalized and distributed for the tenders' preparation. In the report the main components which keep the system under energetic balance are presented and discussed using the Spanish demo as example.



Control Architecture and control requirement for the tender preparation in the three Demos.

The work done during the activity period of 2015 was mainly focused on the development of the control flow charts for the three demo sites. In the following picture an example related to the Spanish demo is showed.



Example of control flow chart for the solar field in Spain.

The last period of activities was mainly focused on the development of specific models and dynamic studies to test the control logic developed during the previous period of activities.

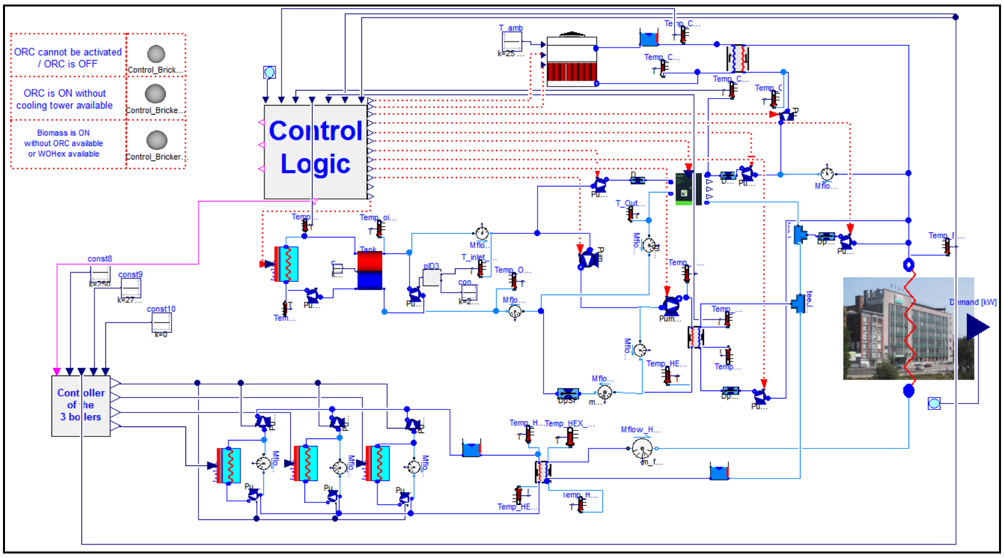
Thanks to the collaboration with University of Liege, a dymola environment model was deployed for each single demo.

The simulations carried out were useful to test the reliability of the system. Important information related to the reactiveness of the systems and capacity to handle automatically specific situations (such ORC maintenance or biomass shortage) were then collected.

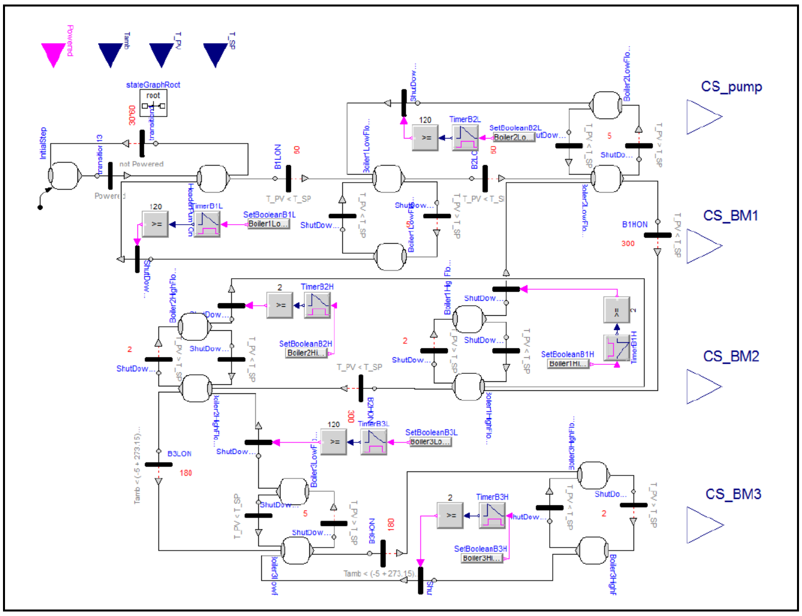
3.5.3 Validation (FBK).

The validation part aims to demonstrate through the use of dynamic models the feasibility and reliability of the control logics developed for the three demo sites. At this stage, Turkish and Belgium demos were completed.

In parallel these models were also used to develop and test the different control strategies for the demo sites related to the 4.4 of WP4 (Development of the operation strategies for the active technologies). The following pictures show the implementation of the Belgian active layout into the Dymola environment and its control logic. Last step of the validation was to compare the real behaviour of the system with the predictions obtained from the models.



Dymola implementation of the Belgian poli-generative plant.



Example of control logic implemented for the Belgian demo.

3.6 Task 3.6. Biomass plant requirements and specific design to work as hybrid system for the cogeneration prototypes (CAR).

The technical characteristics of the biomass boiler plants were described in Deliverable 3.14 to support the building owners in the Public Tender context. The document describes the state of the art of different biomass boilers and the available systems in market for storage, transport and feeding and reports their characteristics and possibilities for being used in the BRICKER system. Furthermore, available biomass types, their prices and possibilities for being used in each demos site. The selection for specific cases of Belgian and Spanish demonstrators was described from a technical point of view. Biomass local markets (specifically Caceres and Liege in Spain and Belgian, respectively) were also studied and an optimization of its supply was considered to minimize the economic and environmental impacts. Additionally, some strategies for the management of ashes and reduction of boiler's emissions have been analyzed.

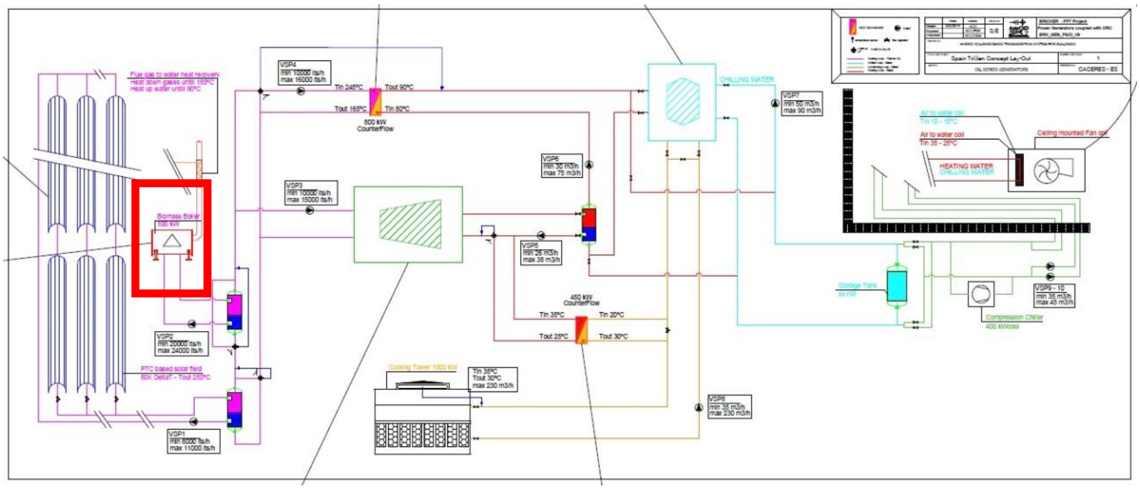
3.6.1 Biomass plant for Spain.

Although it was never installed, a biomass boiler was selected for the Spanish demonstrator in Cáceres. The boiler had a power of 500 kWt with oil as thermal fluid, specifically Therminol SP. The selection of this boiler with this power was mainly to meet the full requirements of the ORC, i.e., to feed the ORC only with the biomass boiler in the worst conditions (e.g. not available solar radiation for solar collectors). The selection of the thermal oil was linked to the possibility to work with high temperatures and with low pressures in comparison with the steam and superheat water, besides other advantages such as the low freezing point, easy control, no risk of corrosion and freezing damages and, it did not require a staff certified in steam boiler on charge of the installation at full time.

On the other hand, the biomass market in Spain was also analysed (and deeply in Cáceres area). The location of manufactures and providers of each type of biomass was identified, together with their supply capacity and prices (pellets, chips and olive kernel). The final decision about the biomass fuel was wood chips. However, in the selection of the biomass boiler, it was taken into account the availability of other cheaper biomass resources, hence, a multi-fuel boiler was selected to be installed in Spanish demo.

Finally, the normative for the installation of this kind of plants was identified in order to know define the specific requirements to take into account.

A layout with the integration of where all the equipment was integrated, including the biomass boiler (red box below), was developed (See figure below).

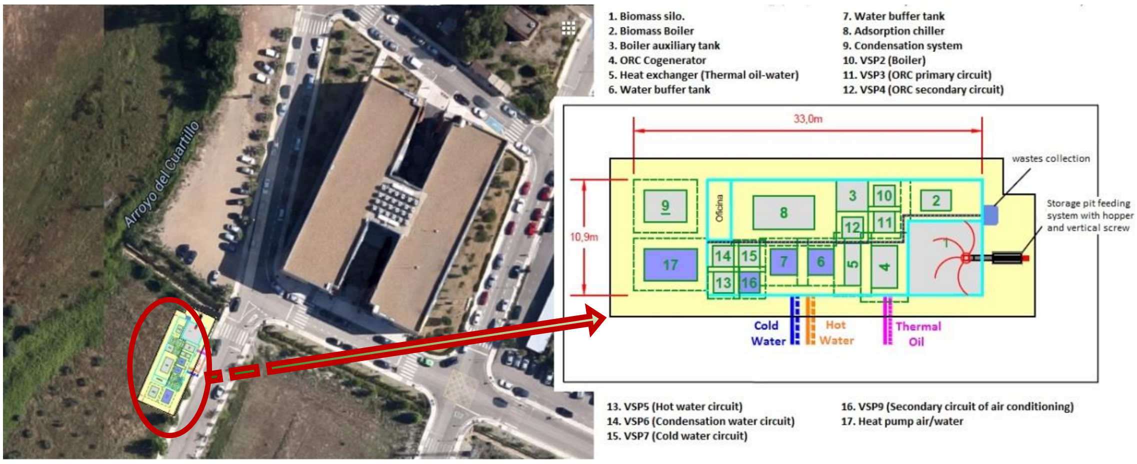


Biomass boiler integration in the Spanish layout.

Possible manufactures/providers of thermal oil biomass boilers were also identified for this range of power. Within the most remarkable are Sugimat and D'Alessandro Termomeccanica (SATIS). They provided budgets (around 100,000€), technical specifications and equipment dimensions. The budget matched with the expense assigned to the project (170,000 €).

For the biomass storage, three different scenarios were developed (conservative, intermediate and minimum) depending on the hours of operation of the boiler. Because the biomass supplier can change during the combustion plant life, and in the same way its transport, a versatile silo was considered. The selected silo allowed to discharge from a tipper truck transport into an external hopper to feed the silo with a screw elevator, and a discharge from a pneumatic truck directly through a hole in the silo's wall.

The location for the biomass boiler and also for the storage and rest of auxiliary equipment was out of the building in a specific room intended to house the BRICKER system. As the technical room was to be built new, there were not any restrictions in dimensions and no need for modifications. A proposal to place the system was provided (see Figure below).



Biomass boiler selection activities Spain.

3.6.2 Biomass plant for Belgium.

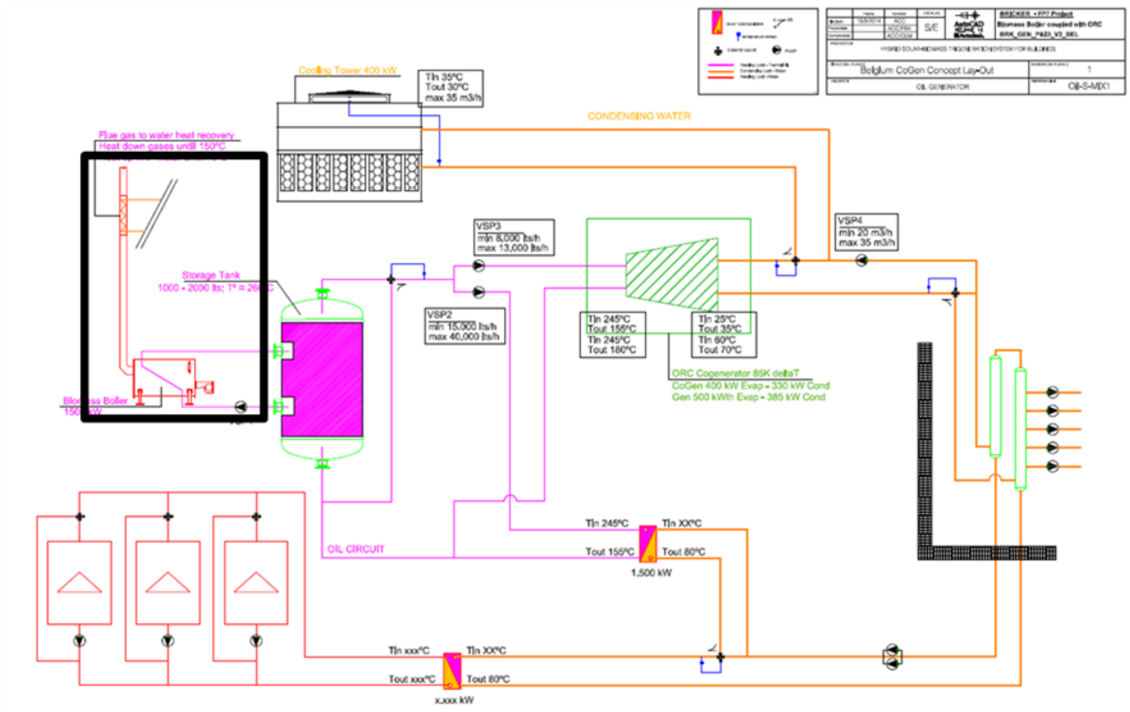
A biomass boiler for the Belgian demonstrator in Liege was selected. The boiler has a power of 1,500 kWt and uses oil as thermal fluid, specifically Therminol SP. Two options had been proposed, OPTION 1: 1 thermal oil boiler 500 kW for the ORC + 1 hot water boiler 1,000 kW low temp. for heating; OPTION 2: 1 thermal oil boiler 1,500 kW for the ORC and (with heat exchanger) for heating.

With this boiler besides to meet the requirements of the ORC, it is possible to provide thermal energy to cover thermal demands of the building (DHW and heating) through a heat exchanger oil-water. The selection of the thermal oil was due to the possibility to work with high temperatures and with low pressures in comparison with the steam and superheated water, besides the same advantages showed for the Spain demo site.

The biomass market in Belgium was also analysed (and deeply in Liege area). The biofuel finally selected to feed the biomass boiler was wood pellet (due to the availability of local providers identified and the limited space inside the building).

The technical regulation for this kind of boilers was identified (Solid fuel heat generators, Burners, Fuel storage, Emissions, etc.). This is important in order to know the requirements to install the system.

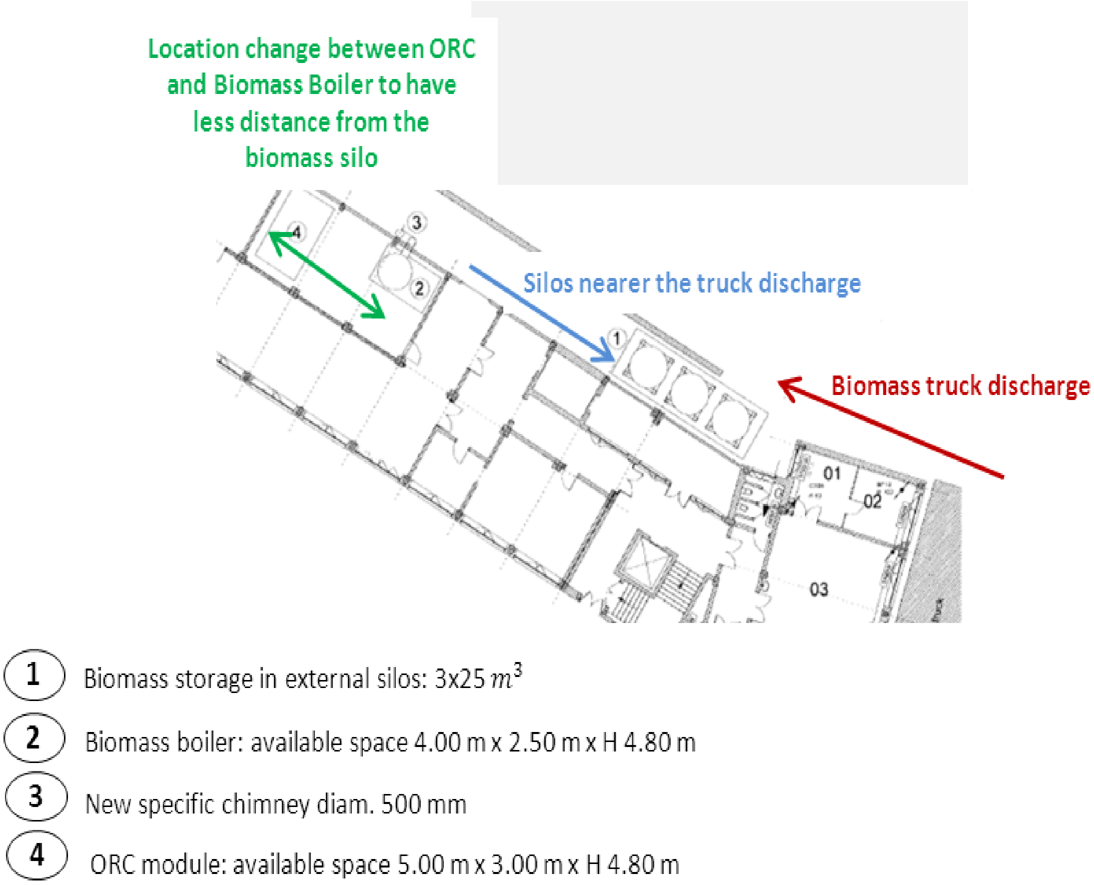
A layout with the integration of all the equipment was developed by the partners involved in the Belgian demonstrator, including within them the biomass boiler.



Biomass boiler integration in the Belgian layout.

Possible manufactures/providers of thermal oil biomass boilers were identified for this power range. Within the most remarkable are L'Solé, Sugimat and D'Alessandro Termomeccanica (SATIS). They provided budgets (between 130,000 to 300,000 €), technical specifications and dimensions for these machines. Some of the budgets (Sugimat) match with the expenses assigned for the project (190,000 €) although the building owner may propose to relocate budget form other interventions to purchase a specific boiler.

The location for the biomass boiler and rest of auxiliary equipment is inside the building in a specific room intended to house the BRICKER system. As this room is inside the building, there were many restrictions in the dimensions of the equipment; anyway the selected proposal was feasible with approximately 6 m of height for the biomass boiler. There were other proposals to locate the BRICKER systems but, due to the space limitations (mainly in height), and distances, these were rejected. The location of biomass boiler and ORC-prototype in a new technical room imposes some additional works to adapt this new technical room (fire-resistant, chimney, etc.).



Locations for the boiler (2) and storage silos (1).

Because of the building is located along an avenue and between many others buildings, the available spaces to storage the biomass fuel is limited as well as the access to the building. It is not possible to discharge a truck with wood pads or other biomass fuel. The adopted solution is storage in external silos and delivering of pellets with pneumatic truck.

Three external silos of 75 m^3 were proposed for the pellet storage. An estimation of the potential working hours at nominal power was also been performed, according to the storage volume (around 130 working hours at nominal power).

Different transport system from biomass storage silos to biomass boiler alternatives were also analysed in order to identify the most suitable. The pneumatic transport was chosen because of the distance and the existence of corners which make difficult other options.

3.7 Task 3.7. Chiller plants requirements and specific design to work in tri-generation mode with the Cogeneration prototypes (CAR).

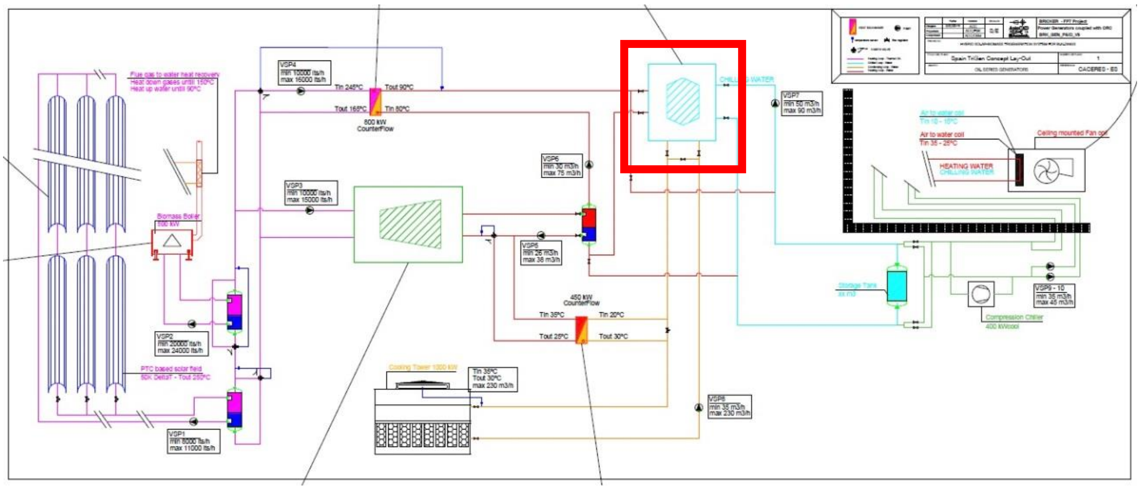
The technical characteristics of the cooling technologies were described in Deliverable 3.15 to help the building owners in the Public Tender context. The document covered a wide state of the art of the thermally activated cooling technologies, including a very detailed list of possible manufacturers/providers. Furthermore, the requirements of the chiller plants for Turkish and Spanish demonstrators to work in trigeneration mode (climate conditions, cooling demand of the building, heat source levels, existing conventional production systems, interaction with the rest of the BRICKER system and conventional systems, etc.) were identified. The selection of the most suitable technology for each demo cases is also included in the report as well as suggestions about potential constructors.

3.7.1 Chiller plant for Spain.

After an exhaustive analysis, an adsorption machine was chosen for the Spanish demonstrator in Cáceres for the cold production. This selection was made considering the limitations of the available heat sources (condensation heat from the ORC) to work in trigeneration mode.

For the selection of the power capacity of this adsorption machine in this specific administrative building, the needs to cover the demand of the building to server were considered. Moreover, the normative analysis concluded that any existing regulation is applied for this kind of machines since there were not any hazardous components nor high pressures existing.

A layout including the adsorption chiller (red box below) was developed.



Chiller integration in the Spanish layout.

Possible manufacturers/providers of adsorption chiller units were identified within the range of power selected for the administrative building (e.g. Mayekawa, GBU and Nishiyodo (ICOGEN). Within them is important to remark Nishiyodo (ICOGEN) as the only provider with whom it was possible to contact, and to get specific information and a continuous feedback (Budget, technical characteristics, dimensions, etc.). The estimated cost for the Nishiyodo machine was 160,000 € which is within the budget available for the project (218,000 €).

The chiller was chosen to be located outside the building in a specific room intended to house the BRICKER system. The only requirement for the chiller was to be protected from the weather conditions and to have enough space for the O&M.

3.7.2 Chiller plant for Turkey.

Because of the limitations to work with a trigeneration system were the same in both demonstrators, the final decision about the adsorption machine was based on the same arguments. The main difference was in the heat source that feeds the ORC unit because in this case, it will be solar thermal collectors supported by a natural gas burner.

In addition, due to the great cooling demands of this building, the selection was based only on the restrictions coming from the ORC and the economic limitations, so the idea was just to cover part of the cooling load of the building.

Possible manufacturers/providers were identified within the range of power selected (e.g. Nishiyodo (ICOGEN), ECO-MAX and Mayekawa). The location of the adsorption unit was going to be out of the building, near the existing chillers as can be seen in the Figure below, therefore there is not dimension restrictions to locate this machine.

Location of the adsorption unit in the Turkish demo case

4 WP4 BRICKER Technologies integration in buildings.

4.1 Task 4.1. Concept design, model design and simulation of the BRICKER technologies in different scenarios (EUR)

4.1.1 Detailed characterization of the demo building (EUR)

This activity deals with the preparatory activities for carrying out a detailed energy simulation of a building. In order to achieve this aim, the following tasks were done:

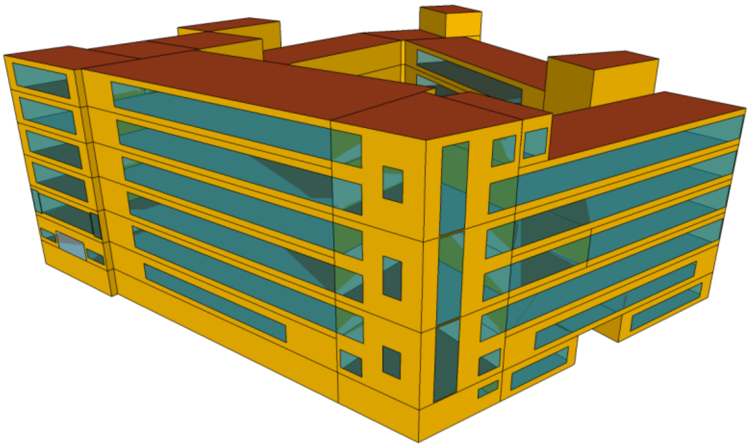
1. Data acquisition and energy audit for detailed building simulation.
    a. Turkey. Task accomplished.
    b. Belgium. Task accomplished.
    c. Spain. Task accomplished.
2. Development a Word document for reporting on building boundary conditions (internal gain, ventilation, infiltration, geometry…). This document will be part of the final deliverables of WP4.
    - The document has been developed and it is continuously updated according to the model development process.
    a. Turkey. Template delivered, document in a draft phase.
    b. Belgium. Template delivered, document in a final phase.
    c. Spain. Template delivered, document in a final phase.
3. Development of an Excel sheet where the specific value of the different boundary conditions are specified.
    a. Turkey. Task accomplished.
    b. Belgium. Task accomplished.
    c. Spain. Task accomplished.
4. Weather analysis of average and extreme data set and weather file definition.
    - The analysis has been carried out by using the software Meteonorm and the weather files have been made available. A further plausibility check has been made by comparing DNI values with those provided by PVGIS.
    a. Turkey. Weather file delivered.
    b. Belgium. Weather file delivered.
    c. Spain. Weather file delivered.
5. Creation of the subdeck on weather boundary conditions.
    - This task has been already accomplished.

4.1.2 Existing building modelling (EUR)

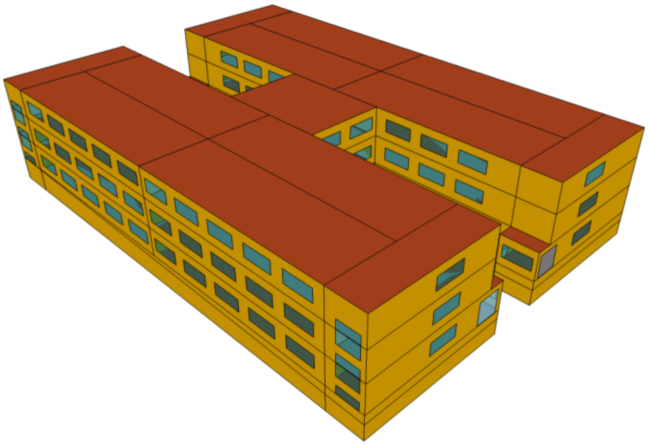
For each demo building the followings activities were done so far.

1. Definition of the thermal zones, according to the existing energy system and control strategy.
    a. Turkey. Task accomplished.

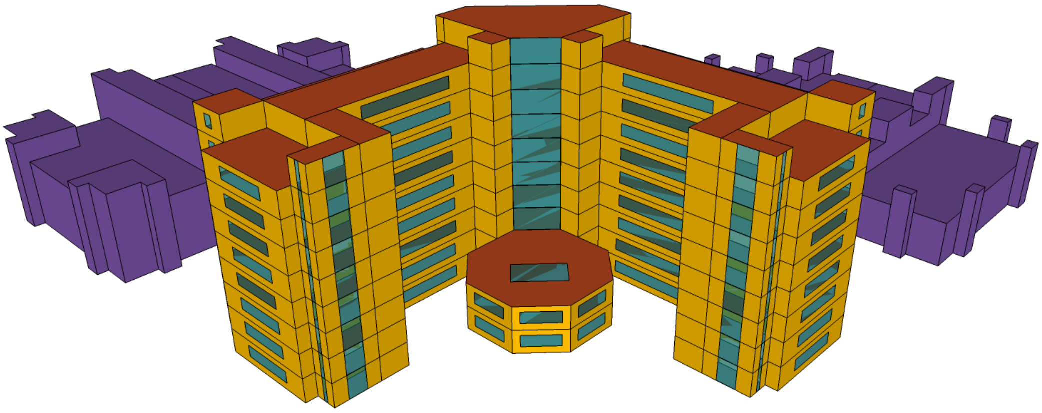
   b. Belgium. Task accomplished.
   c. Spain. Task accomplished.
2. Simplification process of the building model in order to define a trade-off between accuracy of the model and computational effort.
   a. Turkey. Task accomplished.
   b. Belgium. Task accomplished.
   c. Spain. Task accomplished.
3. Definition of the final building model.
   a. Turkey. Task accomplished.
   b. Belgium. Task accomplished.
   c. Spain. Task accomplished.
4. Simulation of the existing building (building envelope + existing energy system):
   a. Turkey. In progress.
   b. Belgium. Task accomplished.
   c. Spain. Task accomplished.
5. Simulation report:
   a. Turkey. A draft version is in progress.
   b. Belgium. Final version has been distributed in March 2015.
   c. Spain. Final version distributed in March 2015.



View of the Belgian demo building model made with Trnsys 3D plugin.



View of the Spanish demo building model made with Trnsys 3D plugin.



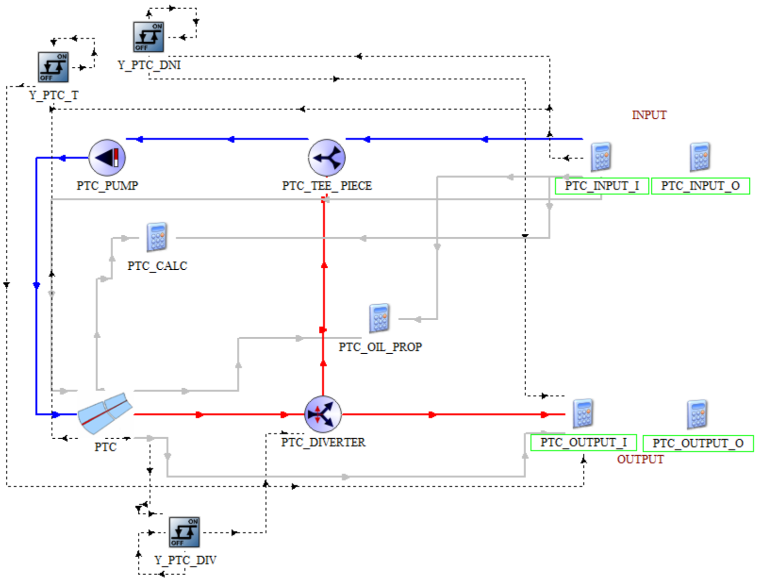
View of the Turkish demo building model made with Trnsys 3D plugin.

4.1.3 Definition of a sub-deck for each active and passive technologies (Studio file) (EUR)

The development process of the sub-deck was achieved by doing the following activities:

1. Definition of the purpose of the model in order to understand which level of detail is required (white, grey or black box model).
    a. PCM insulation material. Task accomplished.
    b. Ventilation façade. Task accomplished.
    c. Aerating window. Task accomplished.
    d. Concentrating solar collector. Task accomplished.
    e. Chiller & biomass boiler. Task accomplished.
    f. ORC unit. Task accomplished.

2. Brief literature review on the existing numerical codes for simulating a given active/passive technology and selection of the Trnsys type.
    a. PCM insulation material. Task accomplished.
    b. Ventilation façade. Task accomplished.
    c. Aerating window. Task accomplished.
    d. Concentrating solar collector. Task accomplished.
    e. Chiller & biomass boiler. Task accomplished.
    f. ORC unit. Task accomplished.
3. Development of the sub-deck eventually with the implementation of a low-level control strategy + documentation of the numerical models.
    a. PCM insulation material. Task accomplished.
    b. Ventilation façade. Task accomplished.
    c. Aerating window. Task accomplished.
    d. Concentrating solar collector. Task accomplished.
    e. Chiller & biomass boiler. Task accomplished.
    f. ORC unit. Task accomplished.
4. Plausibility tests for model verification and validation according to existing monitored data or laboratory test results.
    a. PCM insulation material. Task accomplished.
    b. Ventilation façade. Task accomplished.
    c. Aerating window. Task accomplished.
    d. Concentrating solar collector. Task accomplished.
    e. Chiller & biomass boiler. Task accomplished.
    f. ORC unit. Task accomplished.

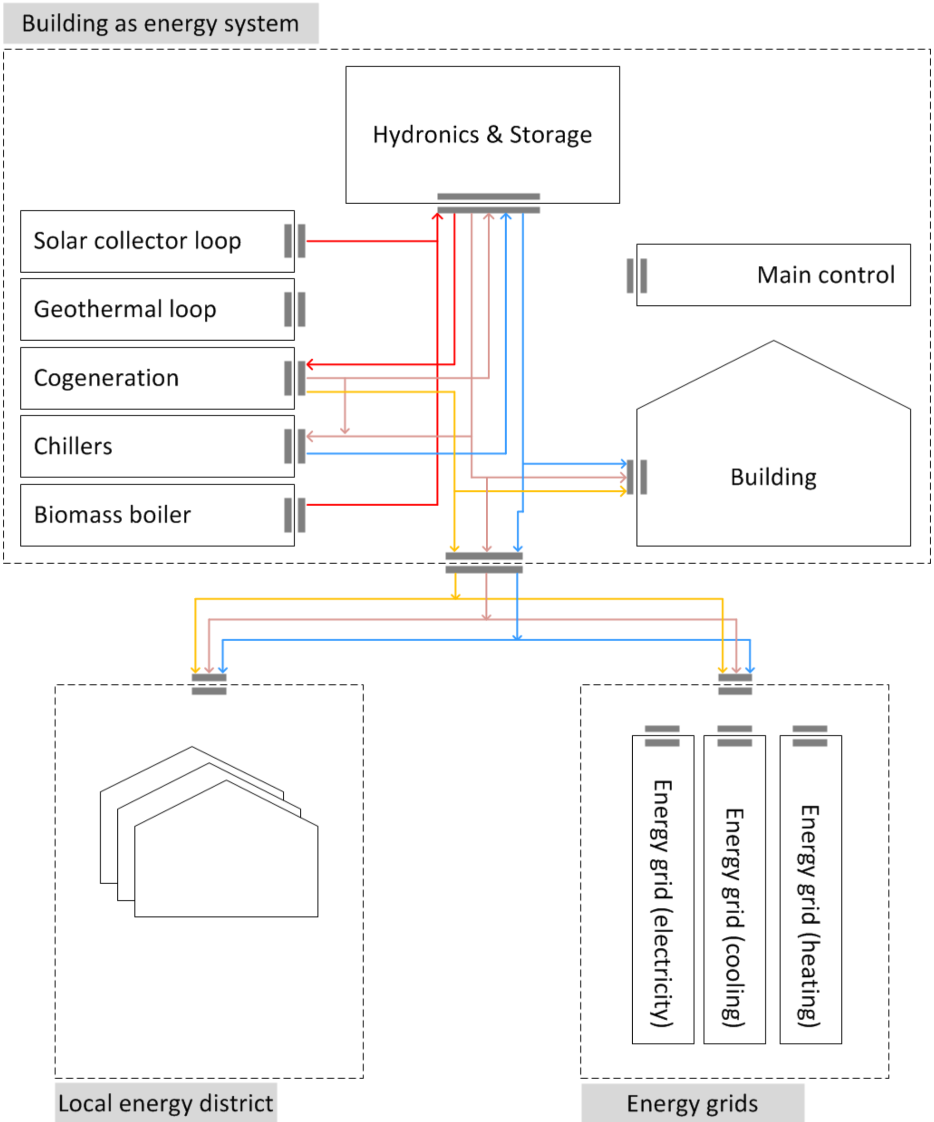


View of Trnsys subdeck of Parabolic Trough Solar Collectors.

4.1.4 Creation of Trnsys deck modular template (EUR)

This task was tackled firstly defining the syntax among the simulating team. The main activity were to formalize the main simulation approach, consisting in defining the structure of the simulation environment based in Trnsys, the nomenclature and the syntax to use for each sub-deck development.

This task was then accomplished.



Concept visualization of the modular Trnsys template.

4.2 Task 4.2. Optimal PASSIVE Systems integration project in the buildings, based on WP2 and WP5 (EUR)

4.2.1 Analysis of the energy saving potential due to passive technologies (EUR)

A set of preliminary simplified simulations was carried out on passive technology in order:

- to evaluate and quantify the impact of passive technologies on the installation site with respect the actual scenario;
- to compare the effectiveness of alternative traditional interventions;
- to recommend optimized operation strategies.

The final status of work is:

a. PCM insulation material: a final document was distributed among partners.
b. Ventilated façade: a final document was distributed among the partners.
c. Ventilated window: a simulation report was shared with Greecom, and the optimization of the system has been reviewed and delivered.

4.2.2 Definition of cost-optimal scenarios for passive technologies (EUR)

The integration of Bricker renovation concepts in the Turkish and Belgium demos was accomplished. A dedicated simulation report was distributed with project partners.

4.2.3 Input to building owners for tender preparation (PASSIVE) (EUR)

The preliminary set of simulation provided inputs for tender preparation for Belgium and Turkish demo buildings. The Spanish demo building did not foresee any intervention on the building envelope.

4.2.4 Detailed project of PASSIVE technologies (EUR)

A detailed project for renovation of building envelope for the Belgium and Turkish demo buildings was prepared. Thanks to the input provided to the building from Task 4.1, a project of the refurbishments intervention was possible.

In Period 3, the pending works in relation to the Turkish demonstrators were finished. These works were the insulation of the façade of the hospital Block A, the replacement of the window sills and the insulation of the Block A roof. In the corresponding deliverable *D.5.28. Technical specifications of the Tenders*, the information prepared in this task was added.

4.3 Task 4.3. Optimal ACTIVE Systems integration project in the buildings, based on WP3 and WP5 (EUR)

4.3.1 Analysis of the energy saving potential due to active technologies (EUR)

This activity on the Spanish demo building was accomplished in Period 2. A Trnsys model of the Bricker energy concept was completed based on the P&ID developed so far. The control strategy of the system was finished in Period 3.

With respect to P4.3 related activities, the Turkish demo installation suffered delays. The simulation activity were focused on the development of the numerical model of the extended solar field.

4.3.2 Definition of cost-optimal scenarios for active technologies (EUR)

Cost optimal scenarios for the Spanish demo building were discussed. Different operation strategies were compared in terms of yearly operational energy costs. The definition of appropriate economic boundary conditions is crucial since it significantly influences the problem. This activity was meant as a starting point for investigating the feasibility of using Bricker energy concept in social housing (see WP4.6).

Cost-optimal scenarios for Belgian and Turkish demo building were finished in Period 3, see Work Package 5.

4.3.3 Input to building owners for tender preparation (ACTIVE) (EUR)

The required information of tender preparation was mainly dealt with the definition of minimum performance requirement of system components such as the biomass boiler or the sorption chiller. The capacity of active components was based on heating and cooling building's loads derived from numerical simulations.

4.3.4 Detailed project of ACTIVE technologies (EUR)

A detailed project was developed for the Turkish demo building in Period 3. This activity for Spanish and Belgium demo buildings can be considered accomplished in Period 2.

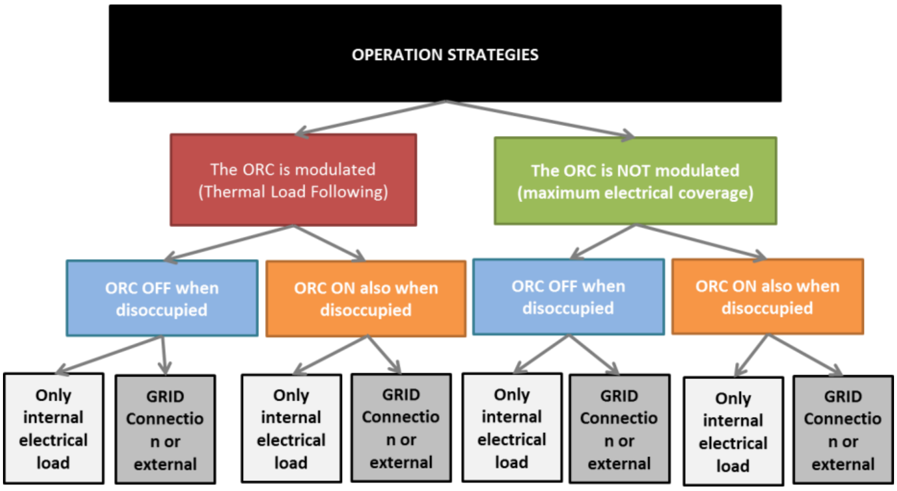
In Period 3, works in relation to Task 4.3. for the Turkish demonstrator were extended after the decision to send there the technologies from the Spanish demonstrator. By this, the works developed by Partner EURAC had to be reconsidered in the new situation.

The main difference was the integration of the new solar field of around 450KW thermal power, to be placed next to the previous one in the surroundings of the hospital in Aydin. The thermal and hydraulic balanced had to be redesigned, and new simulations were carried out by EURAC. Also, the ORC coming from the Spanish demonstrator was sent to Turkey to be operated in parallel to the first one.

4.4 Task 4.4. Operation strategies (FBK)

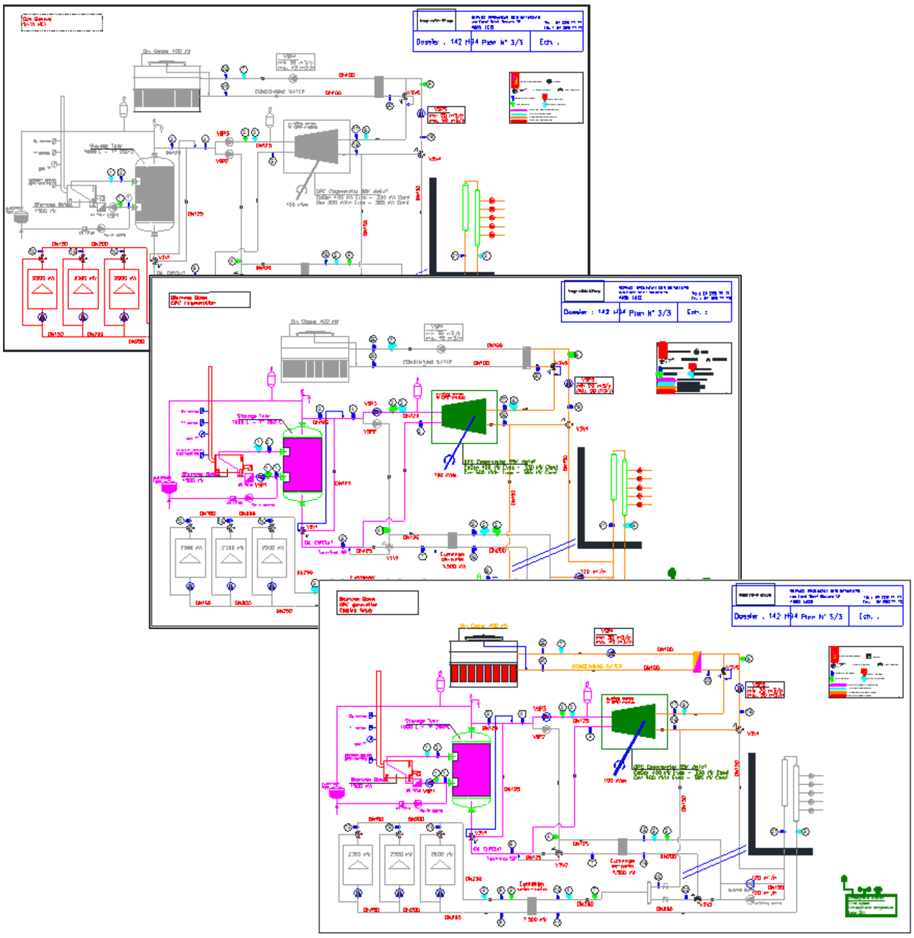
The operation strategies were developed by FBK carrying out simplified numerical simulations in Dymola. The outcome of this preliminary activity was then implemented into a whole system simulation in TRNSYS environment developed by EURAC.

The work related to the operation strategy was finalized for the Belgian demonstrator in P3. Regarding the Spanish demonstrator, as it was out of the Project, works done were not implemented.

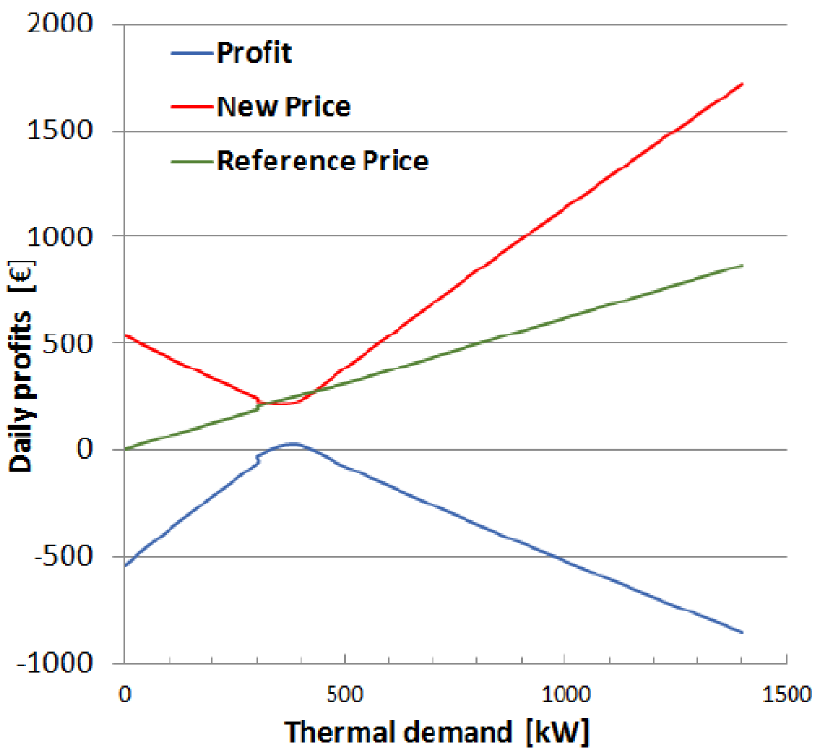


Operation Strategies.

For each demo site, different control strategies are discussed with EURAC and tested individually in order to define benefits and disadvantages of each configuration. The following picture partially describes some of the strategies adopted and studied during the analysis of the Belgian demo.



Control strategies simulated through the use of Dymola software for the Belgian demo site.



Comparison different operation strategies.

The previous picture depicts the result of a typical daily dynamic simulation performed to understand how to make the Belgian demo profitable depending on the biomass price. Next step were to complete the implementation of the Turkish demo in Dymola, then performing the simulations of the proposed control strategies for the last demo site of the Bricker project, all achieved in Period 3.

The fine tuning of the best performing operation strategies keeping in mind long term strategies was also realized through dedicated yearly TRNSYS simulations carried out with support from EURAC.

4.5 Task 4.5. Guides for design, commissioning and maintenance (ONU)

This task has had a direct relation with the works done in Work Package 5, where the BRICKER systems were implemented in the two demonstration sites.

As part of the works done in Work Package 4, it is to be highlighted that the technologies installed in the demonstration buildings will remain there beyond the project termination. This means that the property of the systems will be transferred from the BRICKER technology providers (solar collectors, ORC) to the building owners, and the equipment will be operate din the buildings during the coming years.

In this task, works have been progressing in parallel in the two demonstration buildings, as the two systems were not exactly the same and their operation, maintenance and commissioning were also different. All the information is available in the deliverable reported, *D.4.34. Guides for design, commissioning and maintenance*, presented the last month of the Project.

Here, there is a brief summary of the content of such document:

Belgian demo:

- Building description together with energy behaviour and demand through a normal climatic year.
- Description of the actual energy systems and the new BRICKER systems integrated in the building.
- Commissioning guidelines for all the technologies, provided by the manufacturers and adapted to the specificities of the BRICKER system.
- Operation, transport, installation and maintenance guidelines, provided by each technology manufacturer. Some of them were BRICKER Partners (Aerating windows for example(and some others not (for example the biomass boiler).
- Security recommendations, installation instructions, loading and unloading, operation general guidelines and skills and tools needed to perform all these tasks with a well skilled technical team.

Turkish demo:

- Building and sanitary district description, systems and networks, climatic conditions in the Aydin province.
- Active systems installed via BRICKER Project, regulation specificities in Turkey, thermal and mechanical properties of the solar field, cogeneration description and chiller description. Description of the integration of the new systems in the existing district loops.
- Commissioning of the solar collectors: expected use, how to avoid wrong use, safety standards, personnel training, transportation, installation, assembly, verification of proper execution and tests done by manufacturer.
- Commissioning of the absorption chiller: Connections, insulation, water and compressed air treatment and needs, operation guides, and maintenance instructions from manufacturer.
- Commissioning of the ORC cogeneration units: working principle, installation guides for delivery, handling and storage. Installation and operation manual by manufacturer.
- Operation and maintenance guidelines by manufacturers. For the solar collectors, the chiller and the ORCs, a list of documents has been elaborated including the following: start-up and shut down instructions, operation and control modes, alarms and risks related to abnormal thermal inputs, regulation specificities from Turkey, recommended maintenance protocols, including maintenance plans and maintenance operation descriptions.

4.6 Task 4.6. BRICKER Concept transfer to Social Housing (TEC)

In this Task, the implementation of the BRICKER Concept in Social Housing Residential buildings was analysed and discussed, with the aim of obtaining conclusions about the BRICKER replicability to the residential sector.

In the first approach of this deliverable, the task was planned to be focused on an existing building located in the same region as the Spanish BRICKER Demo, following analogous steps to the other tasks on WP4 and developing a virtual implementation of BRICKER concept. The very first efforts on this task were aligned with this approach, in Period 1.

On the 1st Review Meeting (M18), it was pointed out and agreed the convenience of expanding the scope of the task from one specific building to diverse social housing replication scenarios. Moving from a simulation based quantitative approach to a wider and more qualitative one would improve the replication conclusions of BRICKER concept to social housing at European level.

After reviewing the characteristics of European building stock, example study of BRICKER application in social housing buildings is focused on the stock from the 1970-80s, at seven different representative climates.

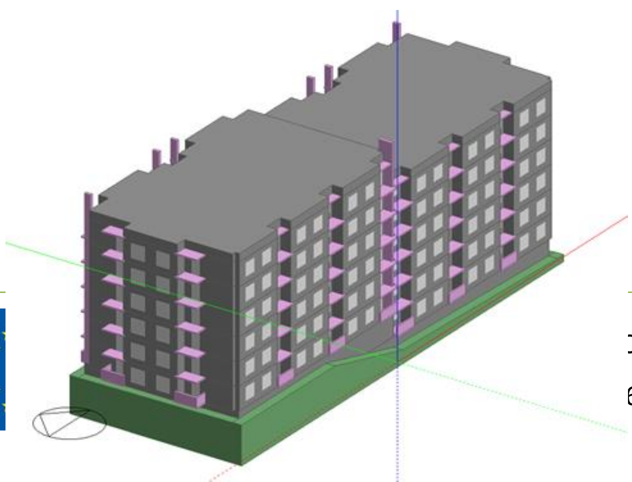
Based on commercial software tools, the implementation of the BRICKER solutions was modelled and simulated. Comparing the numbers obtained with the simulation for the actual performance of the buildings and the performance after implementing the BRICKER concept, economic and environmental KPIs were calculated to identify the most promising scenarios.

Methodology used

The electrical and thermal loads of a building, as well as the RES potential, depend largely on the geographic locations, as well as on other various factors such as building use and typology. Therefore, the first step was to reduce the number of different climates and building typologies around Europe to seven. This selection was based on literature, which ended with the selection of the following climates: Southern Dry, Mediterranean, Southern Continental, Oceanic, Continental, Northern Continental, Nordic.

The literature review provided as well the information required for the simulation of the different solutions.

On a second step, the characteristics of a generic standard building were defined. This standard building has a define area and volume and it is located on a standard urban environment. This model was adapted to the typical constructive properties of the 7 locations, which allowed to quantify baseline scenarios. To estimate the demand of the building for the different climates, Design builder with Energyplus as simulation engine was used.



Once the baseline was defined for all the climates, a second round of simulations were performed. In this second round, the following passive solutions of BRICKER were theoretically implemented on the building to estimate the reduction on energy demand:

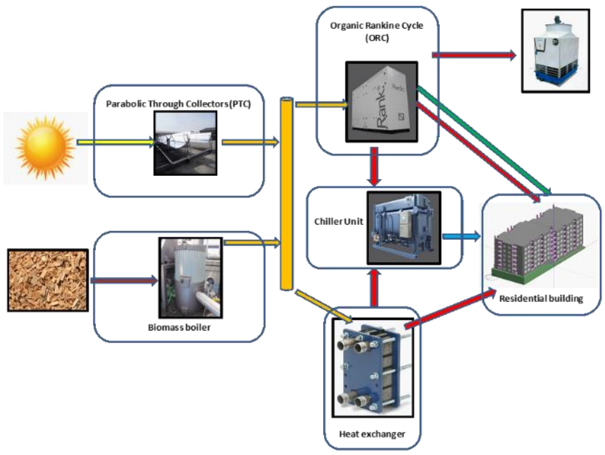
- Insulation of the outer surfaces.
- Ventilated façade.
- Airtightness of the envelope reduced.
- Mechanical ventilation with heat recovery (0.945% efficiency), with the same air changes per hour as the natural ventilation.

Regarding the active solutions, the BRICKER concept was as well simulated based on:

- Integration of solar collectors on the roof.
- Biomass boiler.
- ORC in cogeneration mode to cover both the electric and the heating load.
- Adsorption pump to cover the cooling load.

The systems were seized to cover the estimated demand of the buildings according to the above simulations. Two scenarios were considered:

- 100% of the energy needs of the building are covered with the BRICKER system (both electricity and thermal energy),
- 50% of the electrical demand and 100% of thermal energy demand are covered with BRICKER and the remaining 50% of electricity with electricity coming from the grid.



Finally, an evaluation of the performance in terms of economic, energetic and environmental KPIs was performed.

Results

In the following table, the numbers obtained for the replication of the BRICKER concept to social housing are summarized.

From environmental perspective, the reduction of CO2 shows the convenience of the BRICKER concept. The large savings in terms of energy costs suggest the suitability of the application of the BRICKER concept in all the climates considered. To increase the number of working hours for the system, and therefore reducing the payback of the solutions, it is suggested to implement the BRICKER concept in districts combining both residential buildings and public buildings as nodes of district grids to generate and distribute renewable energy. Public authorities can establish ESCOs to exploit this kind of district systems, releasing the residential occupants from the initial investment.

	Primary energy reduction	CO_2 reduction	Cost savings
Madrid	48%	85%	66%
Rome	38%	83%	62%
Munich	61%	87%	74%
Ljubljana	56%	87%	62%
Copenhagen	51%	85%	73%
Stockholm	42%	86%	72%
Brussels	65%	88%	71%

5 WP5 Demonstration and evaluation in three existing public buildings in Europe.

5.1 Task 5.1. Monitoring and performance evaluation before renovation (ACC).

General budgetary situation for the pre-monitoring (to be confirmed after P2 financials are approved)

#	What?	Spain	Belgium	Turkey
A	Sensors, network analysers, thermometers and other metering equipment.	CEMOSA: 10.000€ to purchase these consumables	ULG: 10.000€ to purchase these consumables	ONU: 10.000€ to purchase these consumables
B	Installation of A, including cables, protections and other material needed.	CEMOSA: 4.000€ to subcontract the installation	ULG: 4.000€ to subcontract the installation	ONU: 4.000€ to subcontract the installation
C	Data collectors and communication equipment: BRICKER monitoring cabinet.	ACCIONA; 25.000€ for the 3 demo sites, to purchase servers or any other communication equipment needed.		
D	Installation of C	GEX, included in their subcontracting demo budget	SPB, included in their subcontracting demo budget	ADU, included in their subcontracting demo budget

Monitoring budget table per demo.

5.1.1 Preparation for monitoring (ACC).

Turkey;

As the Spanish case has been the reference, the adaptation of the Spanish memo to the Turkish case has been finished, and there is a “monitoring report” available for the Turkish demonstrator with technical specifications.

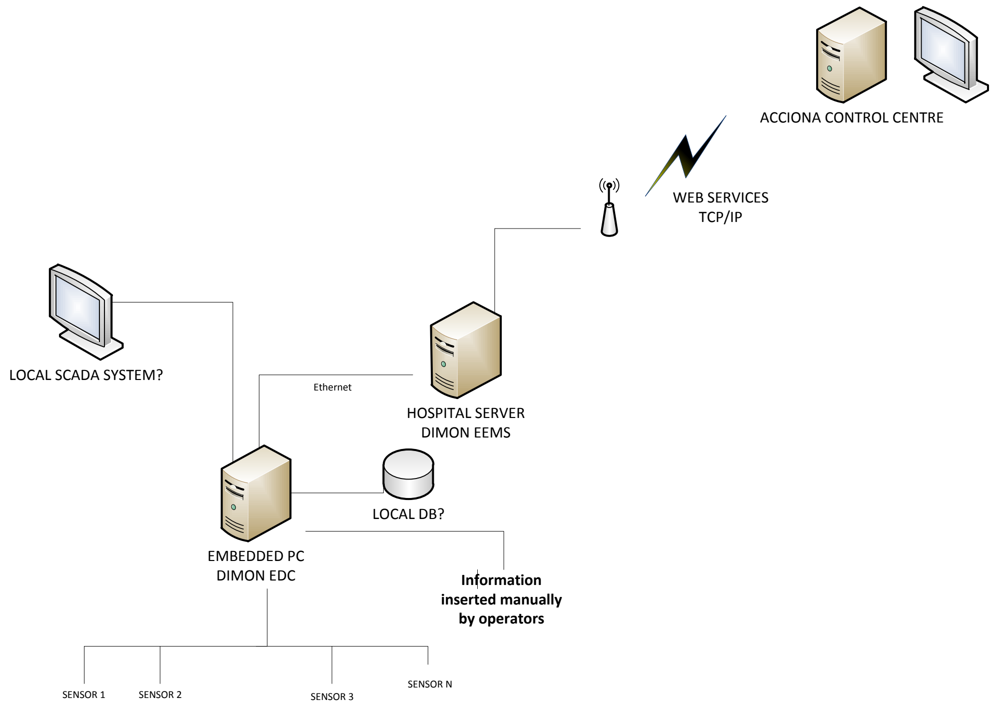
As the Hospital is going to tender the implementation of the monitoring system, the Turkish Partners are working on the preparation of the documentation to select a subcontractor to perform the implementation of the selected measures.

Chilled water demand, heating consumption and Electric consumption of Block A will be measured.

The pre-monitoring architecture has been defined and it's being implemented. A total of 107 signals will be monitored and sent to Bricker control centre using web Services

DIMON EDC (Energy data collection) embedded PC application collects real-time data from the analysers, meters, and sensors installed to monitor the energy behaviour of the building.

The data collected is sent to local SCADA solution DIMON EEMS, the data is published via web services, last 5 days of data can be collected real time, data will be stored with a 10 minute frequency, monthly archives with historical data can be manually sent.



Bricker monitoring layout in the Turkish demo.

<u>Belgium;</u>

There is historical energy consumptions available (bills) from 2010, 2011 and 2012 for the WHOLE BUILDING (all blocks), so this is a starting reference in relation to the building energy use.

BRICKER interventions focus only on Blocks 1 and 6, so we have to break down the energy use for those 2 blocks.

The Belgian building is being monitored (all blocks, gas and electricity) by the local energy provider, E.D.F., since October 2013, so this has been considered as a positive actions from which some synergies and agreements have been made.

Specifically:

- Heating consumption: SPB installed individual heating meters for each of the 11 heating distributing collectors in April 2014 (in agreement with E.D.F.). Taken this into consideration, we focused on the **3 pipes which provide heating service to Blocks 1 and 6**.
- Electrical consumption: After a number of visits to the building started in March 2014, we identified **7 electrical circuits serving Blocks 1 and 6. All these lines were monitored in June 2014.**

In relation to the communication of the monitoring data to the ACCIONA data Centre in Madrid, an FTP server was activated in Madrid, and we are working on the first tests to receive daily files from E.D.F Server in Paris, containing all the relevant measures of SPB Building.

Once the file transfer process is active, a middleware to migrate this data into ACCIONA Data Centre will be implemented. This is the only remaining work in relation to the Belgian demonstrator monitoring.

Files have been received in ACCIONA Data Centre in a daily basis since beginning 2015 and the information received will be displayed in ACCIONA Data Centre.

Spain;

The building is 100% electrical powered. We are monitoring:

- Total Heating and cooling, on one meter.
- Total Ventilation; 3 meters, one per floor.
- Rest of energy (lighting and other uses) on one meter.
- Indoor air quality in floor 1, using 4 sensors in a representative area.

The Spanish monitoring project is to be used as a reference for the other 2 demos.

Up to now, main works already finished are:

- Monitoring project available since March 2014.
- Installation of the monitoring equipment finished in June 2014, performed by a local subcontractor of the Building Owner, Partner GEX.
- Start-up of the data collection and data transfer to ACCIONA Data Centre in progress is active since the 15th of July 2014. This is the official start date of this demonstrator.

Bricker Cabinet installation in GEX building

5.1.2 Monitoring and analysis (ACC).

IPMVP (International Performance Measurement and Verification Protocol) implemented by Efficiency Valuation Organization (EVO) has been followed and data analysis procedures are being developed. All Data from the buildings will be analysed in a monthly base and Excel data templates will be created and used for data analysis.

Turkey:

Data is being stored locally in DIMON EEMS SCADA, integration with ACCIONA data centre is in final stage.

Integration of local data stored in DIMON EEMS SCADA and ACCIONA control centre has been completed. Data has been monitored and stored in ACCIONA database, energy analysis including energy baseline for electric and heating consumptions is being completed. The methodology of the analysis is included in deliverable D5.26 Energy performance assessment of the 3 buildings before renovation.

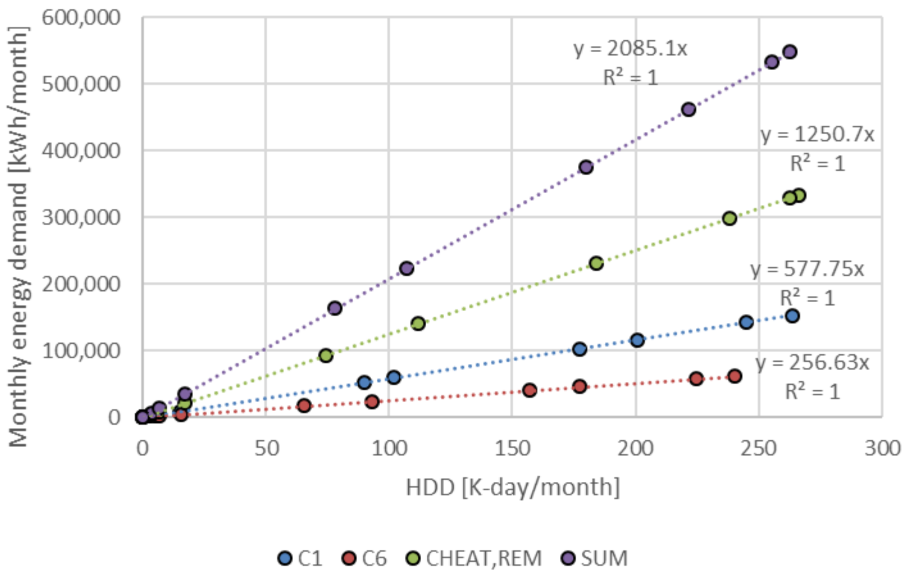
Belgium:

Final communication tests are to be finished before the end of October 2014, and the middleware needed to convert the daily files received in Madrid with the ACCIONA Data Centre is planned to be developed by a subcontractor and installed during the last months of 2014.

Data is being received since 1 July 2014 in a daily base; 26 points are being collected with a 10 minute granularity.

Integration with ACCIONA data centre is in final stage.

Data has been monitored and stored in ACCIONA database, energy analysis including energy baseline for electric and heating consumptions has been fulfilled. Results are included in deliverable D5.26 Energy performance assessment of the 3 buildings before renovation.

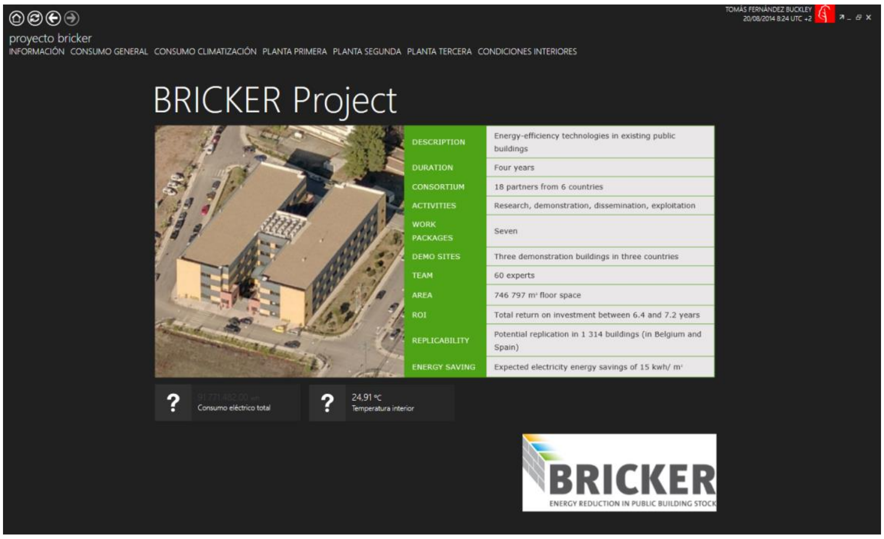


Monthly heat energy demand versus heating degree days.

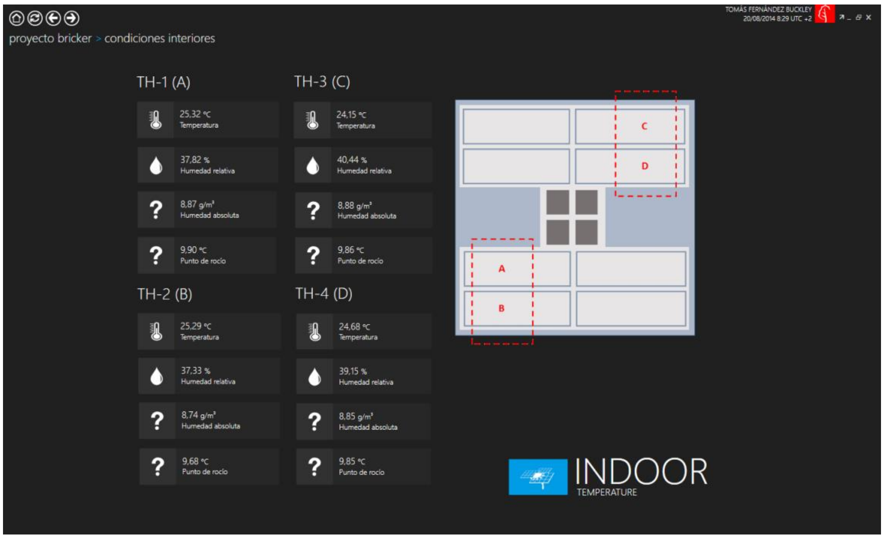
<u>Spain;</u>

Monitoring started in July 15th 2014. Data will be stored for its analysis in the ACCIONA Data Centre System.

Herein below, there are 2 screen shots of the ACICONA Data Centre interface developed by ACCIONA for the Spanish demo. The same structure for presenting data will be implemented in Belgium and Turkey.

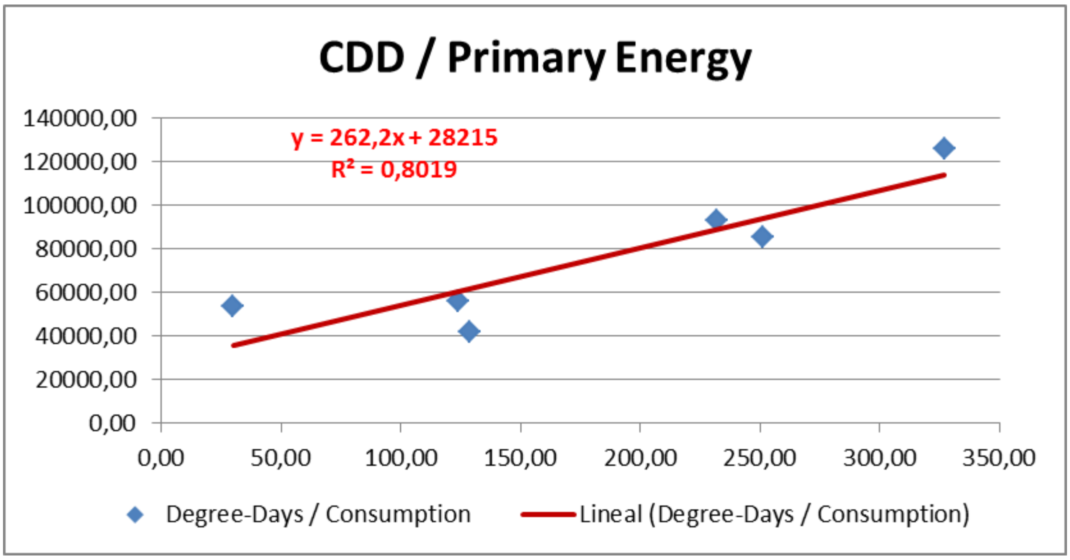


BRICKER monitoring user´s interface, main screen.



BRICKER monitoring user´s interface. First floor indoor parameters.

Data has been monitored and stored in ACCIONA database, energy analysis including energy baseline for electric consumption has been fulfilled. Results are included in deliverable D5.26 Energy performance assessment of the 3 buildings before renovation.



Primary energy baseline.

5.2 Task 5.2. Manufacturing of the solutions to be installed in the demonstration buildings (ACC).

According to the DoW WP5 section, there are three components to be manufactured within this task, which are the ventilated façade for the Turkish demo (ACCIONA), the ventilation units for the Belgian demo (GREENCOM) and the PIR foam panels for the Belgian demo (PURINOVA). In the three cases, works include manufacturing and transportation to demo sites. Again, in the three case, the transportation costa initially planned to be assumed by the manufacturers (or the technology senders) has been relocated to the receiver Partners, the building owners, due to customs and ease of execution.

Partial progress items describe works done up to date:

5.2.1 Ventilated façade for Turkey (ACC).

All the façade elements were ready to be shipped from Madrid to Aydin in due time, according to the original plan. However, there has been a delay in the launching of the Turkish tenders, due to the political situation in this country, among other reasons. By this, the façade was sent by ACCIONA to Turkey, and is there ready to be installed by the selected subcontractor.

It is to be remarked that the subcontracting budget to send the components to Turkey was shifter from the Spanish Partner ACCIONA to the Turkish “receiver” Partner ADU, due to customs and border facilities.

In the following pictures, all material and components are shown as stored in Madrid and the Hospital demo prior to its installation in due time. It is to be remarked that during the transportation, some panels were broken and a new delivery had to be organised by ACCIONA.

BRICKER ventilated façade components stored in ACCIONA facilities in Spain.

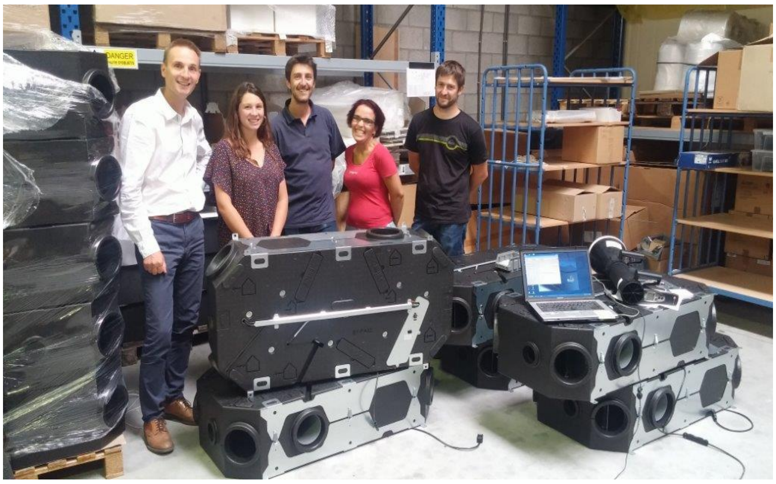
BRICKER ventilated façade components stored in Turkey by the Hospital, ready for installation.

Broken panel after the first delivery.

5.2.2 Double flow ventilation units for Liége (GRE).

In the last proposal for the installation of the double flow ventilation systems from Partner GREENCOM, it was decided to use 22 units, instead of the originally 15 planned. This is due to the fact that each window has 2 units, and in order to monitor 11 windows, we need 22 units.

In the following figure there is a group picture of the GREENCOM team with the first units manufactured.



GREECOM team with the first double flow units.

GREECOM first double flow unit installed at MONTH 36.

5.2.3 PIR foams for Liége (PUR).

All the panels were manufactured by PURIONOVA, using the specifications and the PCMs sent by ACCIONA.

The picture below shows (in month 37), the start of the installation process in the Belgian demonstrator where these are going to be installed and monitored.

PIR foam panels with embedded PCM installation works in Liége.

5.3 Task 5.3. Installation, commissioning and start-up (ACC).

TURKEY (Building owner ADU);

After some meeting and considering different legal, technical and administrative issues, the Turkish Demonstrator will be retrofitted in 5 different tenders, chosen by administrative efficiency, indicated in the table below:

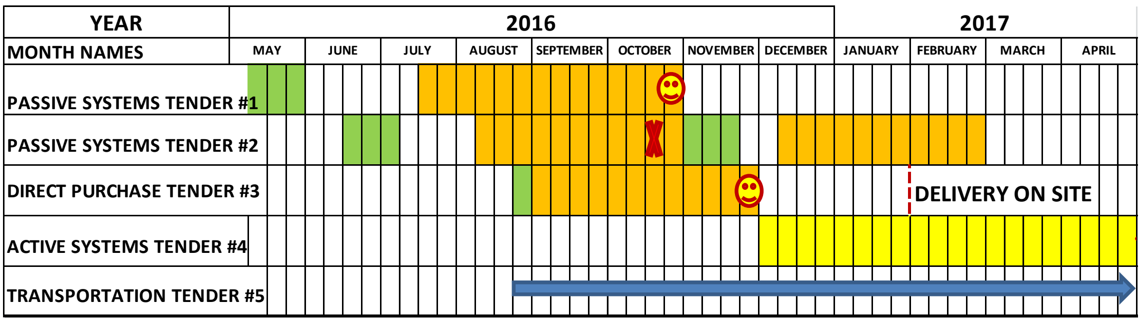
Tenders TURKEY	Description	Budget (€)	Tender start/end date	Works execution start/end date
1 - Passive tender A	Approximately 11000 m^2 mineral insulation on walls. Approximately 800 m^2 Ventilated Façade Works. Approximately 1000 linear meters Window Sills. Approximately 1390 m retrofit and installation of vertical drain pipes.	250.000	May 2016	July to October 2016
2 - Passive tender B	Approximately 4000 m^2 mineral insulation on roof Approximately 550 linear meters	160.000	June to July 2016	August 2016 to February 2017

Tenders TURKEY	Description	Budget (€)	Tender start/end date	Works execution start/end date
	Aluminum coping on the roof Approximately 1350 m^2 Window solar reflective film application			
3 - Active systems BRICKER	BRICKER Active systems integration; solar + ORC + Adsoprtion into the existing HVAC Facilities – EPC contract	670.000	August 2016	September to November 2016
4 - Chiller direct purchase	Independent tender to ease of administration. Direct purchase of the Adsorption chiller	150.000	2016	December 2016 to April 2017
5 - Transport tender	Transport of the façade from Spain to Turkey	12.000	December 2015	February 2016
TOTAL Estimated (€)		**1.242.000**		

Turkish demo tenders´ table updated at month 36.

As for the project progress, tender 5 is finished, and tenders 1, 2 and 4 are ongoing. There is a significant delay with respect to the original plan, but actions have been taken by the Turkish team to absorb them. Although the post monitoring period might be reduced, works are planned to end up on time for the actual project duration, which is ending in October 2017.

The Turkish team has reported an updated Gantt chart for the tenders, dated October 2016, and it looks like the one below;



Considering that the original plan was to end up the construction works in April 2016, the delay is 12 months.

<u>BELGIUM (Building owner SPB);</u>

They have planned the following sequence of procurements, divided in **<u>4 independent contractors</u>**. Up to date, all tenders have been awarded, all contracts signed.

The final economic data is therefore available, and the following table shows the estimations and the final bids awarded, with the deviations respect to the original plan.

				OFFERS	
Nr Files	Description	Bricker Budget (exclusive VAT) defined in the DoW	Budgetary allocations (VAT included)	Awarded Offer (VAT included)	Deviations
142 H94	Works for installation of biomass cogeneration ORC unit, hydraulic piping, electric cables, control system, biomass boiler plant and biomass storage	415.800 €	503.500 €	**860.044,44 €**	**+ 70 %**
143 H94	Works for retrofitting of the main skin facade in block 1	630.000 €	762.300 €	**797.602,82 €**	**+ 5 %**
144 H94	Works for insulation roofs of block 1 and 6	214.500 €	260.000 €	**224.297,63 €**	**- 14 %**
145 H94	Works for insulation of external walls, replacement of windows and integration of decentralized ventilation-units in blocks 1 and 6	1.041.620 €	1.306.120 €	**1.425.769,02 €**	**+ 9 %**
		2.301.920 €	**2.831.920 €**	**3.307.713,91 €**	**+ 17 %**

Belgian demo tenders´ table, estimated and awarded, including deviations, updated in April 2016.

<u>**SPAIN (Building owner GEX);**</u>

The Spanish demonstrator, due to the strong delays and the following reasons, has to leave the BRICKER consortium. After a number of months trying to get the tender launched, it was not possible to assume the delay within the duration of the Project. Although a six month extension was granted by the European Commission, they had to terminated their participation in the CRICKER Project.

In the following two sections, we include the evidence of the construction works for the Turkish and the Belgian demonstrators, according to the tenders structure presented above, and for the whole duration of this task 5.3.

The technical specifications of the tenders are listed in D.5.28, and the pictures and evidence of the installation may be consulted in D.5.29.

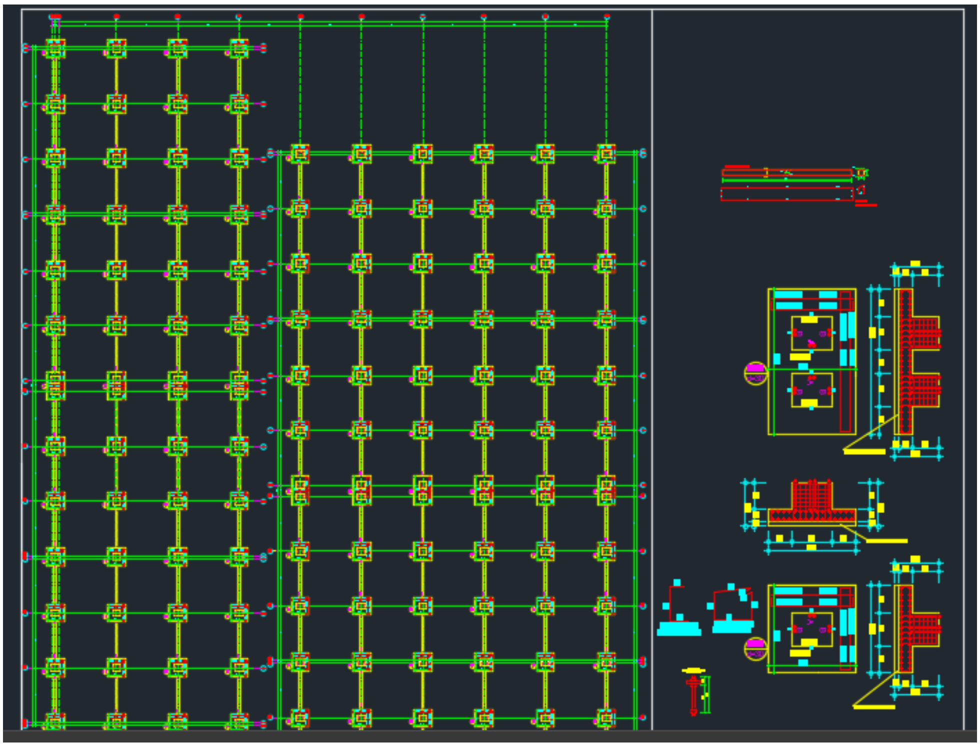
5.3.1 Turkish demonstration execution works.

Main entrance of Block A (centre) original status.

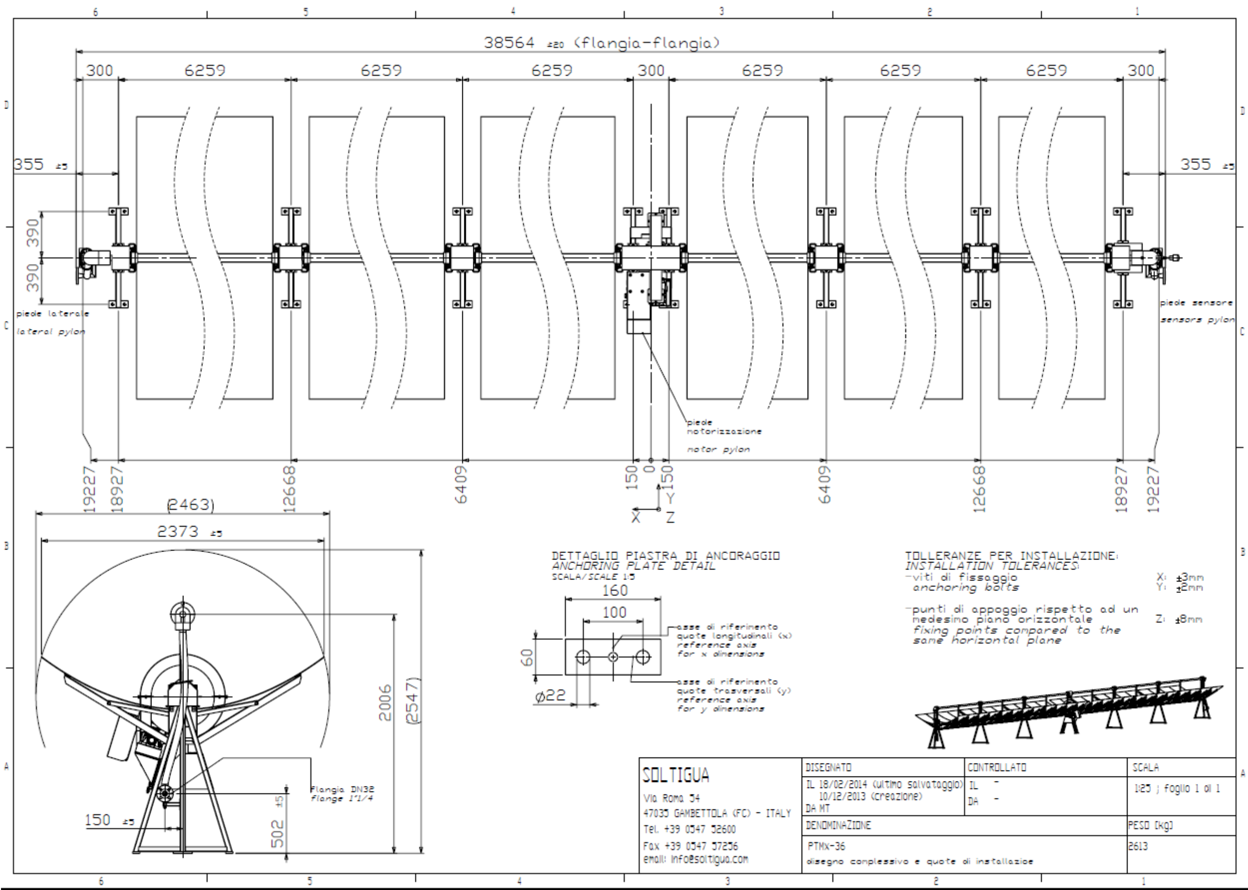
Tender 1: Solar Field Preparation and Roof Insulation

Solar field 1 preparation.

September 2017 – Works for ground preparation for solar field 1.



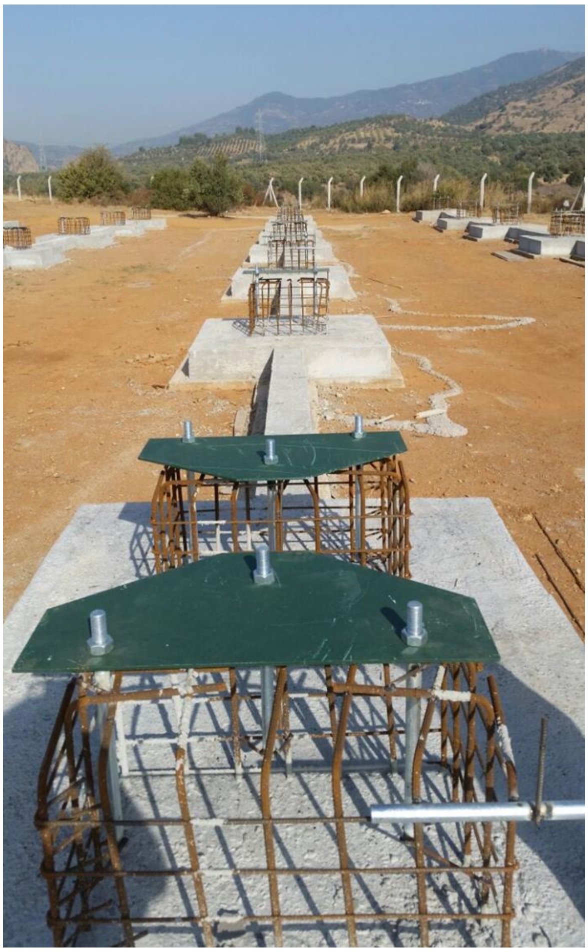
Solar Field 1 Foundation plan.



Solar collector details, and requirements for foundation, provided by Partner SOLTIGUA.

October 2017 - Solar field 1 foundation work in progress.

October 2017 - Solar field 1 foundation work in progress.



November 2017 - Solar field 1 foundation work in progress.

Solar field 2 preparation.

March 2018 - Solar field 2 foundation works

O

March 2018 – Solar field 2: Collectors assembled.

Roof insulation.

October 2016 – 1. phase insulation works / notching & 3 mm main blend application on the roof floor

October 2016 - Insulation works on the upstand

October 2016 - 2. phase insulation works / 26 mm main blending on the roof floor

October 2016 – height control of the insulation layers

October 2016 - 2. phase insulation works / 26 mm main blending on the roof floor

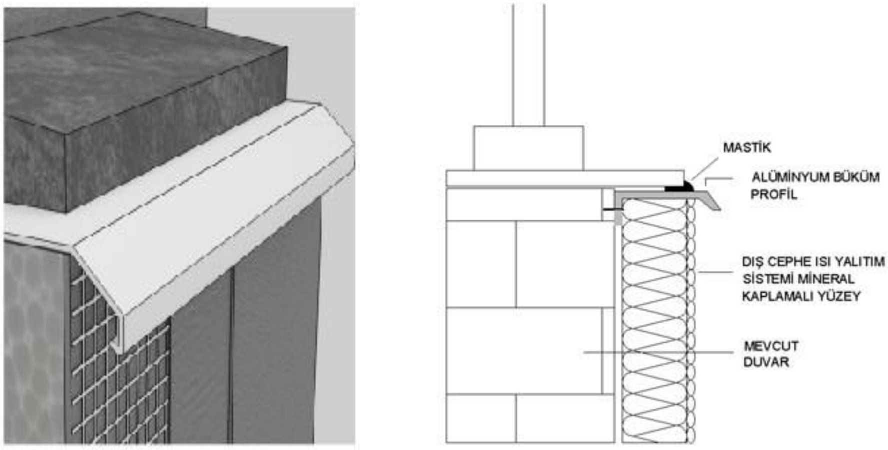
October 2016 – 3. phase insulation works / 5 mm paste blend application

Tender 2 : Adsorption Chiller Purchase

October 2016 - AD-Chiller inspection trip to India by Partner ADU

October 2016 - AD-Chiller placement in BRICKER Warehouse

Tender 3 : Passive Systems

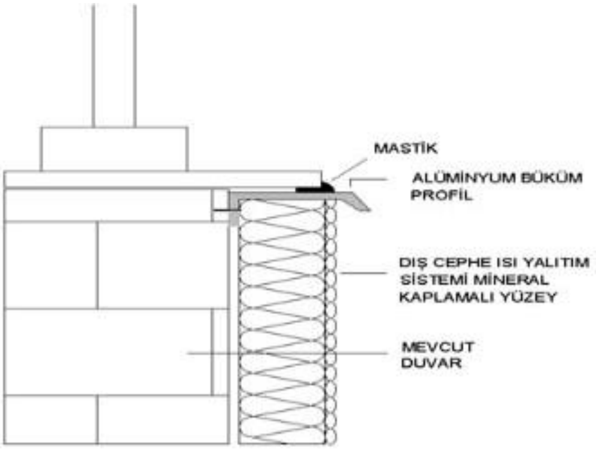


September 2016 - Window sill aluminium water drainage detail studies

September 2016 - Insulation mock-up works

September 2016 - Insulation mock-up works

September 2017 - A block south façade insulation works



September 2017 - Window sill aluminium water drainage detail

September 2017 - Windowsill details pinned on the façade

September 2017 - Windowsill finishes

September 2017 - Dilatation detail

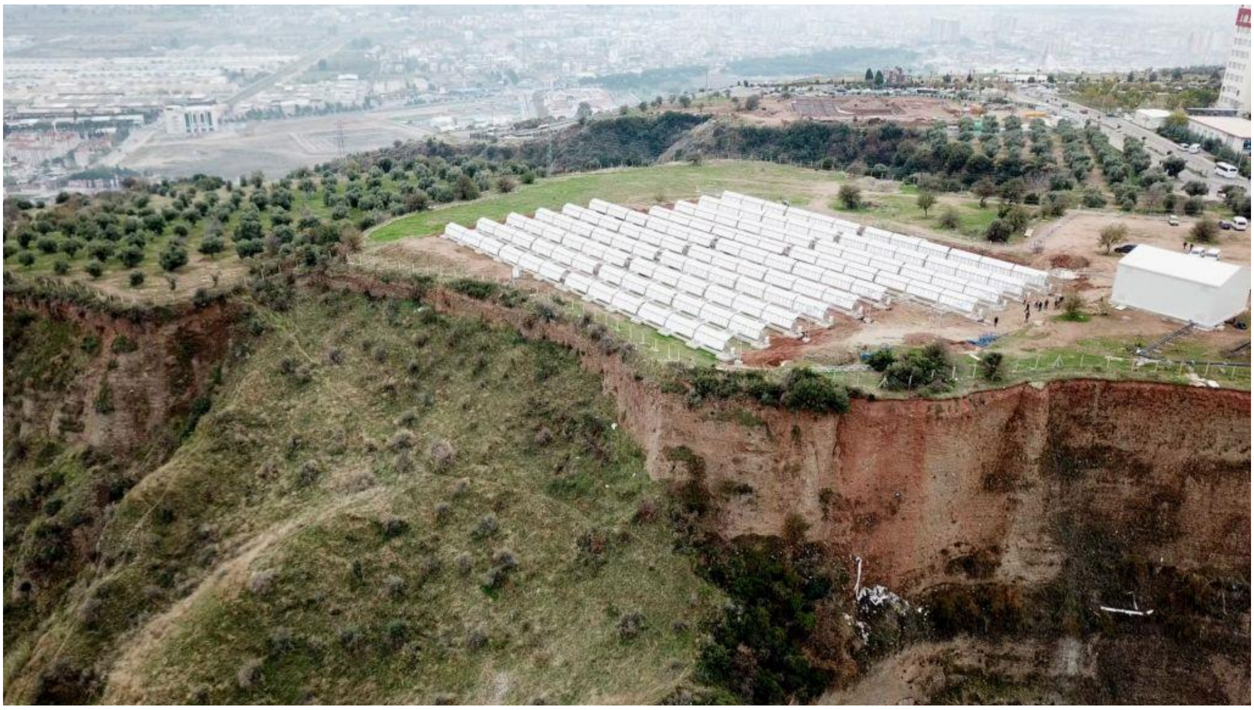
September 2017 – Corner detail

September 2017 – Scaffolding of façade works

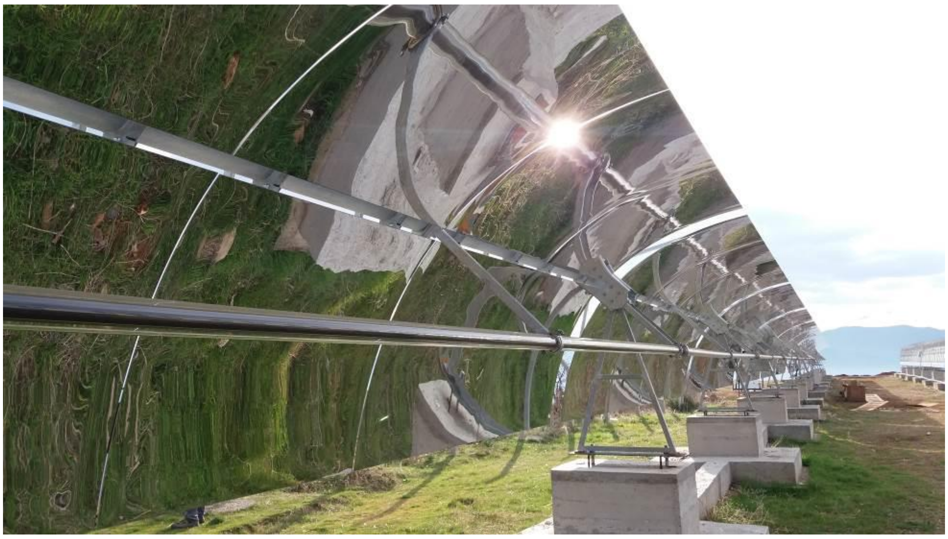
Tender 4 : Active Systems

Active System Installation Works Application Site

February 2018 – Drone view of solar field 1.



February 2018 – Drone view of solar field 1.



February 2018 –View of solar field 1.

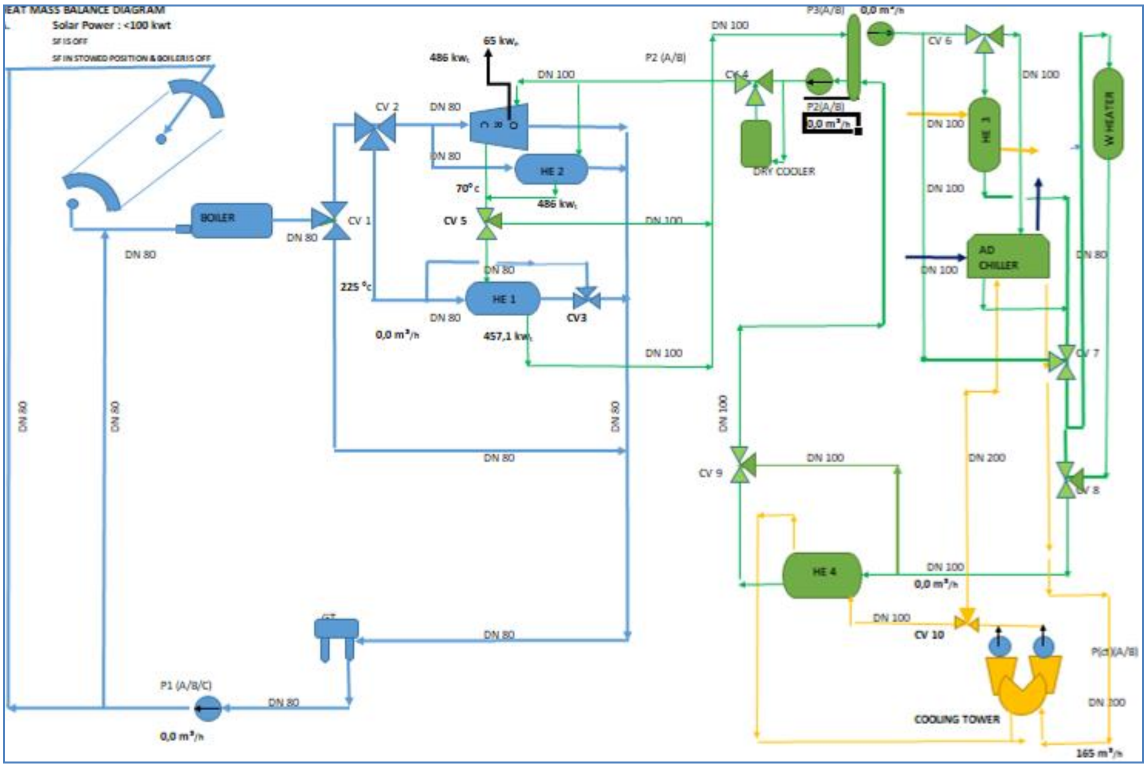
December 2017 – BRICKER warehouse structure raising.

January 2018–Piping works.

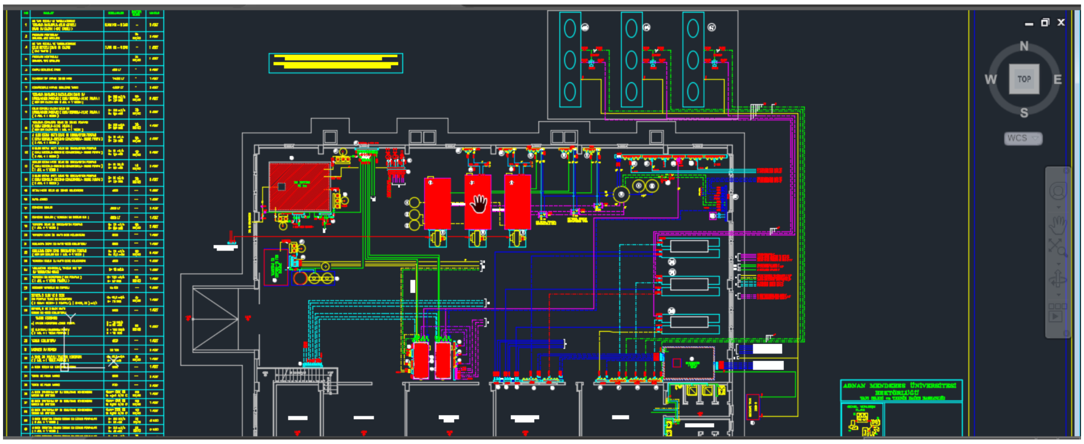
January 2018–Pumps installed.

February 2018– The 2 cogeneration units from Partner RANK are placed in the BRICKER Warehouse.

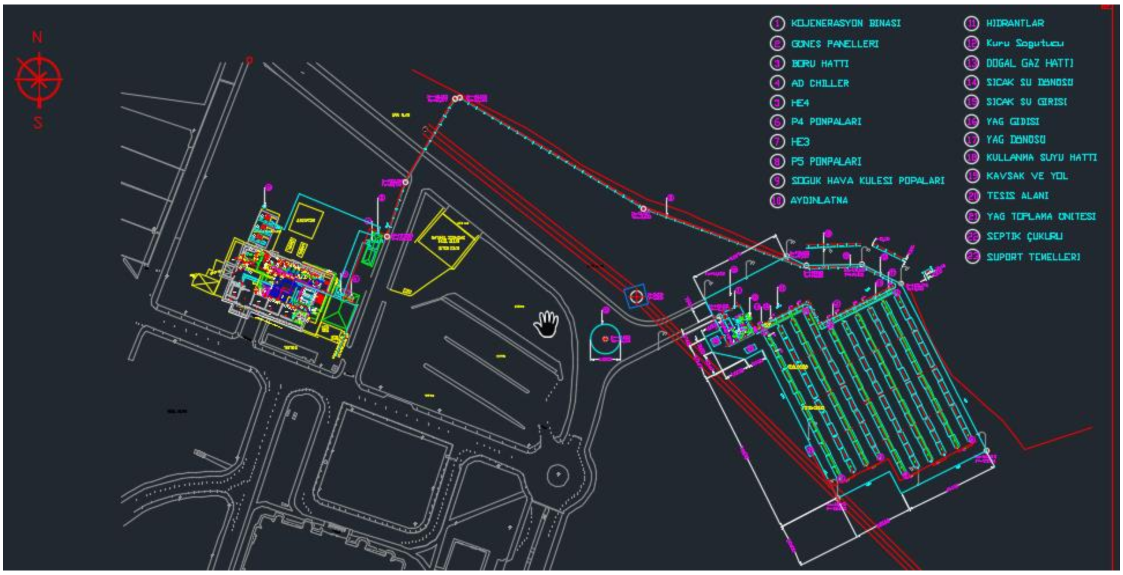
January 2018 – Drone view of the piping system connecting BRICKER to the Hospital.



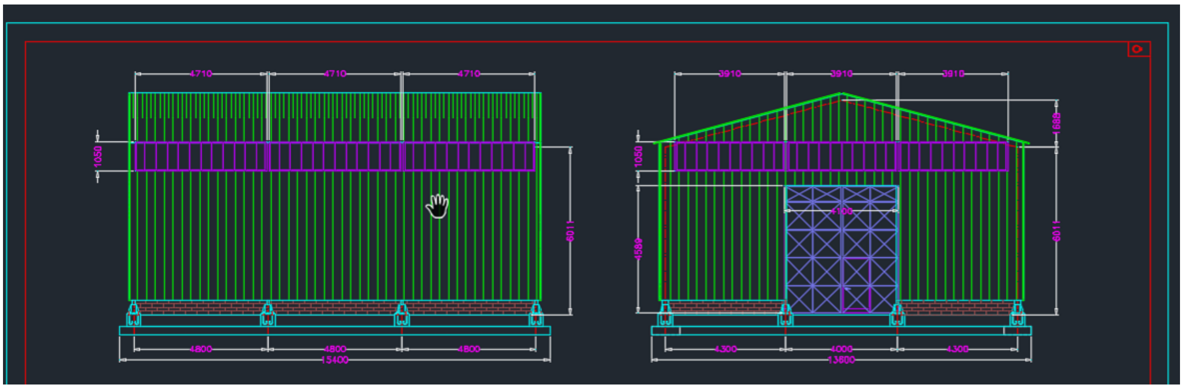
Heat and Mass Balance Diagram for the BRICKER System



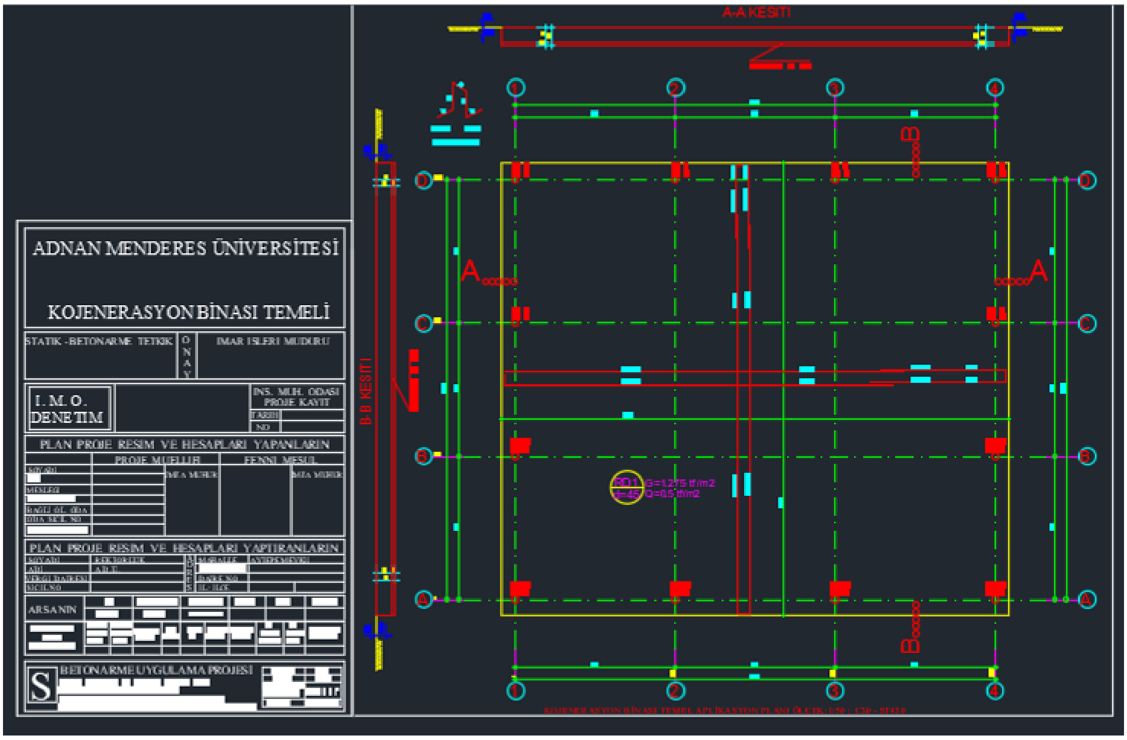
P&ID Diagram for the BRICKER System



General Layout original plans



Cogeneration Building, or BRICKER Warehouse original plans

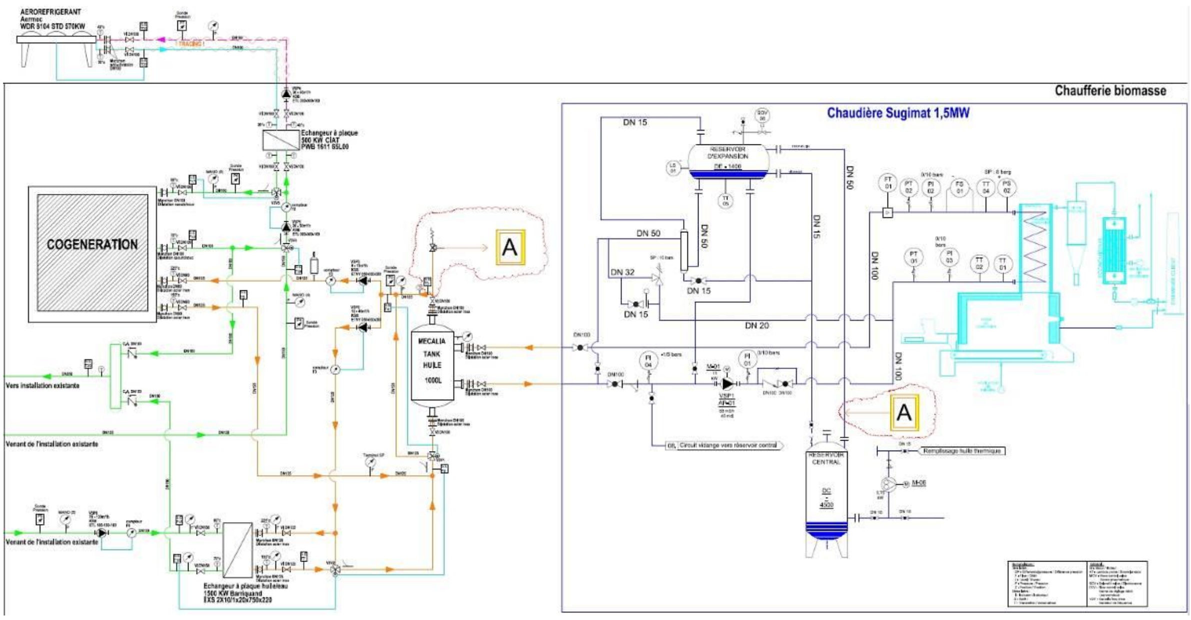


Cogeneration Building Ground original plan.

5.3.2 Belgian demonstration execution works.

Tender 1: Installation of biomass cogeneration ORC-unit, hydraulic piping, electric cables, control system, biomass boiler plant and biomass-storage.

Before BRICKER: Three gas boilers provide all Heating for the whole Building.



After BRICKER – Hydraulic scheme proposed, with biomass boiler and cogeneration unit.

June 2016 – New heating room prepared

October 2016 – Delivery of the ORC-module from partner "RANK"

January 2017 – Assembly of the biomass boiler

January 2017 – Delivery on site of the exchanger thermal oil

March 2017 – Storage of pellets in 3 silos

April 2017 – Chimney extractor and storage tank for thermal oil

June 2017 – Assembly of hydraulics piping

August 2017 – Expansion joints between old and new heating rooms

September 2017 – Insulation works completed

February 2018: Official inauguration with local authorities and Project Coordinator.

Tender 2: Retrofit of the main skin facade for Block 1.

Original view of the façade

February 2016 – Installation of elevators (lifts) on site

February 2016 – Dismantling Curtain Wall A

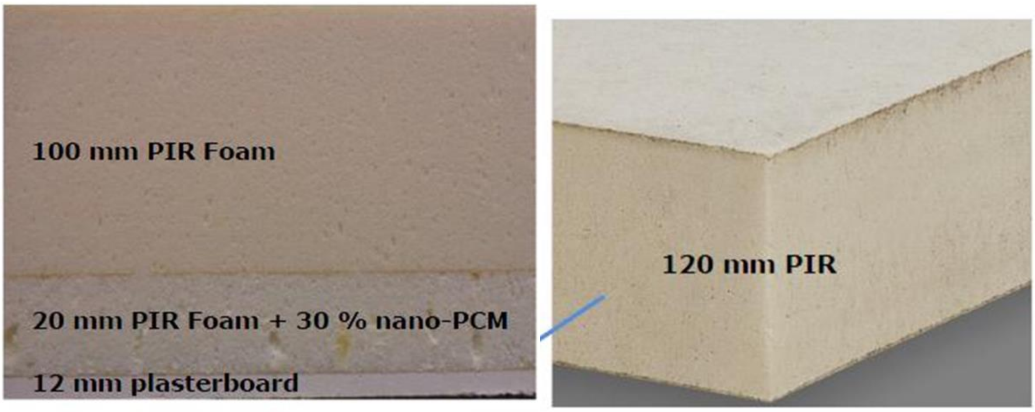
March 2016 – Rebuilding Curtain Wall A – Dismantling Curtain Wall B

April 2016 – Rebuilding Curtain Wall B

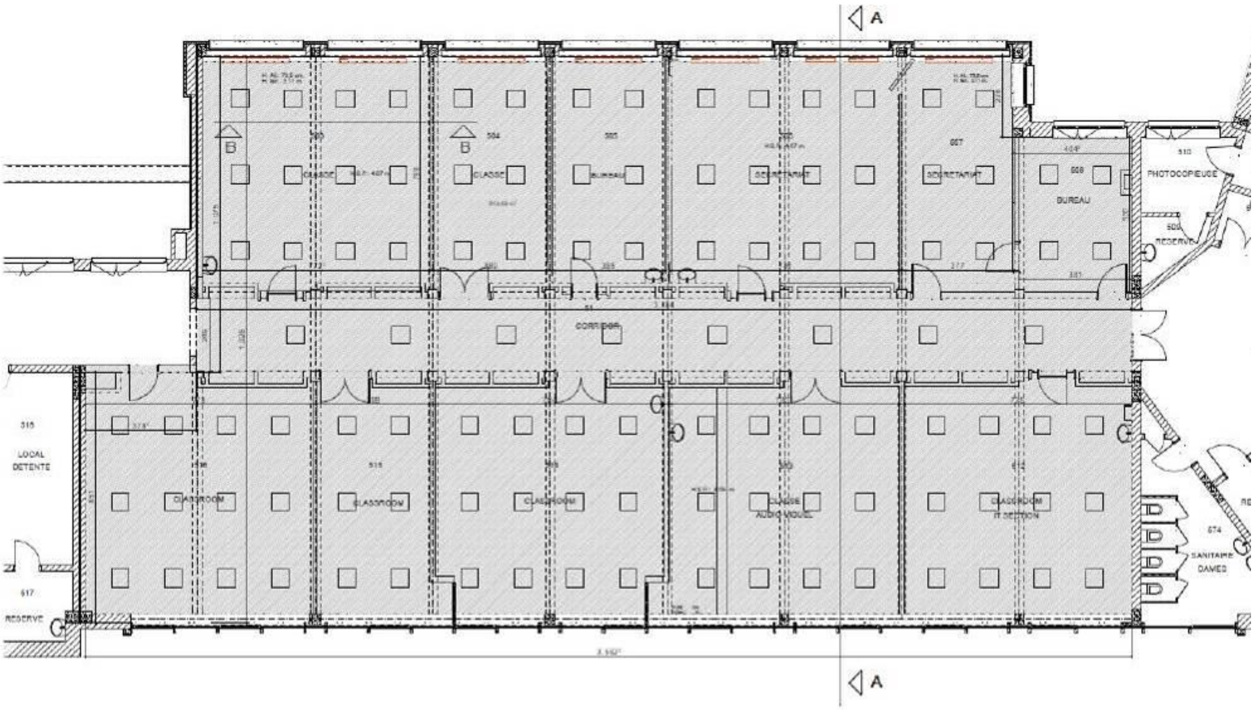
June 2016 – End of works

Tender 3: Roof insulation for Blocks 1 and 6.

Original situation



Selected solution for the exterior insulation (right) and the internal insulation with embedded PCM (left).



Floor plan for the PCM installation.

May 2016 - Dismantling of the ceilings for the PCM-based installation

May 2016 – Reception of Purinova's panels

September 2016 – Installation works of Purinova's panels

September 2016 – Works on the roof – New waterproofing

October 2016 – Acciona installs sensors into Purinova's panels – Post-monitoring

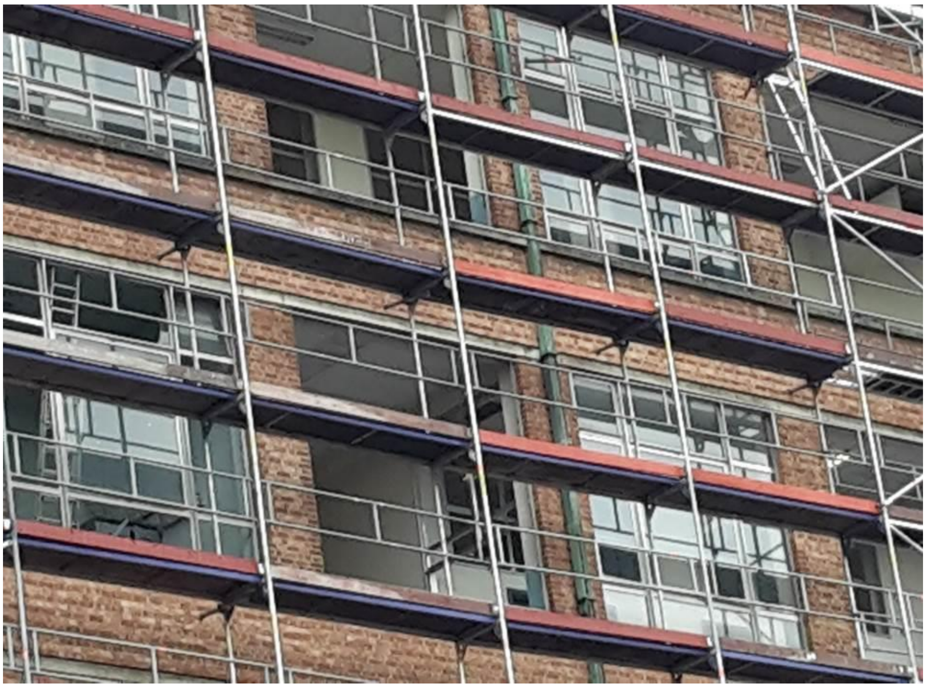
October 2016 – End of installation of Purinova's panels

Final look of the classrooms in Level +5

Tender 4: Insulation of external walls, replacement of windows and integration of decentralized

External façades in patio.

Original status of the façade.



March 2016 – Scaffoldings + dismantling of windows frames – Block Nr 6 – Rear Façade

March 2016 – Replacement of windows frames – Block Nr 6 – Facade in patio

April 2016 – External insulation – Block Nr 6 – Rear Façade

May 2016 – Replacement of windows frames– Block Nr 1 – Facade in patio

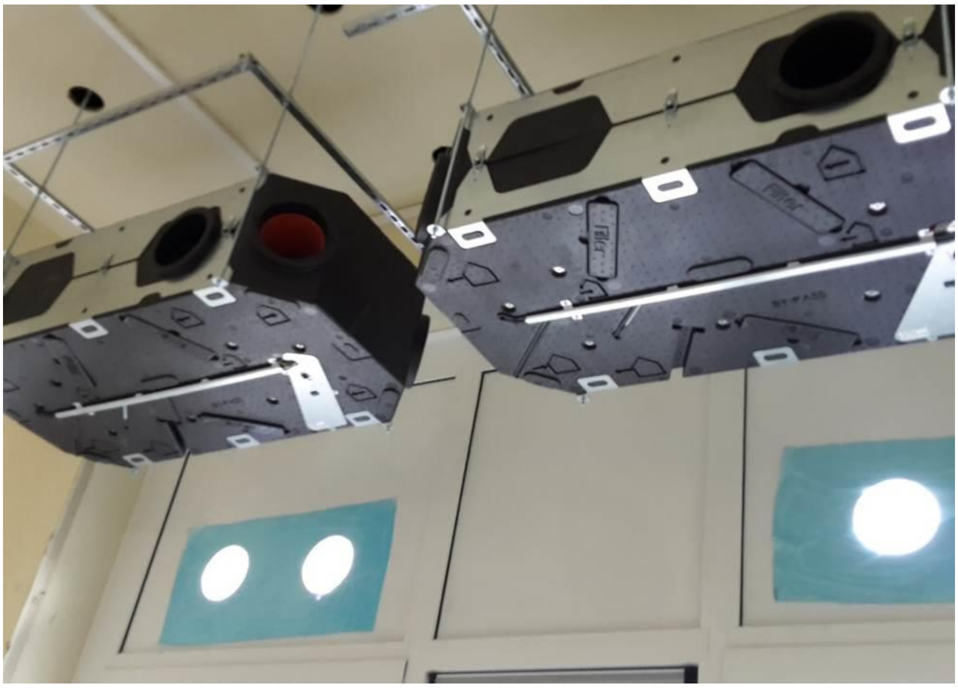
July 2016 – Internal finishing – Block Nr 1 – Facade in patio

September 2016 – Finishing plaster – Block Nr 6 – Rear Façade

October 2016 – Insulation 14 cm rockwool – Block Nr 6 – Facade in patio

November 2016 – Finishing plaster – Block Nr 6 – Final look

Decentralized ventilation system.



September 2016 – Smart ventilation modules Block Nr 6 – Rear façade

September 2016 – Air duct Block Nr 6 – Rear façade

October 2016 – Smart ventilation modules Block Nr 1 – Façade in patio

November 2016 – Smart ventilation Block Nr 1 – Final look

5.4 Task 5.4. Monitoring and performance evaluation of the buildings after the renovation (ONU).

The initial aim of this Task was to report an analysis of the buildings behavior after the renovation works done within the BRICKER Project. This behavior was going to be reported based on real data collection via monitoring. By that, a monitoring plan was defined and a list of sensors was installed in the BRICKER systems in Belgium and Turkey.

However, due to the delay in the commissioning of the BRICKER Systems, the real monitoring period was not possible to achieve. By this, in agreement with the European Officer and the Project Technical Advisor, in the final technical meeting it was explained that these results were to be reported based on the building and system simulation via software.

This Task is therefore, having a different scope from the initial plan, and by that, the information coming from deliverable 4.43c developed by Partner EURAC has been used here again, as an evidence of the expected (not measured) goals achieved in the Belgian demonstrator.

In the case of the Turkish demonstrator, there is another section in this document, prepared by the Turkish Partners, which provides similar evidence of the goals achieved in the Turkish hospital thanks to the installation of the BRICKER System and the passive measures implemented in Block A.

5.5 Task 5.5. Economic analysis of the 3 demo site implementations (TEC).

Introduction

This task is focused on the economic evaluation of the BRICKER implementations in the 3 demo sites. The expected main outcome of the task is to update precisely the economic and energy indicators expected on the proposal phase, basing on the monetary/energy costs of yearly operation of the facility before and after BRICKER implementation, and on the final costs of this implementation.

For this purpose, the output of the simulations has been analyzed in detail, and additional information about the economic and environmental framework for each demo country has been collected in order to be able to calculate the reduction on terms of environmental KPIs (use of primary energy and emissions of CO_2).

Regarding the economic KPIs, two scenarios have been considered. First, the situation at the moment of the project, this is, when the equipment was acquired. The main solutions, this is, ORC co-generator, solar fields and adsorption pump as well as the aerating windows, were not already on the market by the time of acquisition. Their low TRL implied a high cost when compared with market technologies, and therefore the payback and other economic KPIs are higher than usual.

The second scenario considered implied a further economic analysis based in estimations of future market prices, both for the prototypes included in the project and for the energy costs.

Methodology

During the current reporting period, a methodology for carrying out the economic analysis has been designed, with the result of a generic spreadsheet where the sequence of steps and calculations to evaluate the economic and environmental KPIs are implemented in a structured way to manage the various kinds of information needed for the assessment:

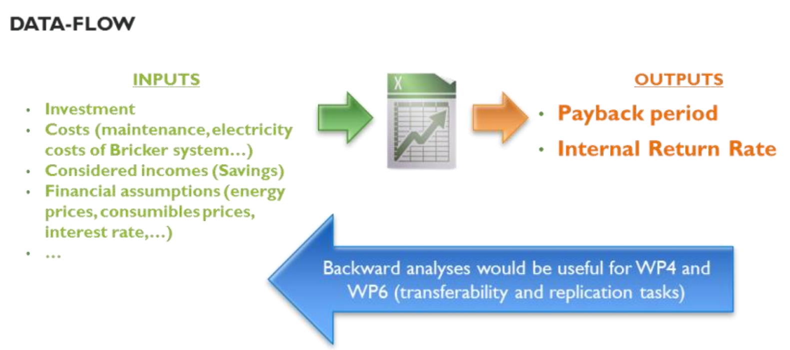


Figure. Data flow of the economic analysis tool.

The methodology of the task included an extensive and structured gathering of data, both in the existing project´s information such as deliverables (framework of the project) as well as framework for each demo such as CO_2 factors or energy prices (framework for each country),

This information was loaded into the spreadsheet. Based on the information of the BRICKER solutions (**Investment and operation costs, energy demand and consumption etc.)** as well as the information for the baseline **(operation costs, energy demand and consumption etc.)**, it was possible to calculate through the spreadsheet the performance of the new solutions when compared to the initial situation.

As it was already said before, two scenarios were considered for the economic KPIs assessment: current prices and estimations of future market costs. In a short-medium term, economy of scale may have modified the manufacturing prices, with the result of more favourable figures such as lower payback. This was the case of the solar fields, which decreased their price more than 30% as a consequence of the BRICKER project.

To complete the work done and in order to compare the BRICKER solutions to other innovative solutions, a comparison with the database of the Smart Cities Information System was performed in terms of savings per invested euro.

Results

One of the main results from the task was the estimations of future market price than can be seen in next table.

Technology	Starting TRL	Demos TRL	Prototypes costs		Expected market Price with TRL 9	
Innovative sustainable and light weight ventilated façade	4	7	226.9	€/m^2	125	€/m^2
Novel insulation foams with embedded PCM	4	7	19.4	€/m^2	14.55	€/m^2
Smart and high-performance aerating windows	4	7	27.4	€/m^3/h	14	€/(m^3/h)
Organic Rankine Cycle (ORC) Cogeneration System	3	7	2300	€/kW	1500	€/kW
Solar parabolic energy generation	4	7	460	€/m^2	300	€/m^2
Biomass boilers for heat generation at 270-300°C	Commercial		210	€/kW	178.5	€/kW
Chillers: absorption / adsorption technologies	Commercial		500	€/kW	425	€/kW

As a core of the BRICKER impact, the following figures were obtained:

KPIs

	Primary energy savings	CO_2 savings	Energy cost reduction
Aydin, Turkey	32%	26%	159,000 €
Liege, Belgium	61%	50%	78,539 €
Cáceres, Spain	78%	97%	6,861 €

Although the positive values in terms of energy and environmental KPIs, the financial indicators bring different conclusions for the different demo-sites. In the case of Turkey, the investment on the passive interventions will be quickly recovered, with a payback of 2 years. In the case of the Belgian demo-site, as the passive interventions were more complex, which required of higher investment, a payback of 19 years is calculated. In the case of the active solution, since they are less matured, have larger paybacks: 24 for Belgium, 11 for Turkey and more than 30 years for Spain. From these indicators, it can be concluded that the BRICKER concept is optimized against large baseline energy consumptions and a high number of operating hours per year.

Through the effort made on calculating the expectable market prices of the project prototypes, paybacks of the BRICKER system in replication scenarios as the Belgium and Turkish demo sites are expected to be reduced in 2 years (for passive interventions) and 3 years (for both active and passive technologies).

Finally, the benchmarking of the BRICKER technologies with similar technologies show that the BRICKER concept can be compared to conventional technologies in terms of cost-effective reduction of primary energy and CO_2 emissions. This shows that the BRICKER technologies are a suitable approach to achieve the objectives of the EU in terms of energy efficiency, integration of renewable energies in buildings and spreading of nearly-Zero Energy Buildings.

6 WP6 Exploitation and replication.

Main objectives of the work package

Work Package 6, dedicated to “exploitation and replication” of the project results has the objective to pave the way to a successful exploitation and implementation of the technologies and knowledge generated in the project through the definition of an exploitation plan, including dedicated business models & plans and the appropriate IPR management for the new knowledge and technologies. The activities are complemented by a replication plan for public building owners to assess the BRICKER potential for future deployment in public building stock.

Main achievements of the work package covered in the period M37-M54

The main focus of this Work Package lays on identifying exploitation routes and commercialisation pathways for the exploitable result packages identified before. A thorough research of possible business models, mainly based on energy contracting models was performed and key business models presented broken down into business cases. This work was led by S2i, but all project partners contributed by providing feedback and background information. Additionally and based on the findings of the demonstration activities in Liège, Belgium and Aydin, Turkey, the potential for replicating BRICKER renovation works was assessed in more detail by TEC. TEC was cooperating closely with all BRICKER partners involved into the demo site activities.

In M54, March 2018, S2i and Tecnalia jointly submitted D6.39/6.40, an updated version of deliverable D6.32/6.33 as planned according to the updated time schedule after the latest amendment. Due to the different project delays within M37 – M47 the activities of WP6 were also slightly interrupted, but picked up in speed and intensity again from month M48 onwards.

6.1 Tasks 6.1. and 6.2. Exploitation and Business models (SEZ).

S2i, as the task leader for T6.1 and T6.2 was focusing in the final reporting period of BRICKER on the development of strategies for the further commercialisation of project results. This work was based on previous exploitation activities, in which a broader number of BRICKER project results, technologies and products was validated and bundled into four exploitable results packages, which had been identified with a potential to be highly exploitable. Within the previous reporting period also the related risk and IPR management, the market analysis of the sector and for the specific Bricker Packages (including value innovation analysis) had been implemented.

Within this final reporting period S2i completely re-designed the deliverable and focused on key elements relevant in order to demonstrate the commercialisation potential and business models of the exploitable results (key context of Task 6.2), therefore providing different context than the two previous versions of D6.39. Major efforts were put into the following activities of Task 6.2:

- Tailoring the existing market analysis down to the commercialisation aspects of the exploitable results and understanding the exploitation potential of the BRICKER solutions
- Analysis of possible business models: Based on Osterwalder's business model canvas S2i identified BRICKER's value proposition, possible cost and revenue streams as well as key resources, customers, channels etc. for each of the exploitable results packages. These canvasses were used in order to compare them to possible business models based on ESCO and energy contracting models. Next to simply selling technologies and services around these technologies, three business models were identified as very suitable for BRICKER if the partners decided to operate together as an Energy Service Company (ESCO): Energy Supply Company (ESC) based on BRICKER active solutions, Energy Performance Contracting (EPC) based on BRICKER passive solutions or Integrated Energy Contracting (IEC), which combines the two. S2i created detailed business models for each of the three models tailored to BRICKER and further suggested a differentiation at services levels.
- Analysis of business cases: In order to analyse the economic viability of the identified business models S2i also started to apply them within different potential business cases. For this, S2i analysed with the feedback and information of all BRICKER partners involved into the demonstration activities the financial aspects if the BRICKER demo sites were constructed at market price level. Here S2i took a closer look at the different partner countries and other relevant EU target markets for BRICKER. S2i used the conditions of the demo sites in Liège and Aydin in order to financially validate whether they could be applied in the different other countries. For each of the investigated countries (Spain, Belgium, Italy, Germany and Turkey) identified national regulations, financial incentives and subsidies for the renovation of public building stock were taken as well into consideration. Per country, S2i created examples and a financing overview for one of the three business models (ESP, EPC and IEC), in particular those which matched national or regional incentives the most in order to understand the payback period for the clients and the break-even points for the BRICKER ESCO.
- Updated recommendations and conclusions: Based on the work and research performed by S2i, but clearly also the experiences from the BRICKER demonstration sites and partners involved into the work in the final project months new conclusions on the market deployment potential could be drawn. By exchanging with BRICKER project partners and analysing the further findings S2i concluded that a current key issue for the general market deployment are the high costs of the BRICKER technologies and their installation. Installation processes are still not standardised enough and further case-specific factors such as national staff costs, energy prices or the availability and easy access to biomass can make a difference in a decision about deploying BRICKER technologies or not.

6.2 Task 6.3. Replication (TEC).

The main objective of this task was to develop a Replication Plan that would facilitate the potential implementation of BRICKER demonstrated technologies in future energy retrofitting actions to be carried out in the European building stock. To address these potentials within the project scope, the European building stock is analysed, and also project partner’s owned stock (over 500 public buildings), in order to identify the most suitable building types for replication of BRICKER concept and to estimate its potential energy, economic and environmental impact.

For these purposes, during the last period of the project, it was reviewed the scientific and technical literature available of the European building stocks and its energy performance, extracting and analysing the most significant information for BRICKER’s interests. In the same sense, Tecnalia visited both physical demonstrator sites (Liège, Aydin) meeting with project partners (SPB, ADU) in order to analyse their building stock, through the implementation of a technical/socio-economic questionnaire previously developed. In summary, the topics addressed in the replication plan were the following:

- European energy and legislative context
- BRICKER replication potential at European building stock (suitability for BRICKER replication, integration potential evaluation and impact assessment, potential at residential sector, renovation strategies at district level)
- BRICKER replication potential in project partners’ building stock (ADU, SPB)
- Main conclusions and recommendations of Replication approach

All the work in this task and the significant conclusions were reflected in the third chapter of D6.39/6.40 deliverable, some of which are summarized in the following lines.

According to the lessons learnt during the BRICKER project, the exploitation of a BRICKER trigen-eration system is maximized in scenarios with high and constant electrical and thermal demand (preferably 24h, 365 days operation), for ensuring the biggest savings and reducing the payback period of the investment. Therefore, the most interesting subsectors for BRICKER replication are hospitals and hotels, which indeed present also the highest energy consumption intensity (up to 300-400 kWh/m2). In addition, public authorities can deploy BRICKER system in their buildings covering also the thermal demand of surrounding residential buildings, acting as energy nodes and providing a renewable district heating/cooling system to their communities.

For achieving these goals, BRICKER retrofitting solution provides flexibility and adaptability, that enable its replication potential. From open spaces as university campuses or large roofs where solar fields can be deployed to dense urban areas where biomass boilers comprise the renewable source for the BRICKER trigeneration system; from global envelope retrofitting of regular buildings to non-invasive methods as PCM and aerating windows for our cultural heritage buildings.

In conclusion, public buildings are expected to set an example for society and the construction sector, acting as lighthouse of the European directives. In fact, the BRICKER solution goes beyond its big energy savings (up to 50%), but promoting the transition from conventional to renewable energy sources and reducing CO_2 emissions dramatically, adding value to the buildings in social, environmental and economic terms.

7 WP7 dissemination and communication.

During the final and most important Project period, the BRICKER dissemination and communication activities were continued from the initially developed strategies and implementations started in Periods 1 and 2. New developments during the 3rd reporting period include:

- Update project web site with final results and outcomes;
- Collection and upload on web site all progress reports about the interventions at the Belgian and Turkish demo site;
- Development and edition of an updated brochure;
- Publication of the BRICKER institutional video;
- Organisation of two final events

Details about these developments can be found below.

7.1 Dissemination and Communication Secretariat build up and operation (YOU).

In the third reporting period, the main activities within Task 7.1 included maintaining the Dissemination and Communication Secretariat, preparing Deliverable 7.41 (Final version of the Dissemination and Communication Plan) launching public communication and dissemination actions (press releases, web articles) and requesting input from partners regarding their stakeholder network, their publications and events participation. In addition the BRICKER LinkedIn page has been set up fed with regular posts about the project life.

7.1.1 Dissemination and Communication Secretariat build up (YOU).

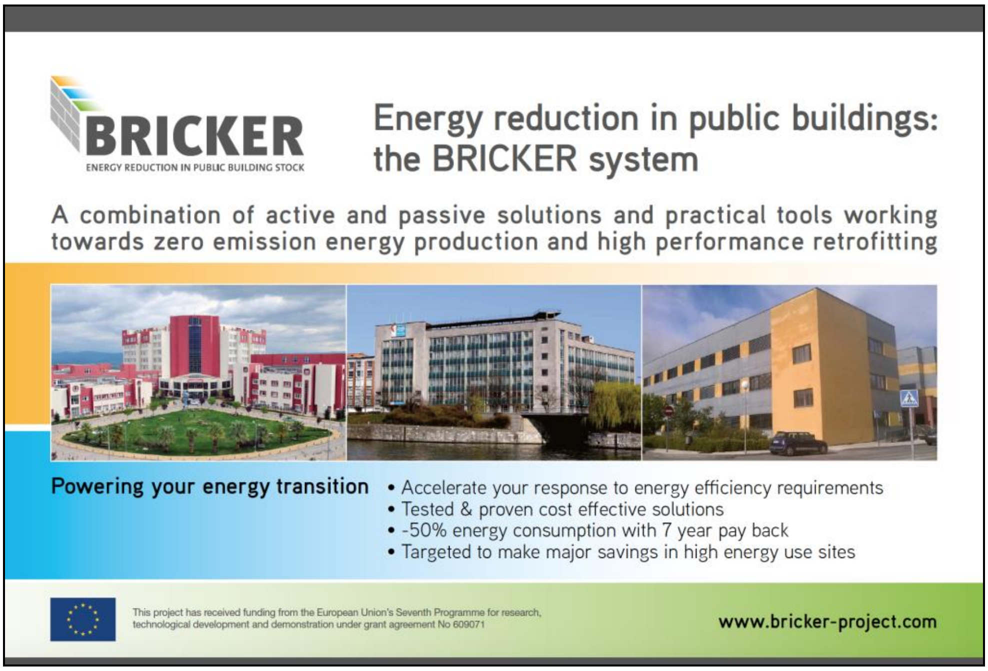
The BRICKER D&C Secretariat has been set up up at the beginning of the project. D7.1 (due in M1) describes details of it's concept and implementation.

7.1.2 Dissemination and Communication Secretariat operation (YOU).

Among the operations of BRICKER D&C Secretariat were the continuous update of the contact and mailing lists of all partners and provision of access to the team site for new team members. Also, regular updates were made regarding the contact details of the D&C group (consisting of representatives of partners as the main interface of the secretariat for dissemination and communication actions), and the ppt and document templates. Additionally the secretariat has prepared press releases.

In the current reporting period, a new version of the BRICKER brochure has been edited, in order to present outcomes and results of the project to the BRICKER stakeholder community. The brochure can also be browsed and downloaded from the web site. The final brochure has been designed and produced for distribution at fairs, conferences and workshops, and include figures and graphics presented in a comprehensive energy balance before and after the

BRICKER implementation, a description of the benefits of BRICKER for public building owners, as well as takeaways from multiple technology best practices. .



BRICKER Final brochure

The secretariat has also designed a poster which has been developed and presented by BRICKER partner CARTIF at the Solar World Congress 2017 in Abu Dhabi.

Poster at SWC 2017

In the third reporting period, three newsletters have been compiled, published and distributed to stakeholders and through stakeholder platforms and on the BRICKER LinkedIn page : in March 2017, in December 2017 and in April 2018.

The BRICKER company page on LinkedIn[1] was fed regularly. 27 posts were uploaded during the reporting period and the page has now over 120 followers. These posts have been seen by 15743 LinkedIn users.

To complete the collection of dissemination actions by partners, started at the beginning of the project and repeated in regular intervals, the secretariat has asked BRICKER partners in January 2018 to provide updates about their publications and events participation. Over the whole duration of the project, partners have reported contributions to 147 conferences, fairs, workshops, study visits and trainings.

Furthermore, the D&C Secretariat is responsible for the implementation of the D&C Plan. Respective actions are described in section 7.3 below.

7.2 Project website (YOU).

The BRICKER web site www.bricker-project.com has been continuously updated with press and news releases, articles and interviews during the last 18 months.

7.2.1 Project website set up (YOU).

The BRICKER project web site contains all the institutional information about the BRICKER project. The web site aims at main communication and dissemination channel for the project's results and for the involvement and enlargement of the stakeholders' community. The site works as a share point for the BRICKER partners containing all institutional information including working documents and deliverables through a reserved partners' area, the team site. Daily upload email alerts have been implemented on the team site. The web site set up has been documented in D7.3 (due in M3).

7.2.2 Project website continuous update with contents (YOU).

The main update of the BRICKER web site during the reporting period consisted in a thorough review of all sections of the web site in order to present final outcomes and results of the project. In particular the sections about facts and figures, impact and replication as well and the section about DEMO SITES in order to take into consideration the withdrawal of the Spanish demo site were modified. New public deliverables – approved by the EC – have been uploaded into the DELIVERABLE section. The final brochure has been uploaded on the web site for browsing and download.

[1] See https://www.linkedin.com/company/bricker

Numerous articles, interviews, press and new releases have been uploaded on the web site during the third reporting period in order to enrich the contents of the web site and keep it attractive for the users.

Recent web statistics reveal that web users are mainly interested in the PROJECT and TECHNOLOGIES sections as these are the most visited after the homepage, though. Since the start of the project, the web site had about 59 000 hits, with a total of over 13 500 visitors and nearly 20 000 sessions.

7.3 Dissemination and communication plan (YOU).

The D&C plan is the operative guide and tool for all dissemination and communication activities to be carried out by the Consortium. The final version of the D&C plan has been delivered in March 2018 (D7.41).

7.3.1 Dissemination and communication plan reports (YOU).

After several updates of the initial Dissemination and Communication plan (D.7.4, D.7.16 and D.7.30), the Final version of the D&C Plan (D7.41) gives a detailed overview about the dissemination and communication actions carried out throughout the project. It is focused on achievements, outcomes and results of the project’s dissemination and communication actions.

7.3.2 Dissemination and communication plan roll out: Publications (YOU).

Some activities such as issuing press releases, collecting information from partners about stakeholders and D&C actions have been organised by the D&C Secretariat (T7.1.2). The roll-out of the D&C plan has started in M7 with the acceptance of D.7.4.

During the third reporting period, 18 press releases about progress and interventions at the demo site in Liège and in Aydin the outcome of BRICKERs second project review and the final review, about participation of partners at events such as Spain’s Construction Technology Platform conference 2016 by ACC or the Hack and Break workshop in 2017 by ONU and the Seville climate change summit 2017 by SPB and ACC , about the two final events organised by the project at WSED2018 in Wels and the Inauguration of the Belgian demo building in Liège, as well as two items with recommendations following BRICKER outcome about ‘Finding the right technology mix’ and ‘learning to lead from the front’. All press releases are published on the BRICKER web site; some were taken up by multiplier platforms and distributed on the social web.

Several shorter news pieces about developments at the BRICKER demo sites as well as partners contributions to events relevant for BRICKER were are also prepared by the secretariat and published on the BRICKER web site in the “Latest News From The Demo Site” and in the “Events” sections.

3 **articles** and 1 **interview** with BRICKER partners have been published on the BRICKER web site[2]. Articles and interview are written by youris.com independent journalists. Articles and interviews were also published on the following online news services: AlphaGalileo, BuildUp, Construction21,Phys.org and Cordis Wire as well as on youris.com web site [3].

The publication of BRICKER content in online news services guarantees wide distribution and take up of BRICKER. A tracking system has been put in place in order to monitor outreach. All articles and interviews published on the BRICKER web site have been tracked. Details about outreach of web communication and referrals for the whole duration of the project are reported in the final version of the D&C plan (D7.41).

In the third reporting period, three BRICKER newsletters have been compiled, published and distributed to stakeholders and through stakeholder platforms, and on the BRICKER LinkedIn page : NL 6 in March 2017, NL 7 in December 2017 and NL 8 in April 2018. The D&C Secretariat sends the newsletters to the web users subscribed to the newsletter on the BRICKER web site and by email to other contacts, e.g BRICKER team members, EC stakeholders. In total, **2178 newsletters** have been sent throughout the lifetime of the project to different recipients. From NL3 onwards, a post about the NL publication has been made on BRICKER LinkedIn page. These posts reached 485[4] followers. Posting the publication of NL3 to NL 7 has generated **2508 views** on LinkedIn. This is more than the total number of newsletters sent.

BRICKER partners have also demonstrated wide publications activities, e.g. press releases in their own web sites and newsletters as well as news items in their networks. It total 63 items have been published online and offline by BRICKER partners during the project. Partners have also published **articles** about BRICKER in **scientific publications and specialised journals**. In the current reporting period 7 contributions to papers and proceedings were made, and 20 publications over the lifetime of the project. [5] Two more articles are under preparation and will be published after the end of the project.

The **institutional video** of BRICKER was published in M53. It is available on the BRICKER web site and on the BRICKER YouTube channel [6] . Due to the withdrawal of the Spanish demo site, the video is mainly about the demo sites in Turkey and Spain. The shooting at the High School in Liége took place late in July 2016. Altogether three interviews were conducted: Raymond Charliér, project coordinator; Christian Ninane, head of the faculty of engineering HEPL; Jonathan Martens, R&D Engineer, Airria; . Installations of the new windows, the renovation of the façade, and the elder part of the building were filmed to be able to directly compare the building in the pre and after status. 3D animations explaining the decentralised ventilation system and the Organic Rankine Circle are also shown. Further shootings and interviews were carried out on the occasion of the technical steering committee meeting in November 2017 in

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[2] See http://www.bricker-project.com/News

[3] See http://www.youris.com/

[4] 485 is the cumulative number of followers on the LinkedIn page who were following the page at the time of the publication of the NL.

[5] Details can be found in D7.41,

[6] See https://www.youtube.com/channel/UCobFU1qh9x4RV7XUepzOpLw

Aydin. Interviews were held with Cavit Bircan, Principal of Adnan Menderes University; Pinar Mengüç Director of CEEE Ozyegin University; Juan Ramon de las Cuevas, BRICKER coordinator, Acciona; Manuel Gonzales , RANK; and Onur Günduru, Onur Enerji. The video is stored in the BRICKER project YouTube channel and has a duration of 5:38 minutes. Additionally, a second video in French has been produced by partners SPB. It can also be watched in the BRICKER YouTube channel.

7.3.3 Dissemination plan roll-out: Fairs, Conferences, Workshops (YOU).

To mark the end of the BRICKER project, two final events were held in order to disseminate results, outcomes and lessons learnt to stakeholders in energy efficient building community as well as to public authorities and building owners.

The first event was held during the World Sustainable Energy Days 2018 (WSED) in Wels/ Austria and took place on 1st and 2nd March 2018. On the first day, the BRICKER project was presented alongside similar projects during the Technology Innovation Conference: Energy and buildings. The presentation was made by BRICKER coordinator Acciona. On the second day, BRICKER held its final workshop as part of a series of parallel workshops by fellow projects at WSED. Members of the consortium including Acciona, Onur Enerji, Özyegin University, RANK, Province of Liège and University of Liège, each showcased various components of the BRICKER system using real-world examples from the demo site works. It was an ideal opportunity to highlight both the BRICKER system and the actual results from the project, a 4.5-year endeavour now coming to its conclusion.

The second event was held on 6 March 2018 in Liège, where the demo site owner S.P.B. organised the official opening of the revamped site. A number of regional journalists attended the morning's press conference given by provincial deputies Muriel Brodure-Willain, in charge of education and André Denis, in charge of public works. In the evening, some 100 guests attended the official inauguration of the retrofitted building. They included project partners, local officials from the Province of Liège, local stakeholders keen to learn about replicability to other places, and members of staff and students. Raymond Charlier, industrial engineer for the Province de Liège who oversaw the site works, organised guided visits of the biomass boiler, the ventilation, heat exchanger and insulation systems.

During the lifetime of the BRICKER project, partners have contributed to events to inform interested targets, to raise awareness about BRICKER, to present the BRICKER approach in general and the methodologies applied, as well as about the deployment of very innovative technologies in BRICKER and the outcomes and achievements of BRICKER.

In total 147 events were organised and/or attended by the BRICKER Consortium. In total BRICKER partners have attended and/organised

- 78 conferences
- 36 workshops
- 20 fairs
- 13 study visits and training sessions

More details about the events attended can be found in D7.41 , Final version Dissemination and Communication Plan in Section 3.2.8 and in Annex 1.4