RepliCable and InnovaTive
Future Efficient Districts and cities

D4.5: Implementation plan of the Turkish demonstrator

WP 4 , T 4.2

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RepliCable and InnovaTive Future Efficient Districts and cities

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[1] PU = Public

PP = Restricted to other programme participants (including the Commission Services)

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Versions

Version	Person	Partner	Date
00	Javier Martín	DAL	14 November 2014
01	Caner Demir	DEM	27 February 2015
02	Hatice Sözer	ITU	03 March 2015
03	Ali İhsan Koca	MIR	04 March 2015
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05	Burak Sefer	REE	06 March 2015
06	Uğur Tekir	SEAŞ	06 March 2015
07	Collaborative work	DEM, ITU, MIR, TUB, REE, SEAŞ, MAN	09 March 2015
08	Andrea Martín	CAR	13 March 2015
09	Collaborative work	DEM, ITU, MIR, TUB, REE, SEAŞ, MAN	19 March 2015
10	Collaborative work	DEM, ITU, MIR, TUB, REE, SEAŞ, MAN, CAR	30 March 2015

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Abbreviations and Acronyms

AC	Alternative Current
BAPV	Building Applied Photovoltaics
BAST	Building Applied Solar Thermal
BIPV	Building Integrated Photovoltaics
BIST	Building Integrated Solar Technologies
BREEAM	Building Research Establishment Environmental Assessment Method
Demo	Demonstration
DH	District Heating
DNO	Distribution Network Operator
ECM	Energy Conservation Measure
EPC	Engineering, Procurement, Construction
EKAP	Electronic Public Procurement Platform
EMRA	Energy Market Regulatory Authority
EPS	Expanded polystyrene
e-QUEST	Quick Energy Simulation Tool
EÜAŞ	Electricity Generation Company of Turkey
ICT	Information and Communication Technology
IPMVP	International Performance Measurement and Verification Protocol
LED	Light-Emitting Diode
PV	Photovoltaic
REVIT	Building Design Software for Building Information Modeling
RTP	Reinforcement Thermoplastic Pipe
SEAŞ	SOMA Electricity Generation & Trading Company
STC	Solar Thermal Collectors

TEDAŞ	Turkish Electricity Distribution Company/Authority
TS 825	Thermal insulation standard for buildings

0 Abstract

The buildings of the Turkish demo site area, placed in Soma, are owned by SEAŞ, a publicly owned thermal power plant company, and are mostly used for its personnel. The strategy of the Soma demo site is to reduce energy demand, energy losses and carbon emissions in residential buildings and the convention centre, while increasing the use of renewable resources by means of using waste heat of the thermal power plant and on site electricity generation by building integrated photovoltaics , BIPV. Installed solar thermal collectors will also decrease the energy demand of the buildings.

Turkish demo site smart grid interventions will cover electricity consumption, heating usage by district heating system, indoor comfort and PV production. There are 4 different residential building types and 3 different buildings in the Turkish demo site. Each building has its own design for smart grid interventions. Also, several selected buildings will act as demo samples where appliance-level monitoring and control will be carried out.

Since the beginning of the project, measuring end user acceptance has been a delicate issue at Soma. After the CITyFiED project was approved by the European Commission (EC), SEAŞ power plant was included in the scope of privatization by the Turkish government. One of the plants of SEAŞ (Soma-B) has been privatized in December 2014. Soma-A Plant, remains as a public facility, fundamentally engaged in research and development as well as the properties that are used by Soma-A plant, which includes the lodgings on the demo site. The demo site will be heated using the waste heat from the power plant and the personnel will continue to live in the dwellings.

SEAŞ, as a publicly owned company, needs its investment budget to be approved by the Turkish Ministry of Energy and Natural Resources, due to government regulations. CITyFiED project budget has been approved by the Ministry in 2014, and a plan to divide the budget and its use in different years will be developed. Another constraint for the implementation of the interventions is the reduced number of employees of SEAŞ after privatization.

The district heating investment of the city is the responsibility of Manisa Metropolitan Municipality. As a public body, Manisa Municipality is also bound by Turkish Public Procurement Law No. 4734 [18], similar to SEAŞ.

1 Introduction

The objective of this deliverable is to define and develop an implementation plan of the complete renovation for the Turkish demonstrator. This renovation has considered the technical definition of the Turkish demo site, and the implementation plan includes technical solutions and specifications of the retrofitting process.

The implementation plan also includes private and public procurement processes, from selection of equipment and installers to requests of licenses and permits. Finally the implementation plan presents a planning that includes owner's commitments and manufacture and installation times.

1.1 Relationship with other WPs

Deliverable	Task	Relation
D4.2	T4.1	Technical definition of the Turkish demo site
D2.1	T2.1	Retrofitting solution of building's envelope
D2.7	T2.2	CHP solution for thermal and electrical production.
D2.16	T2.3	Report on technologies for steering the buildings energy demand and minimising peak loads in the district heating system
D2.18	T2.3	Definition of renewable systems for district heating
D2.26	T2.3	Report on eliminating of disadvantages of conventional distribution systems
D2.27	T2.3	Report on new efficient heating and cooling systems to improve the efficiency of energy generation systems

Table 1.1: Relationship with other WPs

1.2 Contribution from partners

Partner	Contributions
CAR	Coordination of work and revision or the document
DAR	Coordination of work
TUB	District heating design
ITU	Building retrofitting, energy modelling
SEAŞ	Technical support to other partners
MIR	Radiant heating/cooling and district heating distribution system
DEM	Summary of the technical description of Turkish demo site. Electricity generation, green building certification, end user's acceptance and end users' commitments
REE	Smart grid interventions
MAN	Technical support to other partners

Table 1.2: Contributions from partners

2 Technical definition of the Turkish demo site

The objective of this section is to summarize the information from D4.2 “Technical definition of the Turkish demo site (Soma, Turkey)” [1], in order to establish the current situation and starting conditions of the demo site.

2.1 Description of the district

Soma is a town of Manisa Province in the Aegean region of Turkey. SEAS Power Plant produces electricity by using local lignite and the same lignite is used for heating purposes throughout the city of Soma. The main details of the district are as follows.

The demo area includes 82 buildings in total, divided into 33 three story residential buildings, 32 two story buildings, 8 duplex and 6 one story residential buildings. Moreover, the demo site area includes lodging for single people, a kindergarten, a guest home and a convention centre. Below, details of each building type can be found.

Type of Building	3 story	2 story	Duplex	1 story	Guest Home	Convention Center	Single Lodging
Total number of buildings	33	32	8	6	1	1	1
Total number of dwellings	198	128	12	8	-	-	-

Table 2.1: Buildings in demo site

The distance by road between SEAS Power Plant and the demo site is nearly 4.5 km.

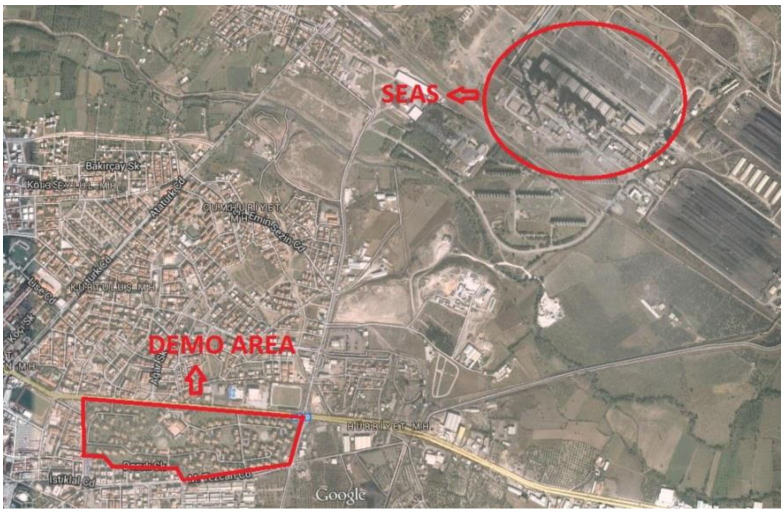

Figure 2.1: View of SEAS and demo site area

Figure 2.2: Turkish demo site area

2.2 Buildings description

Buildings of the demonstration district are owned by SOMA Electricity Generation & Trading Joint Stock Company (SEAŞ) and are mostly used by its personnel. The "Soma Power Plant Lodging Buildings" site has nearly 160,600 m^2 land area that includes 31 year old 82 blocks with a total of 346 apartments, 2 guest houses and 1 convention centre.

In total, 64,971 m^2 gross area in which, 41,158 m^2 corresponds to the heating and cooling area. The building blocks are categorized and identified according to the following building typologies.

- **Residential building blocks** have a total 59,297 m^2 gross area as they are,
  - 3 storey; 33 building blocks, (32,535 m^2 gross area – 20,374 m^2 conditioned area)
  - 2 storey; 32 building blocks, (22,506 m^2 gross area – 13,171 m^2 conditioned area)
  - 1 storey; 6 building blocks, (2,524 m^2 gross area – 1,235 m^2 conditioned area)
  - Duplex; 8 building blocks, (1,733 m^2 gross area – 1,477 m^2 conditioned area)
- **Guest houses** have two building blocks and total 3,028 m^2 gross area and 2,470 m^2 conditioned area.
- **Convention centre** has a total 2,646 m^2 gross area and 2,431 m^2 conditioned area.

Figure 2.3: One, two and three storey buildings

The building blocks and their locations are shown on the figure below.

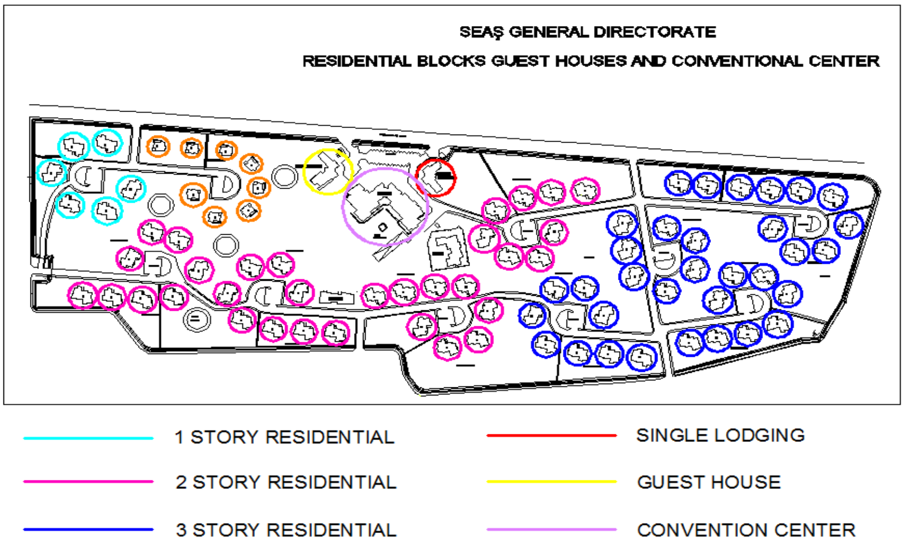

Figure 2.4: Site plan of the district

Building Plans

Each type has its own characteristics and facilities, as well as certain similarities. Detailed descriptions of each building type are shown in the tables below.

Residential Blocks

The typical floor plans of residential building blocks are shown in the following figure.

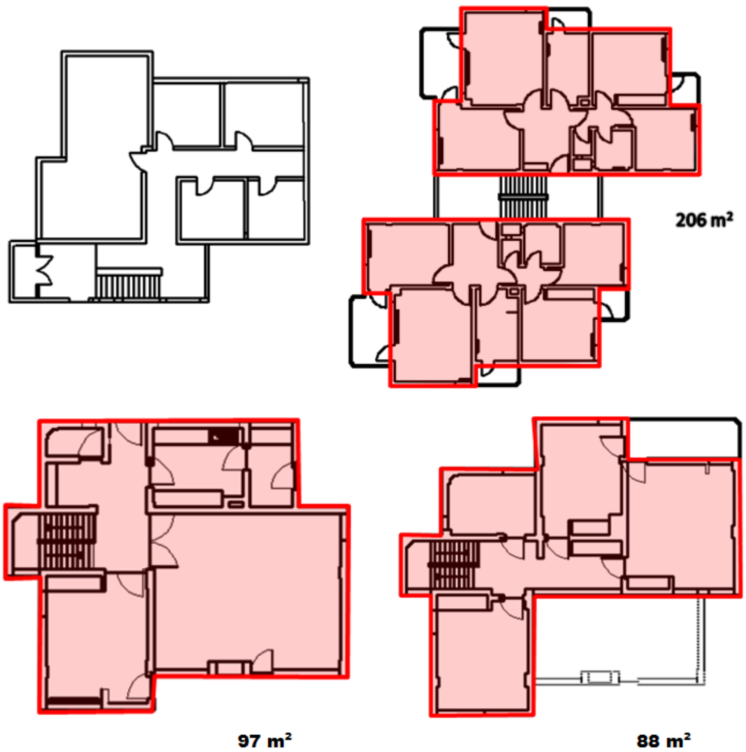

Figure 2.5: Basement and floor plan of residential buildings

<table>
<tr><th>Description</th><th>Details</th><th>Picture</th></tr>
<tr><td>1 storey residential

Total gross area for each block: 421 m^2

Conditioned area for each block: 206 m^2

Number of blocks : 6</td>
<td><table>
<tr><th>Summary of façade areas</th><th>Area [m^2]</th></tr>
<tr><td>Façade
windows and doors excluded</td><td>241</td></tr>
<tr><td>Window
double glazed – PVC frame</td><td>34</td></tr>
<tr><td>Door
double glazed – PVC frame</td><td>17</td></tr>
<tr><td>Roof
pitched roof</td><td>291</td></tr>
</table></td>
<td>
REVIT Model
</td></tr>
<tr><td>2 storey residential

Total gross area for each block: 703 m^2

Conditioned area for each block: 412 m^2

Number of blocks: 32</td>
<td><table>
<tr><th>Summary of façade areas</th><th>Area [m^2]</th></tr>
<tr><td>Façade
windows and doors excluded</td><td>436</td></tr>
<tr><td>Window
double glazed – PVC frame</td><td>68</td></tr>
<tr><td>Door
double glazed – PVC frame</td><td>34</td></tr>
<tr><td>Roof
pitched roof</td><td>291</td></tr>
</table></td>
<td>
REVIT Model
</td></tr>
<tr><td>3 storey residential

Total gross area for each block: 986 m2

Conditioned area for each block: 617 m2

Number of blocks: 33</td>
<td><table>
<tr><th>Summary of façade areas</th><th>Area [m^2]</th></tr>
<tr><td>Façade
windows and doors excluded</td><td>632</td></tr>
<tr><td>Window
double glazed – PVC frame</td><td>100</td></tr>
<tr><td>Door
double glazed – PVC frame</td><td>51</td></tr>
<tr><td>Roof
pitched roof</td><td>291</td></tr>
</table></td>
<td>
REVIT Model
</td></tr>
</table>

Duplex

Total gross area for each block: 217 m2

Conditioned area for each block: 185 m2

Number of blocks: 8

Summary of façade areas	Area [m^2]
Façade windows and doors excluded	237
Window double glazed – PVC frame	39
Door double glazed – PVC frame	12
Roof pitched roof	150

Table 2.2: Building models for residential blocks

Guest House

A typical floor plan of the guest house and single lodging are shown in the figures below.

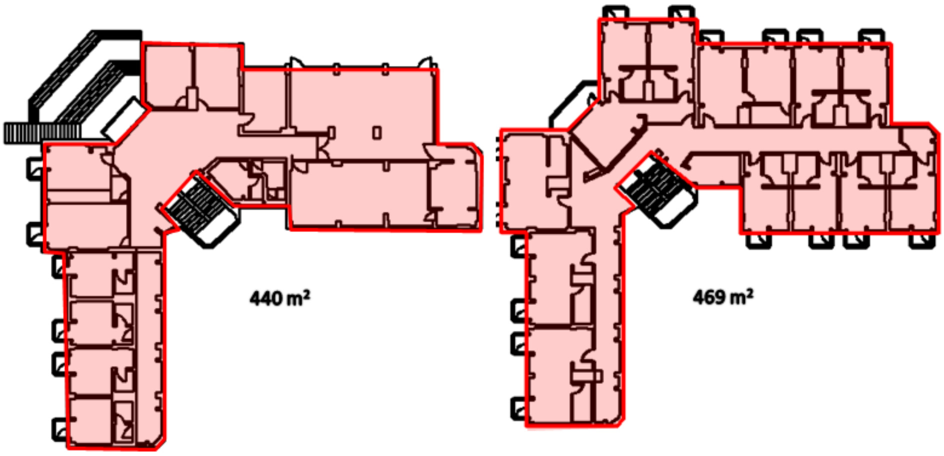

Figure 2.6: First floor and floor plan of the guest house

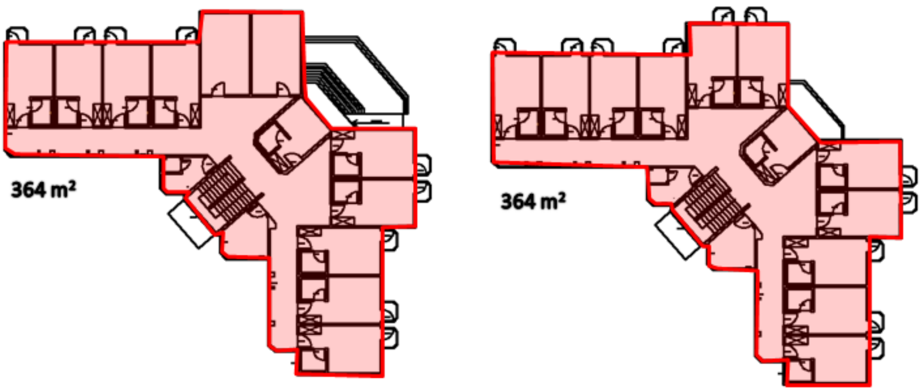

Figure 2.7: First floor and floor plan of the single lodging

<table>
<tr><th>Description</th><th>Details</th><th>Picture</th></tr>
<tr>
<td><u>Guest house with 3 storeys</u>

Total gross area for each block: 1,678 m^2

Conditioned area for each block: 1,377 m^2

Number of blocks: 1</td>
<td>
<table>
<tr><th>Summary of façade areas</th><th>Area [m^2]</th></tr>
<tr><td>Façade
windows and doors excluded</td><td>942</td></tr>
<tr><td>Window
double glazed – PVC frame</td><td>168</td></tr>
<tr><td>Door
double glazed – PVC frame</td><td>95</td></tr>
<tr><td>Roof
pitched roof</td><td>611</td></tr>
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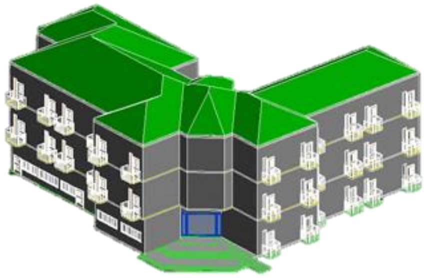
</td>
<td>
REVIT Model
</td>
</tr>
<tr>
<td><u>Single lodgings with 3 storeys</u>

Total gross area for each block: 1,350 m^2

Conditioned area for each block: 1,093 m^2

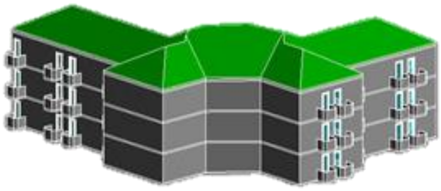
Number of blocks: 1</td>
<td>
<table>
<tr><th>Summary of façade areas</th><th>Area [m^2]</th></tr>
<tr><td>Façade
windows and doors excluded</td><td>645</td></tr>
<tr><td>Window
double glazed – PVC frame</td><td>109</td></tr>
<tr><td>Door
double glazed – PVC frame</td><td>62</td></tr>
<tr><td>Roof
pitched roof</td><td>434</td></tr>
</table>
</td>
<td>
REVIT Model
</td>
</tr>
</table>

Table 2.3: Building models for guest house

Convention Centre

A floor plan of the convention centre is shown in the below figure.

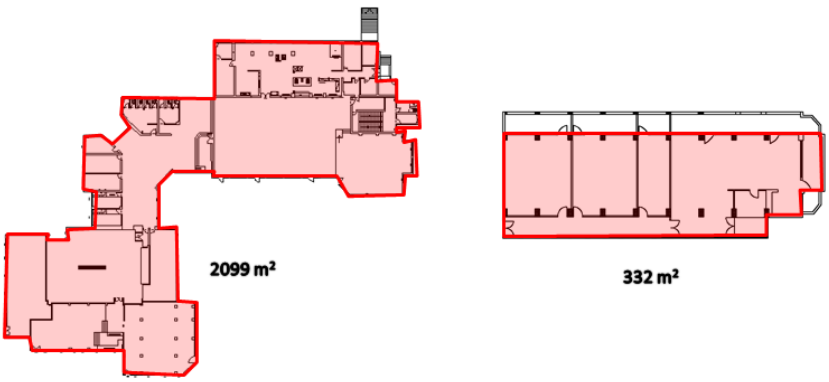


Figure 2.8: First and second floor plan of the convention centre

<table>
<tr><th>Description</th><th>Details</th><th>Picture</th></tr>
<tr>
<td>Convention Center with 2 stories

Total gross area for each block: 2646 m^2

Conditioned area for each block: 2431 m^2

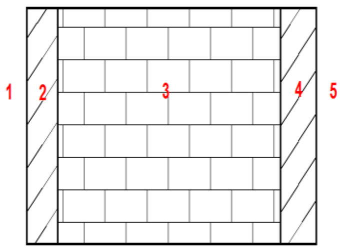
Number of blocks: 1</td>
<td>
<table>
<tr><th>Summary of façade areas</th><th>Area [m^2]</th></tr>
<tr><td>Façade
windows and doors excluded</td><td>736</td></tr>
<tr><td>Window
double glazed – PVC frame</td><td>329</td></tr>
<tr><td>Door
double glazed – PVC frame</td><td>56</td></tr>
<tr><td>Roof
pitched roof</td><td>2290</td></tr>
</table>
</td>
<td>
Revit Model
</td>
</tr>
</table>

Table 2.4: Building models for convention centre

Building Envelope characterization

The total façade area of the buildings (not including façade window and door areas) is 37,660 m^2, where approximately 34,940 m^2 corresponds to the residential buildings, 1,919 m^2 to the guest houses and 802 m^2 to the convention centre.

The building envelope characteristics play a key role regarding the energy audit, as the building envelope components are the most influential on building energy performance. The building envelope and its thermal characteristics are identified by their external wall, roof, ground floor and windows and the information is given in the tables below and also these properties are the same for all buildings.

<table>
<tr><th>Element description</th><th>Detail (section's sketch from inner face to outer face)</th><th>Picture</th></tr>
<tr>
<td>External wall
1. Internal Paint
2. Internal Plaster (2 cm)
3. Brick Wall (25 cm)
4. External Plaster (2 cm)
5. External Paint
U-value = 1.786 W/(m^{2}K)</td>
<td></td>
<td></td>
</tr>
</table>

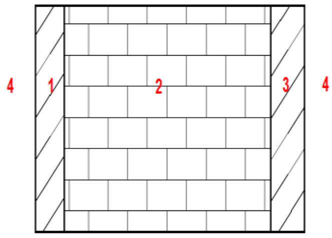
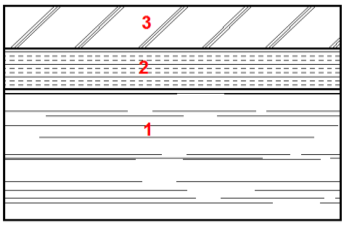
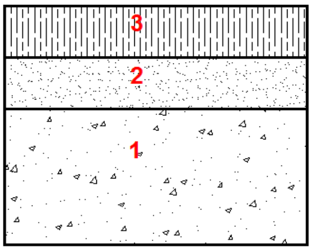
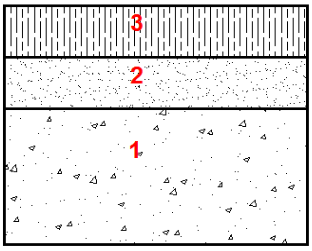
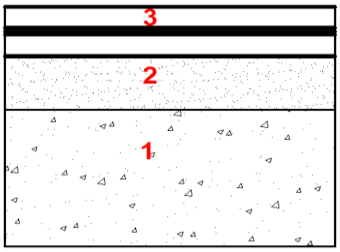
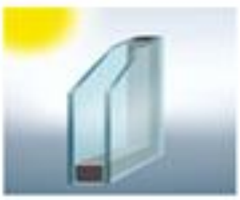
Internal wall 1. Internal Plaster (2 cm) 2. Brick Wall (15 cm) 3. External Plaster (25 cm) 4. Paint (2 cm) **U-value = 0.45 W/(m²K)**		
Roof 3. Tile 2. Membrane (Waterproofing-3mm) 1. Pitched roof **U-value = 0.732 W/(m²K)**		
Ground floor 2. Cement finish **1. Concrete** **U-value = 2.839 W/(m²K)**		
Internal floor (Type 1) 3. Tile finish 2. Cement finish 1. Concrete **U-value = 1.83 W/(m²K)**		
Internal floor (Type 2) 3. PVC finish 2. Cement finish 1. Concrete **U-value = 1.83 W/(m²K)**		
Window **Double glazed** **(4+12+4) cm** **U-value = 1.95 W/(m²K)**		

Table 2.5: Description of the Building Envelope and Thermal Characteristics

2.3 Energy system description

District Heating

Buildings in the demo site are heated by a local district heating system. There is a heating centre nearby the demo site. Heat is supplied from the heating centre for heating and domestic hot water to the demo site buildings.

Figure 2.9: Overview of Demo Site and Heating Centre Building

There are two boilers in the heating centre for heating purposes. One of the boilers is kept as a backup boiler. Heating boilers are directly connected to radiator systems inside the buildings.

Soma lignite is used as fuel in the local central boiler. There is also a coal stock warehouse near the heating centre with a storage capacity of 300 tons. Each boiler is fed from a coal bunker with 30 tons coal storage capacity. Coal is initially transferred from the warehouse to the coal bunkers, and then introduced into the boilers by conveyor belts.

Current district heating system consists of 4 local heating zones. Four circulation pumps are used for each zone. The capacity of each pump is 110 m^3/h flow rate and 10 mWc pressure. All boilers and circulating pumps are operated manually and there is no control system in the heating centre.

Figure 2.10: Current Local District Heating System Scheme in Demo Site

Pipes of the heating system are made of steel and located in channels that connect the heating network to the buildings. Insulation of the district heating system pipes is very old and timeworn and also pipes are exposed to water due to leaking joints. For those reasons it is estimated that significant heat loss from the pipes occurs.

In principle, the heating season was determined to be between the dates of October 15 and April 15 of the year in the SEAŞ Site, but this may vary depending on seasonal conditions. Heating system is operated 24 hours a day in the heating season. In practice, supply water temperature of the heating system is 70 °C, whereas the return water temperature is 50 °C.

Energy demand for domestic hot water consumption in buildings is also supplied from a small boiler in the heating centre. Domestic hot water generated in the boiler is stored in two accumulation tanks which have 3 ton capacity. An additional circulation pump is used for supplying domestic hot water from accumulation tanks to the buildings.

The heat energy that is extracted from plant cycle is delivered to dwellings via the main pump station which is located nearby the plant.

District Heating	
Boiler	Type: Coal fired Number: 2 (one of them is backup)
Circulation Pumps	Number: 4 (one for each zone) Flow rate: 110 m^3/h Pressure: 10 mWc
Pipes	Material detail: RTP (reinforced thermoplastic pipe) has 3 layers; – Inner plastic pipe layer (thermoplastic material) – Middle reinforcement layer (continuous fibre reinforced material) – Outer protective layer (thermoplastic material)
Inlet Temperature	70°C
Outlet Temperature	50°C
Domestic Hot Water	
Boiler	Number: 1 small boiler
Accumulation Tanks	Number: 2 Capacity: 3 tone for each
Circulation Pumps	Number: 1
General Information	
Heating Season	15^{th} October – 15^{th} April

Table 2.6: Information about the existing heating system

Figure 2.11: Central Heating Boiler

Figure 2.12: District Heating Pipe Connection inside the building

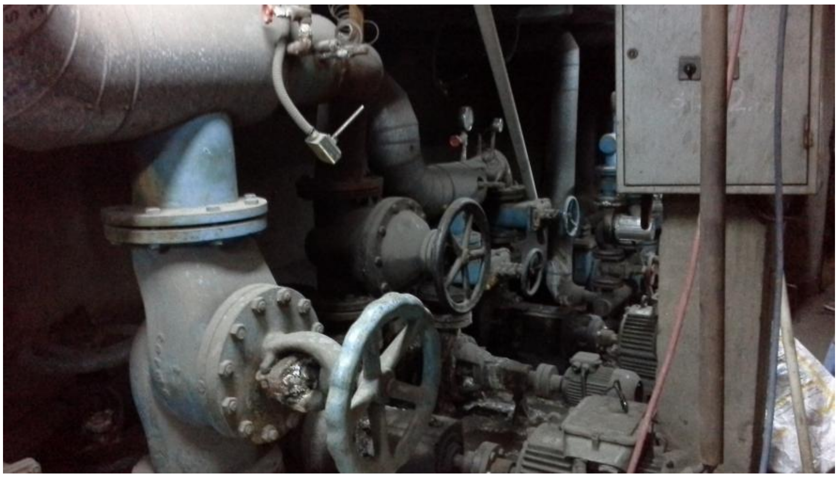


Figure 2.13: Circulating Pumps for Heating System

Electricity

Electricity system around SEAŞ is distributed over 4 transformers with linear typology, each has 400kVA capacity. Buildings location is designed according to the buildings types and TR1 connected to the Alternative Current (AC) distribution panels of 3-story buildings E24-33, E9-16 and Water treatment plant. TR2 connected to the AC distribution panels of 3-story buildings E17-23, E1-8, 2-story buildings D1-8 and Exchanger. TR3 connected to the AC distribution panels of 2-story buildings D9-16 and Elisko, Congress Centre and Single Dorm. TR4 connected to the AC distribution panels of 2-story buildings D17-24, D25-32; duplex buildings C1-6; 1-story buildings B1-8; Guest House and Security buildings.

Figure 2.14: Power Distribution system of Demo site

2.4 Definition of needs

All dwellings contained in the buildings need a major renovation for interior design. SEAS management decided to change the energy systems by another more efficient during the renovation. Since Soma Electricity Generation and Trading (SEAŞ) is a thermal power generation company and have already been heating 1,500 dwellings in the city of Soma with its heat recovery system, they have decided to heat their own housing.

After performing a preliminary analysis it was decided to retrofitting with thermal insulation together with efficient energy systems and energy management measures to decrease the heating and cooling demands of the buildings. Installation of solar thermal systems would decrease the need to heat water and provide a substantial decrease in heating water demand.

Generating electricity with PV panels will minimize the electricity demand of the convention center which will provide a reduction in energy costs.

Smart grid and ICTs interventions introducing renewable energy sources will allow a higher control capacity with smart metering. This will also lead to more efficient use of energy by the tenants.

3 Building retrofitting technical solutions

In the Turkish demo site, buildings were categorized under the building types (residential blocks, guest house and convention centre) mentioned in the section above. The existing building conditions were analysed on the basis of their energy performance, and all building characteristics were identified in terms of architectural, electrical and mechanical systems. The 3D models of the demo site buildings were developed with Revit Architecture programme to characterise building features, and the energy models were developed with Quick Energy Simulation Tool (e-QUEST) programme to simulate existing building's energy performance. The strategies for retrofitting buildings in each category were established accordingly. The results of these analyses are provided in deliverable D4.2 "Technical definition of the Turkish demo site (Soma, Turkey)" in detail. The selected applicable technologies for retrofitting based on these strategies are:

- Implementation of thermal insulation;
- Replacement of the lighting appliances;
- Installation of radiant heating and cooling systems
- Installation of solar thermal systems;
- Installation of Building Integrated PV systems;

3.1 Thermal insulation increase and thermal bridges elimination or reduction

The purpose of thermal insulation in buildings is to maintain a comfortable and hygienic indoor climate throughout the year, decreasing the heating and cooling demand. Strategies to reach these aims are the single use of innovative or standard low cost techniques or a combination of them. These solutions include the use of standard thermo hygrometric materials, innovative high-performance products, such as thermal insulating paint or/and panels, or/and waterproofing membranes, and colours to optimize the solar absorption and reflection of the external envelope.

Thermal insulation materials are specifically designed to reduce the flow of heat by limiting conduction, convection, or both.

The effectiveness of insulations is indicated by their R-value, or thermal resistance value. The R-value of a material equals the thickness (d) of the insulation divided by the thermal conductivity (λ). R-values are measured in SI units: m^2K/W.

As the thickness of insulating material increases, the thermal resistance also increases. However, adding layers of insulation has the potential of increasing the surface area, and hence the thermal convection area.

Thermal transmittance or U-value is the rate of transfer of heat through a structure divided by the difference in temperature across the element. It is a measure of how well the building element is insulated and it is expressed in W/m²K. The lower the U-value means that the better the thermal performance of the element will be.

There are essentially two types of building insulation: bulk insulation and reflective insulation. Most buildings use a combination of both types to make up a whole building insulation system but the buildings in the Soma demo site, only bulk insulation is used. The type of insulation used is matched to create maximum resistance to each of the three main forms of building heat transfer (conduction, convection and radiation).

Bulk insulators block conductive heat transfer and convective flow either into or out of a building. Materials which have low density are known as thermal insulation materials. The denser a material is, the better it will conduct heat. The air has a very low density, which makes it a good insulator. Insulation to resist conductive heat transfer uses air spaces between fibres, inside foam or plastic bubbles and in building cavities like the attic. This is beneficial in an actively cooled or heated building, but can be a disadvantage in a passively cooled building.

Bulk insulation comes in many shapes, thicknesses and materials and is primarily used in ceilings and walls. The most common bulk insulation materials are mineral wool and glass fibre. Other materials include recycled and virgin polyester, wool and cellulose fibre. Bulk insulation stops heat flow by trapping air in small air pockets [2].

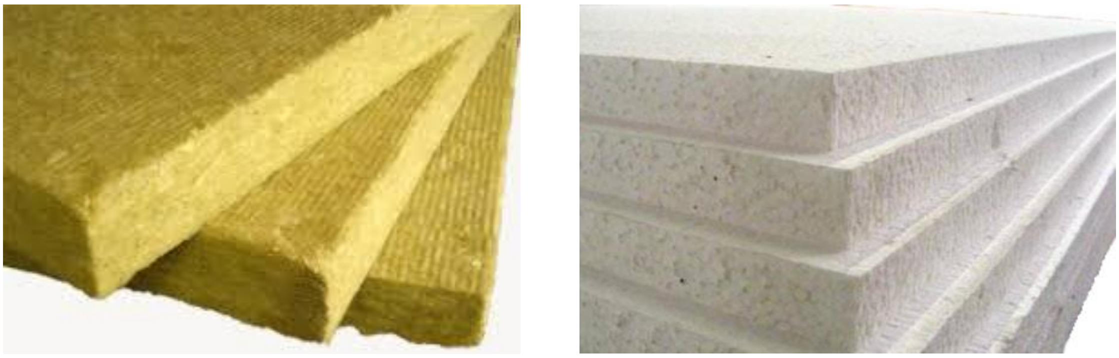


Figure 3.1: Bulk insulation materials: mineral wool and expanded polystyrene (EPS)

In cold conditions, the main aim is to reduce heat flow out of the building. The components of the building envelope (windows, doors, roofs, walls, and air infiltration barriers) are all important sources of heat loss. In an otherwise well insulated home, windows will then become an important source of heat transfer. The resistance to conducted heat loss for standard single glazing corresponds to an R-value of about 0.17 m^2K/W, whereas the R-valued for insulated elements reaches about to 2-4 m^2K/W. Losses can be reduced by bulk insulation and minimising the amount of non-insulating (particularly non-solar facing) glazing. Indoor thermal radiation can also be a disadvantage with spectrally selective (low-emissivity) glazing. Some insulated glazing systems can double or triple R values.

In hot conditions, the greatest source of heat energy is solar radiation. This can enter buildings directly through windows or it can heat the building shell to a higher temperature than the ambient, increasing the heat transfer through the building envelope. The Solar Heat Gain Co-efficient (SHGC) or G-value (a measure of solar heat transmittance) of standard single glazing can be around 78-85%. Solar gain can be reduced by adequate shading from the sun, light coloured roofing, spectrally selective (heat-reflective) paints and coatings and various types of insulation for the rest of the envelope. Specially, coated glazing can reduce G-value to around 10%.

Nowadays there are many types of thermal building insulation materials available, which can be classified as follows [3].

Type	Material	
Insulating concrete forms	Autoclaved aerated concrete	Light weight concrete
Spray foam	Polyurethane foam	Flexible elastomeric foam
	Polyethylene foam	
Plastic foam	Extruded polystyrene	Polyurethane rigid panel
	Expanded polystyrene	
Fiberglass	Glass wool	Rockwool
Natural	Perlite loose-fill	Hemp wool
	Vermiculite loose-fill	Cotton wool
	Expanded clay	Reed panels
	Soft and hard Wood panels	Sheep wool
	Cellulose	Duck feather
	Expanded cork	Straw bale
Aerogel	Air-filled SiO2	Vacuum siO2
Phase-change material (PCM)	Hydrated Salts	Organic Materials
Vacuum insulation (VIP)	Aerogel, open-cell polyurethane, fiberglass, powder materials as internal filled materials	Plastic, multilayer films containing aluminum, stainless steel as protective barriers
Nanotechnologies	Contains insulation materials such as aerogels, VIP, PCM	

Table 3.1: Proposed classification of insulation materials.

According to results of the existing building's energy performance analysis, the first strategy was developed to improve the thermal characteristic of the building envelope. Hence the different insulation materials and their applications were evaluated. As mentioned above the purposes of thermal insulation in buildings besides decreasing the heating and cooling demands are to maintain a comfortable and hygienic indoor climate throughout the year. In this sense, 5 cm thickness EPS (expanded polystyrene) foam was proposed to integrate on external walls as well as on roof and ground floor.

The specific insulation material will be selected with the tender process which will be handled by SEAŞ.

3.2 Replacement of the existing lighting systems

Electrical appliances account for a significant portion of the utilities' bill, in particular lighting is a major source of electricity consumption in buildings. Because of the prevalent use of inefficient lighting technologies, especially in the residential sector, there is a great need for energy efficiency initiatives.

In this context, a complete replacement of the lighting system in the demo buildings is planned as part of the retrofitting project. The existing fixtures will be replaced with more efficient LED systems. The number and the specific locations of the replaced lighting systems will be determined after the project implementation. The benefits of energy efficient lighting installation include energy saving and reduced electricity bills.

LEDs or light emitting diodes are solid light bulbs which are extremely energy efficient and that produce visible light when an electrical current passed through them. LED lighting is very different from other lighting sources such as incandescent bulbs and Compact Fluorescent Lamps (CFLs). Key differences are:

- **Light Source:** LEDs are a mix of red, green and blue but they are typically used to produce white light.
- **Direction:** LEDs emit light in a specific direction, reduce the need for reflectors and diffusers so can trap light. This feature makes LEDs more efficient for many uses such as recessed down lights and task lights. At the other type of lighting, the light must be reflected to the desired direction and more than half of the light may never leave the fixture.
- **Heat:** LEDs emit very little heat. In comparison, incandescent bulbs release 90% of their energy as heat and CFLs release about 80% of their energy as heat. In LEDs, a heat sink which is a passive device that absorbs the heat produced and dissipates it into the surrounding environment is used. This keeps LEDs from overheating and burning out.
- **Long-lasting:** LED bulbs last up to 10 times as long as compact fluorescents, and far longer than typical incandescent.
- **Durable:** since LEDs do not have a filament, they are not damaged under circumstances when a regular incandescent bulb would be broken. Because they are solid, LED bulbs hold up well to jarring and bumping.
- **Mercury-free**: no mercury is used in the manufacturing of LEDs.
- **More efficient:** LED light bulbs use only 2-17 watts of electricity (1/3rd to 1/30th of Incandescent or CFL). LED bulbs used in fixtures inside the home save electricity, remain cool and save money on replacement costs since LED bulbs last so long. Small LED

flashlight bulbs will extend battery life 10 to 15 times longer than with incandescent bulbs.

- **Cost-effective:** although LEDs are initially expensive, the cost is recovered over time and in battery savings. LED bulb use was first adopted commercially, where maintenance and replacement costs are expensive, but the cost of new LED bulbs have gone down considerably in the last few years and are continuing to go down. Today, there are many new LED light bulbs for use in the home, and the cost is becoming less of an issue.
- **Usefulness:** light for remote areas and portable generators - because of the low power requirement for LEDs, using solar panels becomes more practical and less expensive than running an electric line or using a generator for lighting in remote or off-grid areas. LED light bulbs are also ideal for use with small portable generators which homeowners use for backup power in emergencies.

Comparison between different bulbs	Incandescent	CFL	LED
Light bulb projected lifespan	1,200 hours	10,000 hours	50,000 hours
Watts per bulb (equiv. 60 watts)	60	14	10
Cost per bulb*	0.50 €	3.50 €	15.00 €
kWh of electricity used over 50.000 hours	3000	700	500
Cost of electricity (€0.13 per kWh)*	390.00 €	91.,00 €	65.00 €
Bulbs needed for 50k hours of use	42	5	1
Equivalent 50k hours bulb expense	21.00 €	17.50 €	15.00 €
Total cost for 50k hours	411.00 €	108.50 €	80.00 €
Total cost for 25 light bulbs for 50 k hours	525.00 €	437.50 €	375.00 €
Savings to household by switching from incandescents	0.00 €	7,475.00 €	8,125.00 €

Table 3.2: Financial Comparison of incandescent, CFL and LED light bulbs
(*) Costs of electricity and bulbs are relevant for Turkey. The results may differ from country to country depending on the prices.

The benefits of energy efficient lighting's installation include energy savings and electricity bills reduction.

Figure 3.2: LEC lamp

LED Lamps	
Power density	0.84 W/m^2

Table 3.3: Power density of the lamp

3.3 Installation of radiant heating and cooling systems

In the demo site, radiant heating & cooling systems will be implemented into the buildings after district heating retrofitting process. Low temperature heating & high temperature cooling systems and radiant heating & cooling systems are efficient systems because they consume less energy and use the possibility of renewable energy systems such as heat pumps and solar energy. Moreover, thermal conditions are more comfortable than in conventional systems.

Before implementation, heat loss & gains were simulated in order to know heat loss & gain of each volume in flats and in buildings both in heating and cooling season. Before implementation, heat loss/gains have been simulated with the energy simulation programme "eQuest" by ITU in order to know heat loss/gain of each volume in flat and in building both in heating and cooling season. Below, a sample analyse result is shown in figure.

After these simulations, calculations were made for the radiant heating & cooling implementation. In buildings, radiant ceiling heating & cooling panels were preferred and the panels were drawn by "Autocad" 2D CAD programme. A sample of radiant ceiling heating project is shown below.

SPACE D4-SALON
SPACE TEMPERATURE USED FOR THE LOADS CALCULATION IS 66 F / 19 C

MULTIPLIER	1.0		FLOOR MULTIPLIER	1.0
FLOOR AREA	266 SQFT	25 M2		
VOLUME	2581 CUFT	73 M3		

	COOLING LOAD		HEATING LOAD	
TIME	AUG 21 7PM		JAN 28 6AM	
DRY-BULB TEMP	92 F	33 C	23 F	-5 C
WET-BULB TEMP	69 F	21 C	22 F	-6 C
TOT HORIZONTAL SOLAR RAD	73 BTU/H.SQFT	230 W/M2	0 BTU/H.SQFT	0 W/M2
WINDSPEED AT SPACE	5.3 KTS	2.7 M/S	5.3 KTS	2.7 M/S
CLOUD AMOUNT 0(CLEAR)-10	0		0	

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	SENSIBLE (KBTU/H)	SENSIBLE (KW)
WALL CONDUCTION	0.661	0.194	0.000	0.000	-0.797	-0.234
ROOF CONDUCTION	0.229	0.067	0.000	0.000	-0.388	-0.114
WINDOW GLASS+FRM COND	0.409	0.120	0.000	0.000	-0.742	-0.218
WINDOW GLASS SOLAR	2.571	0.753	0.000	0.000	0.210	0.061
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	0.073	0.021	0.000	0.000	-0.345	-0.101
OCCUPANTS TO SPACE	0.150	0.044	0.121	0.035	0.126	0.037
LIGHT TO SPACE	0.058	0.017	0.000	0.000	0.030	0.009
EQUIPMENT TO SPACE	0.160	0.047	0.000	0.000	0.057	0.017
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.240	0.070	0.062	0.018	-0.621	-0.182
TOTAL	4.551	1.333	0.183	0.054	-2.471	-0.724
TOTAL / AREA	0.017	0.054	0.001	0.002	-0.009	-0.029
TOTAL LOAD	4.734 KBTU/H		1.387 KW		-2.471 KBTU/H	-0.724 KW
TOTAL LOAD / AREA	17.79 BTU/H.SQFT		56.103 W/M2		9.284 BTU/H.SQFT	29.282 W/M2

Figure 3.3: Peak load of living room of Flat 4 in 12 H buildings

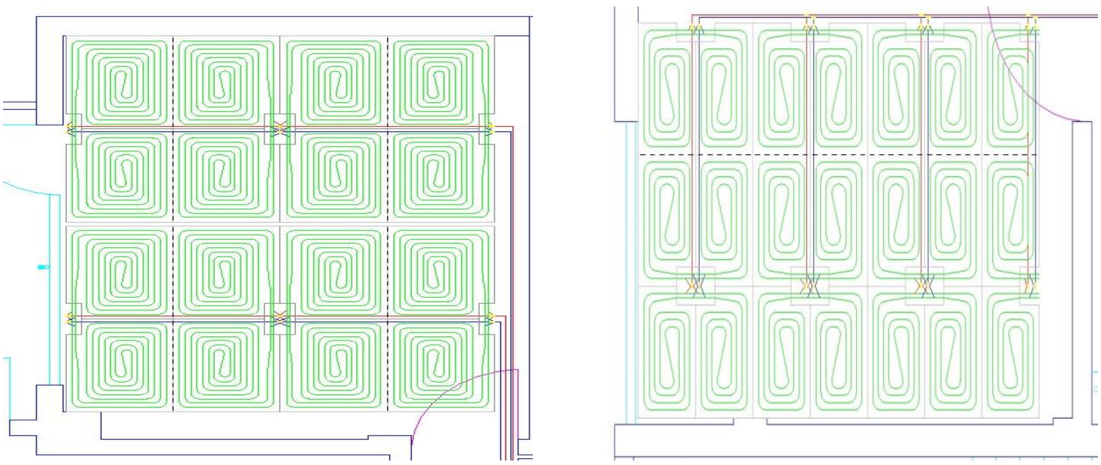


Figure 3.4: Low temperature heating system to be implemented on the living room and master room (Note: Red line shows hot water while blue line shows the cold water)

Beside the radiant heating & cooling systems, control systems will be applied to the buildings. Thanks to control systems, the radiant heating & cooling systems will work more efficiently than under current conditions and the energy saving will be increased by the hybrid system.

First, two chosen blocks will be completely equipped with radiant heating & cooling panels. Thereby, the mechanical sanitary system will be revised and all heating equipment regenerated in accordance with this system. Monitoring will also be implemented.

Living Room	
Panel Type	Cool Comfort 55 1.2x 2
Number of Panels	4
Panel Area [m^2]	9.6
Heating Capacity [W]	480
Cooling Capacity [W]	384
Flow rate [l/min]	1.664

Table 3.4: Panel properties for Living Room

Master Room	
Panel Type	Cool Comfort 55 0.6x1 and 0.6x2
Number of Panels	7 and 7
Panel Area [m^2]	12.6
Heating Capacity [W]	630
Cooling Capacity [W]	504
Flow rate [l/min]	2.184

Table 3.5: Panel properties for Master Room

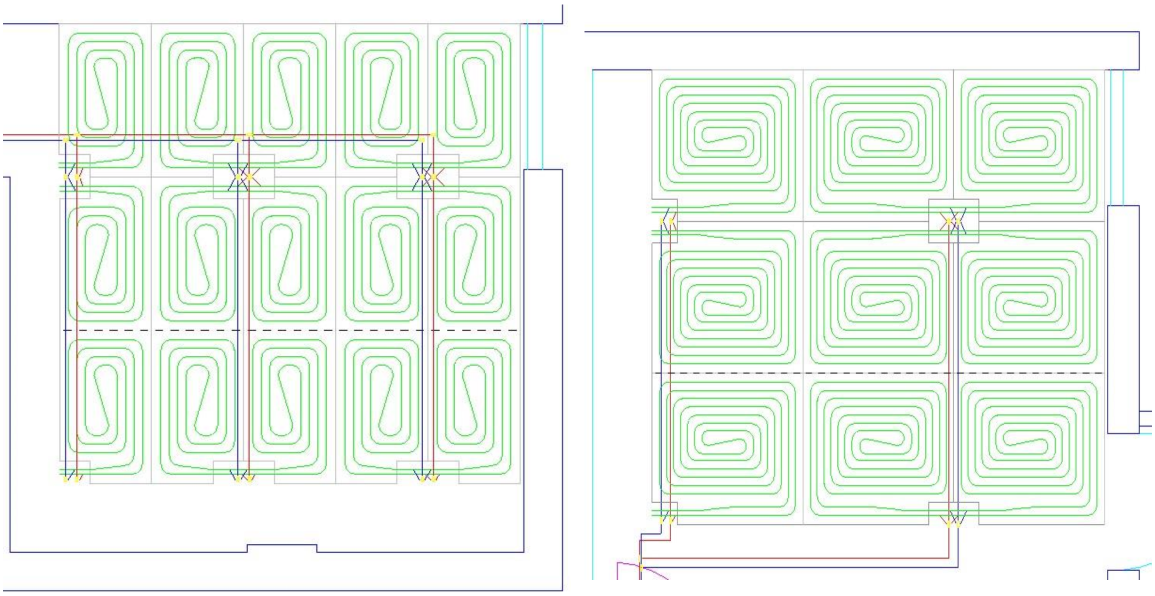


Figure 3.5: Panel instalments for other Common Room 1 and Common Room 2
(Note: Red line shows hot water while blue line shows the cold water)

Common Room 1	
Panel Type	Cool Comfort 55 0.6x1 and 0.6x2
Number of Panels	5 and 5
Panel Area [m^2]	9
Heating Capacity [W]	450
Cooling Capacity [W]	360
Flow rate [l/min]	1.56

Table 3.6: Panel properties for Common Room 1

Common Room 2	
Panel Type	Cool Comfort 55 1.2x1 and 1.2x2
Number of Panels	3 and 3
Panel Area [m^2]	10.8
Heating Capacity [W]	540
Cooling Capacity [W]	432
Flow rate [l/min]	1.872

Table 3.7: Panel properties for Common Room 2

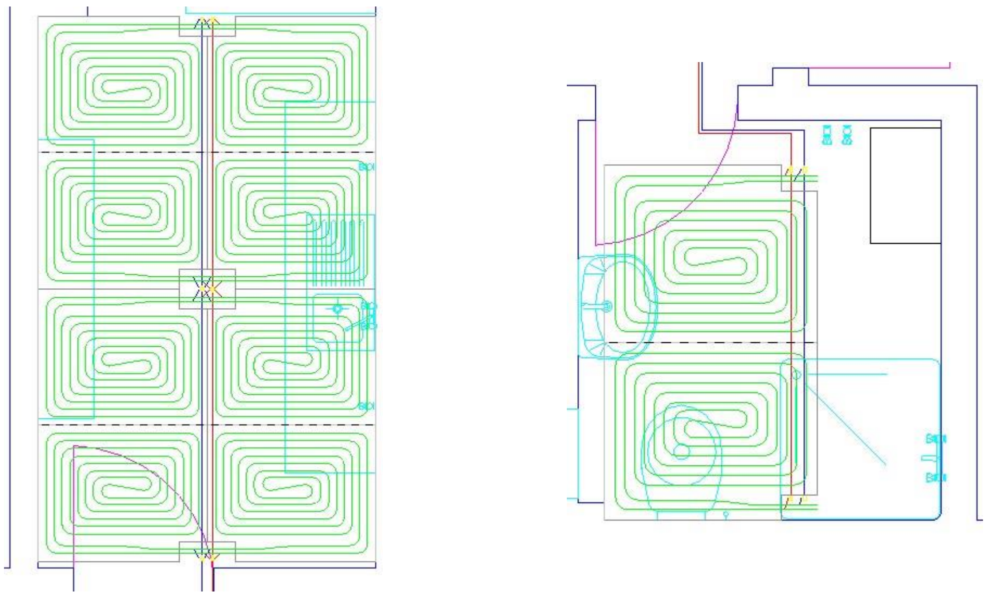


Figure 3.6: Panel instalments for kitchen and bathroom
(Note: Red line shows hot water while blue line shows the cold water)

Kitchen	
Panel Type	Cool Comfort 55 1.2 x 2
Number of Panels	4
Panel Area [m^2]	9.6
Heating Capacity [W]	480
Cooling Capacity [W]	384
Flow rate [l/min]	1.664

Table 3.8: Panel properties for Kitchen

Bathroom	
Panel Type	Cool Comfort 55 1.2 x 2
Number of Panels	1
Panel Area [m^2]	2.4
Heating Capacity [W]	120
Cooling Capacity [W]	96
Flow rate [l/min]	0.416

Table 3.9: Panel properties for Bathroom

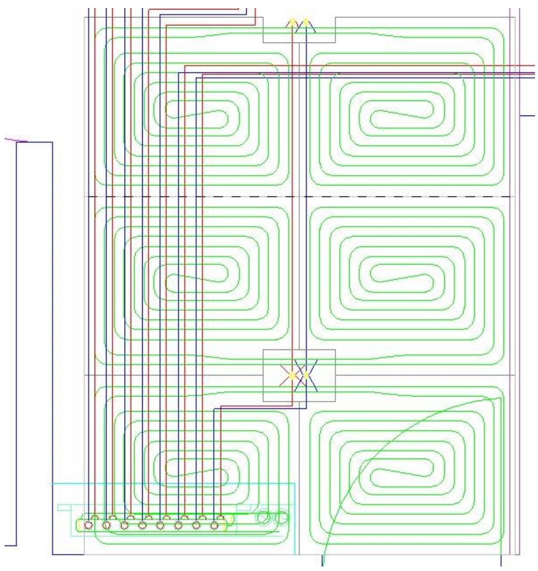


Figure 3.7: Panel instalments of Hall
(Note: Red line shows hot water while blue line shows the cold water)

Hall	
Panel Type	Cool Comfort 55 1.2x1 and 1.2x2
Number of Panels	2 and 2
Panel Area [m^2]	7.2
Heating Capacity [W]	360
Cooling Capacity [W]	288
Flow rate [l/min]	1.248

Table 3.10: Panel properties for Hall

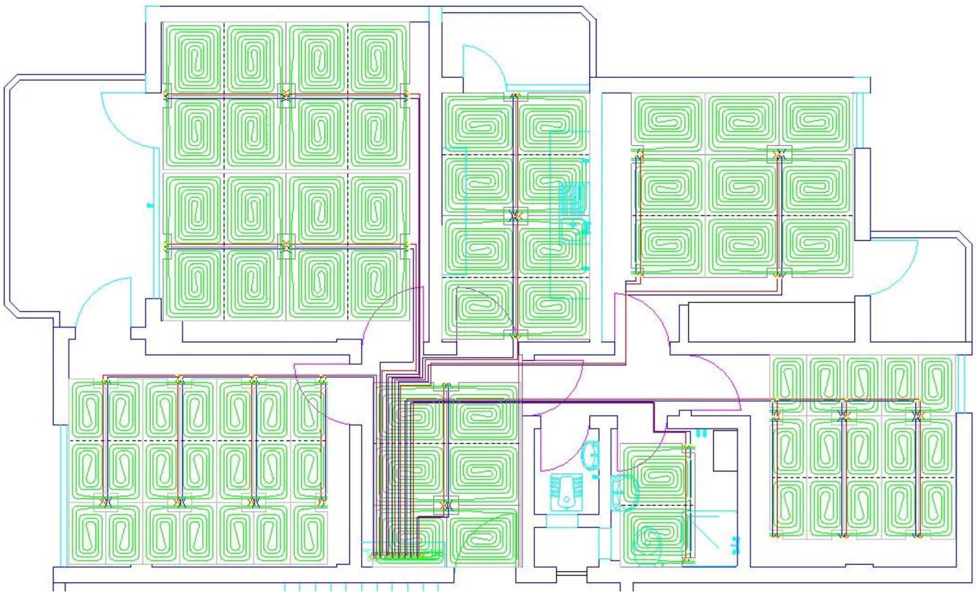


Figure 3.8: Radiant panel instalments for a flat
(Note: Red line shows hot water while blue line shows the cold water)

The new system will work with water collectors (hot and cold), thermostats (T) and mixture tanks. A mixture of 70°C water enters the mixture tank while the cold 30°C water returns from the panels to the same tank. In the mixture tanks, water temperature is mixed and the resulting water (40°C) is sent to panels as a water inlet to radiant panels. Also, thermostat controls the room temperature and it can change the temperature of the mixture water according to the conditions of the room. Each flat has a mixture tank and all the room heating systems work in this circulation. In the figure, a simple chart is shown as a heating system in heating season.

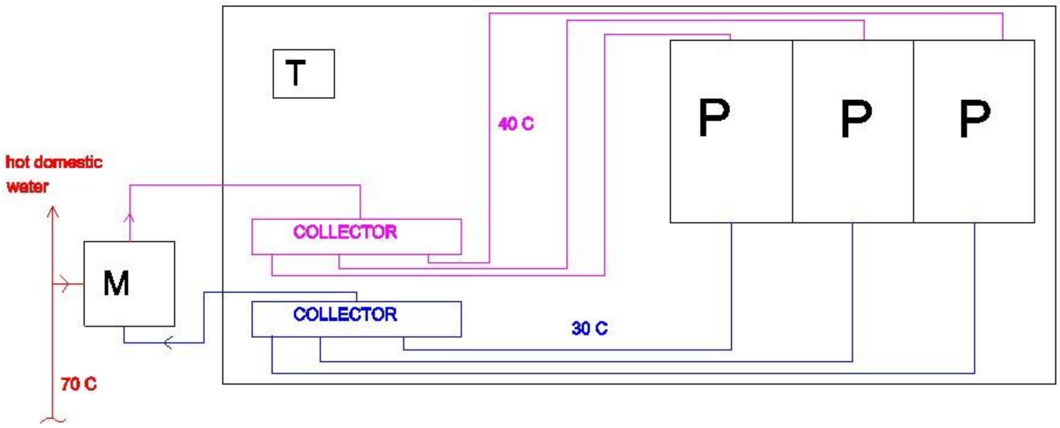


Figure 3.9: Radiant heating system distribution chart

After the first implementation, radiant heating & cooling panel system will be implemented in ten blocks. Predesign will be done for each building in order to prepare tendering documents. After the tendering process, final design and calculations will be made and the first two blocks will be commissioned. Monitoring will be executed after the implementation.

3.4 Installation of solar thermal systems

Solar thermal panels are devices that take the advantage of direct sunlight and convert it into heat that can be used in different processes, most commonly domestic hot water supply. As domestic hot water is required throughout the year, solar thermal panel application to the envelope provides high rates of energy saving.

Collector technologies based on capacity can be defined in two different types as non-concentrating and concentrating Solar Thermal Collectors (SCT). Non-concentrating collectors can be divided in three and concentrating collectors can be divided in two groups based on their technologies.

Non-concentrating STC

- **Unglazed collectors**

Unglazed collectors does not include glazing or insulated collector box. They only consist of an absorber. They are used for low temperature applications most commonly.

- **Glazed collectors**

Glazed collectors are thermally insulated on their back and edges. They are provided with a transparent cover on the upper surface. They can heat fluid up to 80°C.

- **Evacuated collectors**

Collector type that contains a glass tube with vacuum inside, that minimizes heat losses to environment. Working temperature of evacuated tube collectors are between 50°C and 200°C which is relatively high when compare with other non-concentrating collectors.

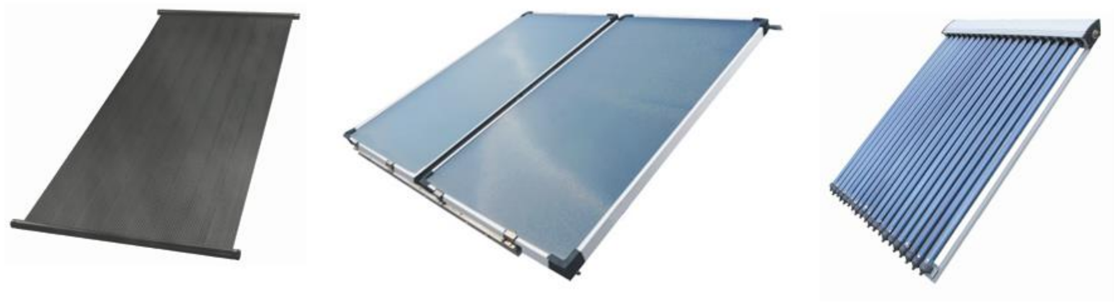


Figure 3.10: Non-concentrating STC types

Concentrating STC

- **Parabolic collectors**

Parabolic collectors can be used with both non-evacuated flat plate collectors and evacuated tube collectors. PTC collectors are designed for a high concentration ratio. They can heat the working fluid up to 240 °C and they are used for high temperature application.

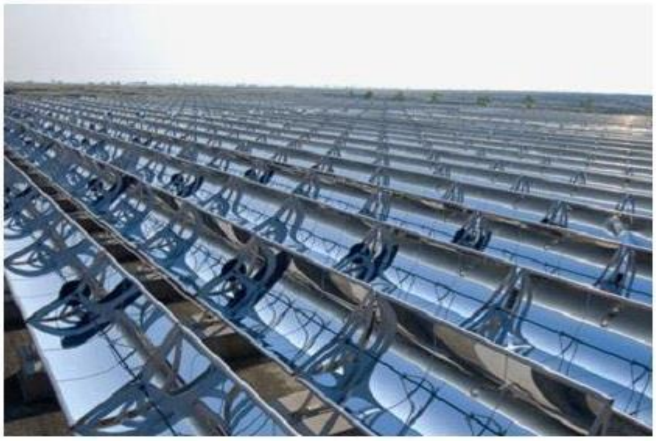


Figure 3.11: Parabolic collectors

- **High concentrating collectors**

High concentrating collectors have sun tracking technology which can generate temperatures high enough to operate a thermodynamic cycle and produce electricity. Additionally, they can be used in (process) heat applications.

Solar thermal systems components

Application of solar thermal collector technology is identified under two main categories as they are roof and façade applications.

System components of a solar thermal panel are listed below [4];

- Collector: Main component of the system which is used to transform solar radiation to heat
- Storage tank: Equipment to store generated heat in collectors. Also important for the heat balance

- Pump and Controller: Pumps move the fluid through piping circuits. Pump operation is controlled by the controllers
- Auxiliary heating system: Supporting system when storage tank cannot provide required temperature to the building system

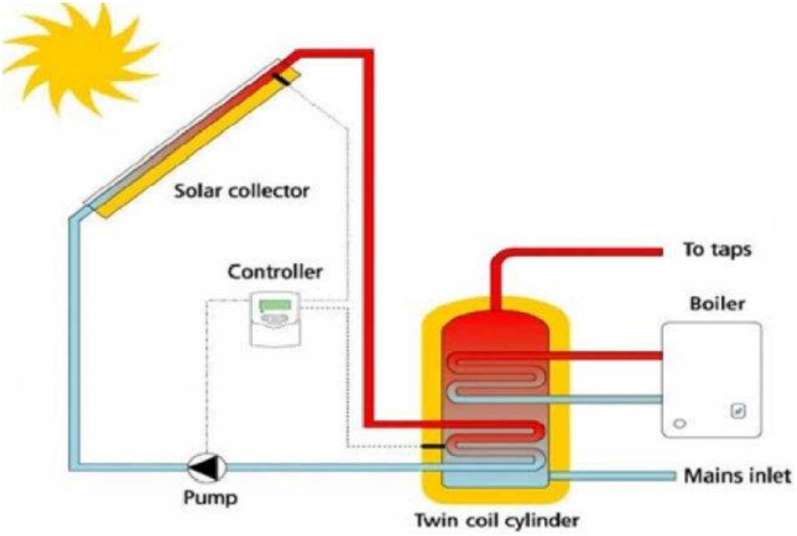


Figure 3.12: Simple application of solar thermal system

Solar thermal panels have 3 additional main targets apart from domestic hot water supply: they are space heating, pool heating and solar cooling. All four applications require various temperature ranges and collector types accordingly to their function. Solar thermal panels are used only for domestic hot water in the buildings of Soma demo site area.

Domestic water heating system

Domestic water heating system by solar thermal collectors is the most common residential technology that can be applied in order to provide hot water for buildings and districts. STC systems are more efficient in warmer climates thus they have a direct relation with the climatic conditions. Temperature requirement of a domestic hot water is generally below 80°C and STC system can recover 30% of total energy consumption. Success of the system depends on the area of the collector and the size of the storage, besides climate. In case of optimum conditions, it is possible to satisfy domestic hot water demand at 100% by solar thermal systems.

Two main system configurations are used for solar DHW heating systems [5]

- **Thermo syphon systems**

In thermo syphon systems, water is circulated automatically from solar collector to storage tank by using the density difference between different temperatures of water in different aspects of the system. Thermo syphon systems neither include pump to transfer hot water nor controller due to its self-starting and self-controlling properties. All these characteristics make the system simple and cost-effective. This type solar thermal system is better to be used in frost-free climates.

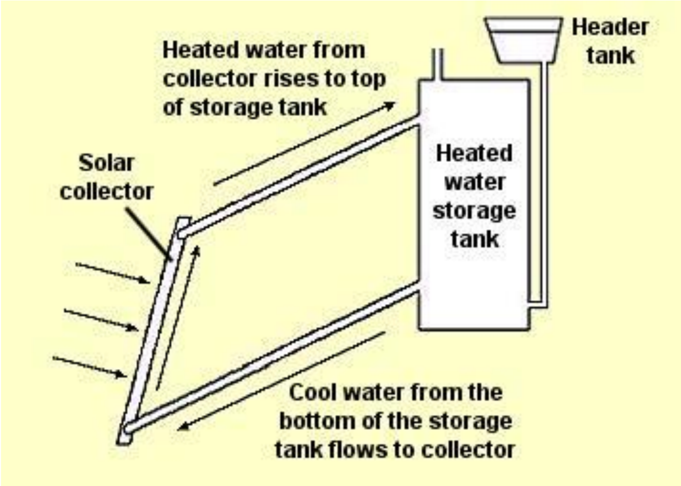


Figure 3.13: Thermo syphon system

- **Forced-circulation system**

In forced-circulation systems, water needs additional mechanical pump to start circulation process in the system. Sensors and controller devices are also needed in order to ensure the system. For this reason, forced circulation systems are relatively more complex, energy consuming and expensive. Nevertheless, the amount of collected solar energy is higher due to the pumping system, which is efficient under low solar energy gains as well.

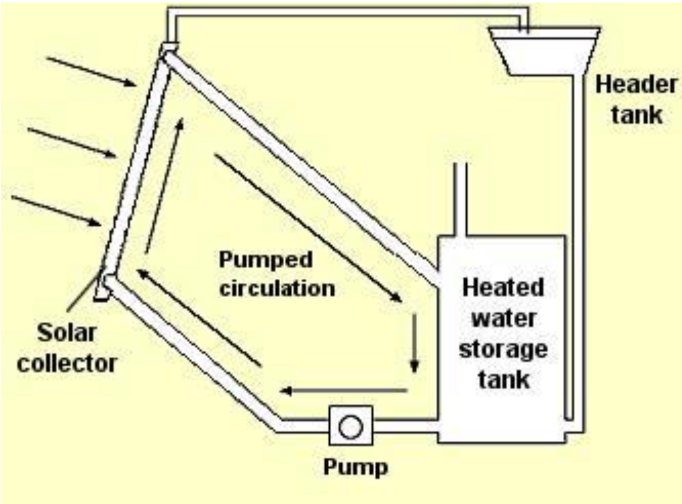


Figure 3.14: Forced-Circulation System

STC applications on roof

Solar thermal collector integration and location for roof applications can be divided in two subcategories as they are listed below;

- **Building integrated solar thermal (BIST)**

Collectors used for heat generation also work as an architectural element. For roof applications, collectors are placed instead of roof tiles, which mean that they also acts like construction elements of the building and provide considerable reduction on some system application requirements. This method is most suitable for new constructions. There are three applicable collector technologies for BIST roof systems: flat plate collectors, unglazed collectors and evacuated tube collectors. Suitable collector area and weight must be defined and made accordingly to the application areas [6].

Figure 3.15: BIST solar thermal collectors

- **Building applied solar thermal (BAST)**

Building applied solar thermal system is a simple and conventional method for existing buildings. The solar collectors are mounted on building façade or roof. In this method, the collector does not replace any other building elements such as tile. Consequently, there is no material or cost saving when they are compared to BIST systems. Parabolic through collectors can also be defined as an applicable solar thermal collector technology additively to applicable BIST technologies.

Figure 3.16: BAST solar thermal collectors

Depending on the available area in the building, storage of the storage tanks can be placed as integrated or inside storage. In case of integrated storage, the tank is attached to the solar thermal panel as shown in the figures below [7].

Figure 3.17: Integrated storage of solar thermal storage tanks

When the storage of the tank is done in the available internal space, storage tank locates as it is shown in the figure below. Inside storage is the best solution in order to provide protection for the tank.

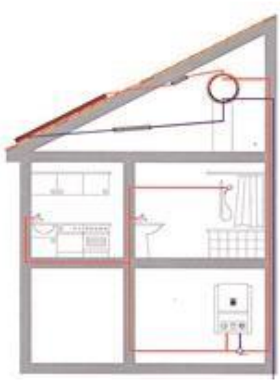


Figure 3.18: Internal storage of solar thermal storage tanks

Piping system of the solar thermal solution

Piping system of the solar thermal technology provides the connection between collector panel and the storage tank. According to the location of the system, piping may be visible or hidden. Visible piping systems are the one that locates between panels on the roof area and can be easily seen. Hidden piping systems are generally located in the backside of the panel, in the garret of the building so that it becomes invisible. Hiding the technical part of the system is always better in terms of aesthetic and safety [8].

Figure 3.19: Example of system with visible or hide piping system

Installation of solar thermal systems in Soma demo site

Solar thermal technology uses the sun's energy as the primary energy source to generate thermal energy that can be used for the domestic hot water production. By utilizing solar energy instead of fossil fuels, solar thermal systems reduce the amount of greenhouse gases emission and fuel consumption. The system includes solar thermal collectors mounted on the roof and facing south with a tilt angle to optimize solar energy gain. Another basic component of the solar thermal system is the hot water storage tank: monovalent or bivalent tanks in the heating room will be connected to the solar thermal collectors with their heat exchanger coils inside. Between tanks and solar thermal collectors there will be circulators and solar controllers.

For residential buildings, thermo-syphon solar water heaters were planned to be installed to cover the hot water demand. Their passive design allows heat transfer using natural convection in a closed fluid loop. The advantage is that they do not require pump, this keeps the complexity and costs of a thermo-syphon system low. In addition, being a compact solution, tanks, solar thermal collectors and other equipment will be installed on the roof and will not require an additional room inside the building.

346 solar thermal collectors have already been installed in the dwellings, 12 in the convention centre, 16 in the guest house, and 16 in the single lodging.

Figure 3.20: Solar thermal collectors on buildings in the demo site

3.5 Installation of PV systems

As it is described by its name, photo (light) voltaic (voltage) panels use direct sunlight in order to convert it into electricity. Those panels are formed by many photovoltaic cells. Integration of cells to the rooftops and façade area of the buildings are the most popular PV applications. The main purpose of the PV system is to generate electricity and to get direct penetration of the sunlight without hitting any physical barrier. Energy supplied by PV panels can be used in order to provide energy demand in buildings as well as districts.

The installation of solar photovoltaic systems is considered a high cost active solution to improve the building energy efficiency in terms of electricity generation. By producing energy, the building envelope becomes active due to self-sufficiency. Solar photovoltaic systems are installed on the roof of the guesthouses and convention centre to absorb and directly convert sunlight into electricity in the Soma demo site area.

Consolidated PV technologies

Consolidated building integrated photovoltaic (BIPV) technologies can be evaluated in two different subtitles as they are Crystalline Silicon Technology and Thin-Film Technology.

- **Crystalline Silicon Technology**

Crystalline silicon photovoltaic panels are preferred as BIPV products due to their properties as they are listed below:

- Development of the technology and its market recognition provides high variety of product range.
- Quality level is high when compared to other technologies as a result of research carried on for a long period of time.
- Conversion efficiency of the PV panels is important for area limited applications and crystalline silicon technology is able to provide more efficient results with high efficiency of energy conversation.

Although crystalline silicon technology is the most efficient among PV technologies, its thick and rigid physical characteristic give rise to disadvantages in BIPV applications especially due to panel configurations that prevent visibility. Moreover, their efficiency varies depending on orientation on the building thus their performance is directly related to the light incidence angle. An example of a crystalline silicon cell with seven layers can be seen in the figure below [9].

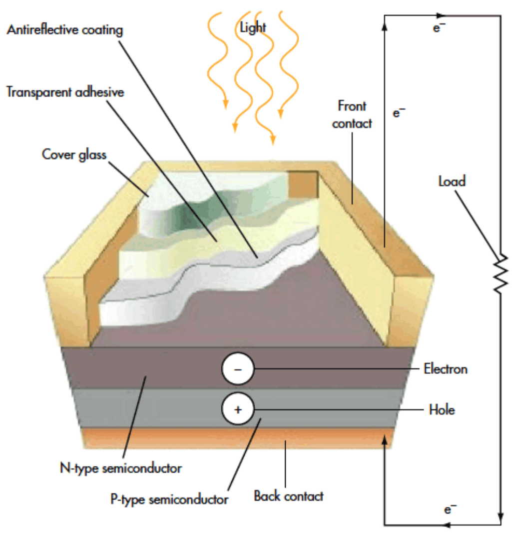


Figure 3.21: Examples of a Crystalline Silicon Technology

- **Thin-Film Technology**

Thin film solar panels can be one of three types in accordance with the used material:

- Amorphous silicon (a-Si) and thin-film silicon (TF-Si)
- Cadmium telluride (CdTe)
- Copper indium gallium selenide (CIS or CIGS)

Thin film technologies have lower power generation efficiencies when they are compared to crystalline silicon technology. However, their properties like easy installation, adaptability and lower incident ray dependencies thus higher overall yearly yields should be considered as one of their main advantages. While making a decision about type of the PV technology, the temperature factor should be considered in order to choose the most effective solution. Thin film technologies usually possess lower thermal degradation coefficients allowing them to be useful at higher outside temperatures. Thin film technology can sometimes be described as the optimal solution when considering installation costs due to its adaptability and convenience on integration and installation. Flexible substrate thin film PV panels have the added premium of being comparatively lighter and easier to install on roofs.

An example of a thin film solar cell with six layers is shown in the figure below.

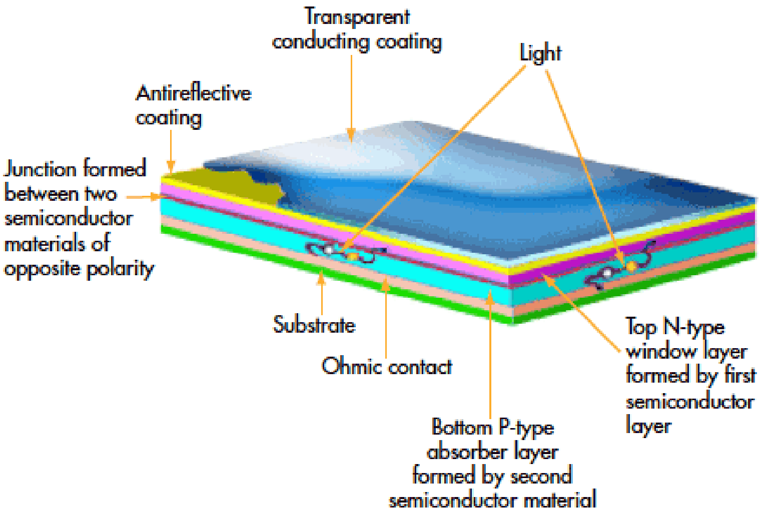


Figure 3.22: Example of Thin-Film Technology

Crystalline silicon technology has the dominant market share with approximate share of 90%. According to European Photovoltaic Industry Association [10], more than 70% of the total solar products use this technology. From that kind of distribution, it is possible to state that the crystalline silicon is the most developed PV technology.

PV applications on roof

PV applications on roofs are done by application or integration of photovoltaic systems on top of the building structure. Implementation can be categorized into two main categories as building applied and building integrated.

- **BAPV: Building Applied Photovoltaics**

Building Applied Photovoltaics refer to photovoltaic panels which are mounted on roof, on top of the building's existing structure – tile most commonly. BAPVs only provide electricity production from the solar energy. There are no additional benefits provided besides.

BAPV are generally preferred in case of application after the construction period of the existing building is finished.

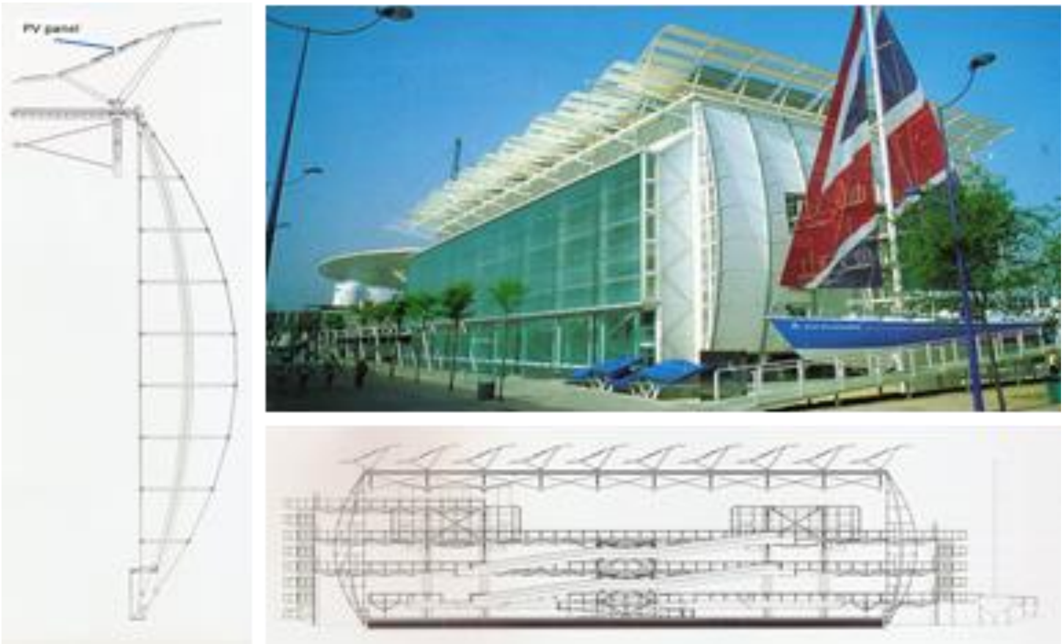


Figure 3.23: BAPV in Expo 92 building, Sevilla [11]

- **BIPV: Building Integrated Photovoltaics**

Building integrated photovoltaics are solar cell panels which can possibly be used as an original component of the building instead of conventional materials such as roof tiles. It gives opportunity of installation even during the construction phase of the building. While they produce electricity they also satisfy building demand as a building element. They assure a boundary between interior and the exterior space of the building. By providing layer for both waterproofing and air stabilizing function they increases thermal comfort relatively thus BIPVs are also responsible for daylighting, ventilation and energy production issues in depending on surfaces applied.

During the decision for BIPV integration, every parameter should be taken into account and appropriate products should be chosen in order to get the highest benefit. With their wide variety and the advantageous properties, it is sensible to replace existing materials mainly on facade and roof areas of the buildings in order to maximize energy efficiency.

Generation of on-site distributed power at the Soma demo site will be solely realized by the installation of Building Integrated Photovoltaics Systems, whose technical attributes have been described above.

Figure 3.24: BIPV system in a family house

Installation of PV systems in Soma demo site

PV integration on roofs of the buildings will be carried out in the Soma demo site. The important data and condition that must be provided during the design is the direct incidence of sunlight without any shading. Energy supplied from PV panels can be used in order to provide with power demand in the buildings as well as the demo site as a whole. For the Soma demo site, photovoltaic panel integration is planned to be applied only in two guesthouses and the convention centre. PV panels of size 1,345 × 990 × 50 mm will be mounted on the available usable roof areas and 230 Wp energy generation is planned from a single panel. It is expected that approximately 900 panels will be integrated on the rooftops of the selected buildings.

Figure 3.25: Building Integrated Photovoltaics

4 District heating system renovation strategies

4.1 District heating system

As described in section 2.3 "Energy system description" the buildings in Turkish demo site are heated by a central heating system which is fed by a boiler. In the new heating system, heat will be supplied by surplus heat of Soma Thermal Power Plant instead of by the existing central heating system.

Currently Soma Thermal Power Plant supplies heat energy to nearly 1,500 dwellings. Heat energy that is extracted from the plant cycle is delivered to dwellings via the main pump station, which is located nearby the plant. It is planned to construct a new transmission line to supply heat energy from the main pump station to the demo site. In addition, a new local pump station will be established in the demo site. Thus heat energy will be transmitted to the new local pump station and then will be supplied to the buildings by the new district heating network.

Figure 4.1: Scope of the Soma demo site application

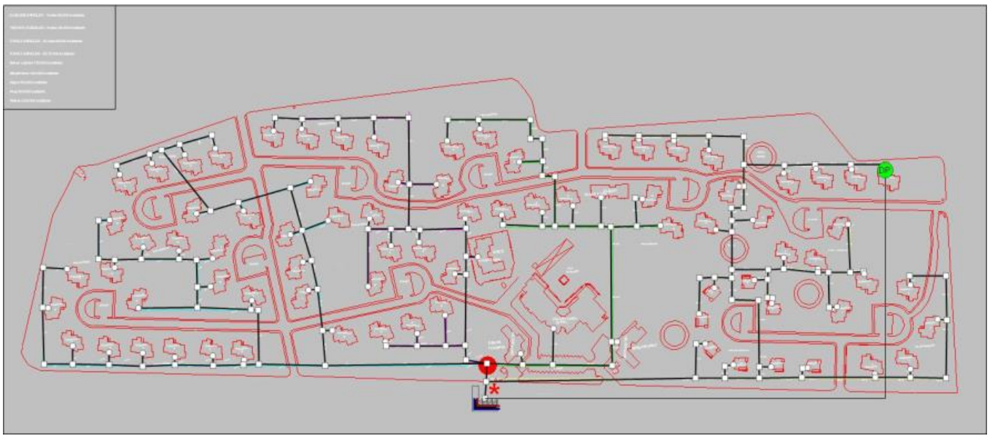


Figure 4.2: New district heating distribution network in Soma demo site

In the new district heating system, surplus heat from Soma Thermal Power Plant will be used as heat source instead of coal fired boiler. Soma Thermal Power Plant supplies heat energy to the buildings from the main pump station which is located nearby the plant.

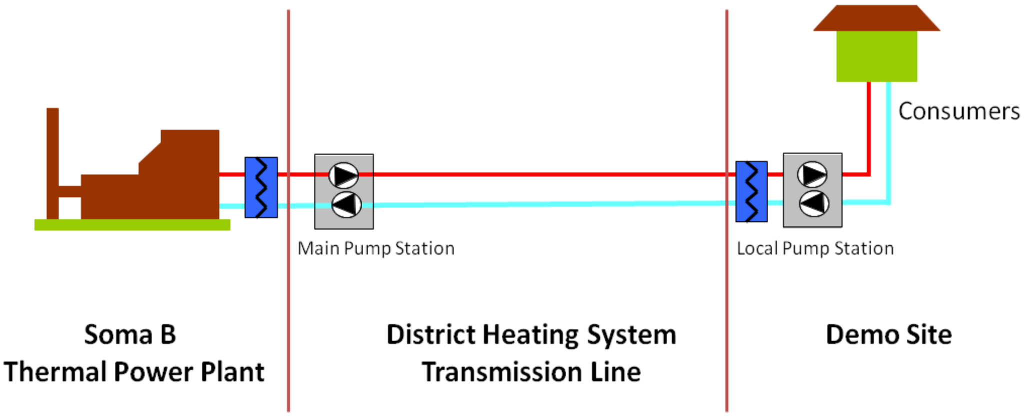


Figure 4.3: Schematic view of the new district heating system

Currently, Soma Thermal Power Plant supplies heat energy to nearly 1,500 dwelling (Figure 4.4). Heat energy that is extracted from plant cycle is delivered to dwellings via the main pump station which is located nearby the plant.

Figure 4.4: A view from Soma Thermal Power Plant heat production unit

Figure 4.5 shows new DH transmission line between the plant and the demo site and new DH distribution network in the demo site.

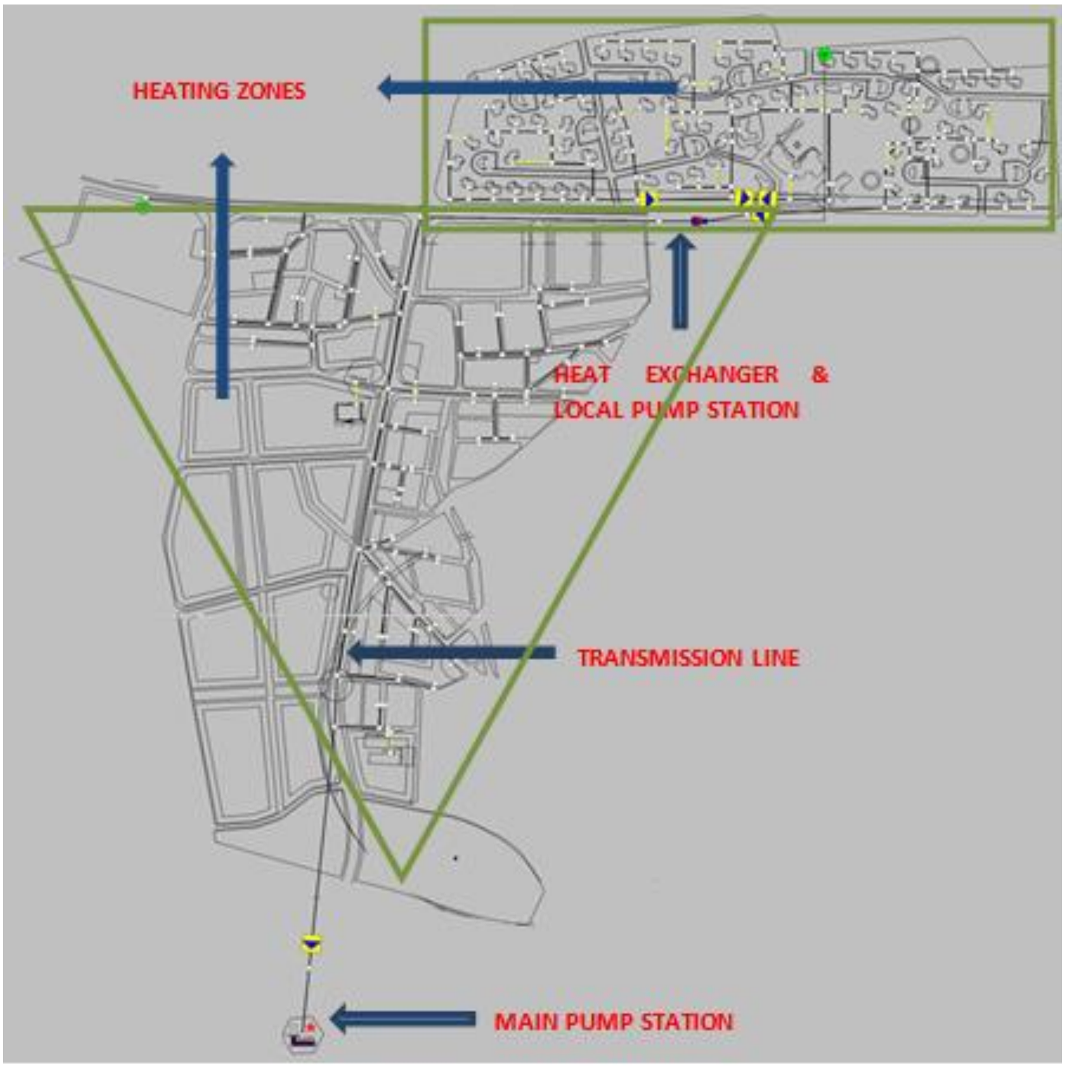


Figure 4.5: Scope of The Soma demo site application

The criteria used in new DH system design are given in Table 4.1:

Equipment/Criteria	Type/Value
Piping network type	Branching network with 2 pipe
Heat Supply Medium	Hot Water
Building Connection Type	Direct Connection
Pipe Type	Geothermal RTP Pipe over DN50 and Pre-insulated Pipe under DN50
Piping Network Position	Under The Ground
Pressure Resistance	25 bar
Supply/Return Temperatures	80°C – 60°C for the main transmission line and 70°C – 50°C for the distribution network

Equipment/Criteria	Type/Value
Maximum Velocity and Pressure Gradient (Distribution Line)	1 m/s and 100 Pa/m
Maximum Velocity and Pressure Gradient (Building Connection Line)	1 m/s and 80 Pa/m
Network Static Pressure	4.5 bar
Pump Type	Centrifugal Pump
Pump Control	Frequency Controlled
Minimum Pressure Difference in the end user	100 kPa

Table 4.1: District heating system design criteria

A transmission pipeline will be constructed for the new district heating system between the main pump station and demo site area. According to the conceptual design of DH system the total length of the transmission line pipes including both supply and return is nearly 3,500 meter and the length of all pipes including house entry branches is nearly 13,500 meters. Types and diameters of pipes starting from main pump station are as given in Table 4.2.

Pipe Dimension	Pipe Length [m]
DN25	607
DN32	1,339
DN40	2355
DN50	873
DN65	1157
DN80	1388
DN100	1818
DN125	311
DN150	48
DN200	1,219
DN300	2,193

Table 4.2: Pipe properties in demo site DH network

It was previously determined that the temperature of the water supplied from the power plant is 80°C because of RTP DH pipe mechanical properties. A new plate heat exchanger will be installed to the main pump station to ensure that operating temperature is below 80 °C in the main transmission line (Figure 4.6). A new local pump station will be constructed in the demo site area instead of current heating centre building. The new transmission line will be connected to the new local pump station with a heat exchanger between. The temperature of supply heat to the end user varies between 70°C and 60°C according to operational conditions.

Figure 4.6: Plate heat exchangers

High efficiency and frequency controlled pumps will be used in the local pump station to supply heat energy to the buildings (Figure 4.7). Heat meters will be installed into the new local pump station and energy performance of each zone will be monitored. And a heat meter will be installed for each building to observe the energy performance after renovation. A new district heating distribution network will be developed in the demo site area, from the local pump station to the buildings, by using the new developed district heating pipes.

Figure 4.7: Frequency controlled pumps

At local pump station, a plate heat exchanger and 4 pressure booster pumps are used to supply water to 4 different zones in the demo site. The specifications of pumps are given in the table below;

	Zone 1	Zone 2	Zone 3	Zone 4	Transmission Line (6 pumps)
Flow Rate [m³/h]	28.4	13.8	11.1	16.2	94.7
Head [m]	21.9	24.1	24.4	23.5	84.5
Power (kW)	3.04	1.86	1.72	1.98	30 kW
Pressure Category	PN6	PN6	PN6	PN6	PN16

Table 4.3: Pump Specifications

The plate type heat exchanger capacity is 1.74 MW, where it is optimized for the peak heat load in the demo site is 1.60 MW. Thus, heat loss/exchanger capacity yields below %1 which is a satisfactory value for energy efficiency. Hydrophore pressures at local and main pump stations are 450 and 815 kPa, respectively.

After completing the new DH pipeline construction a heat storage system will be constructed between the local pump station and the buildings to ensure security of heat supply (Figure 4.8). To achieve that, hourly based annual heat consumption within the demo site is calculated. In accordance with the daily recursive heat demand, necessary discharge power is calculated based on instantaneous peak heat load, and the heat storage tank is sized based on capacity which is an output of the longest duration of heating under coldest conditions. Heat storage discharges hot water from tank when heat demand is over daily average. Otherwise, water charges to the tank. As next step, pipe sizes at inlet and outlet of the tank is determined, and then diffusers are placed into the tank to obtain thermal stratification.

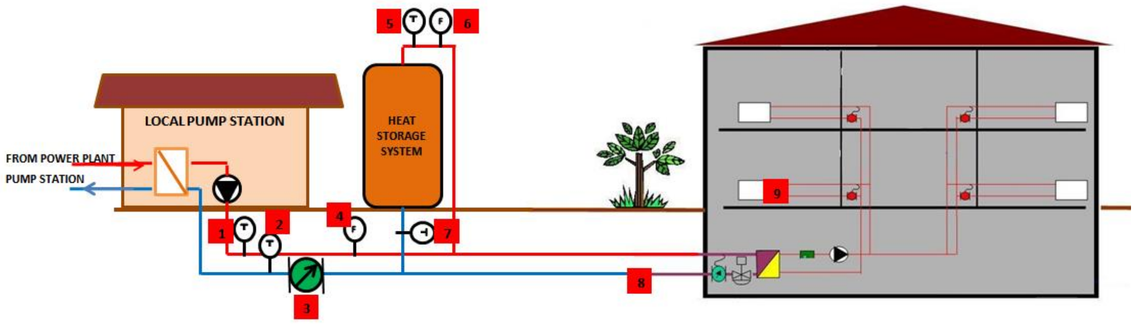


Figure 4.8: Placement schematic of thermal energy storage

4.2 Distribution of DH system

Existing pipes of the heating system are made of steel and located in channels that connect the heating network to the buildings. Isolation of the district heating system pipes is very old and timeworn and also pipes are exposed to water due to leaking joints. For those reasons it is estimated that the significant loss of heat from the pipes occurs [1].

In new piping system, according to R&D studies by MIR, distribution line will be renewed and transmission line will be designed and implemented. Pipes will be made of reinforced thermoplastic pipe (RTP) which has three layers: inner plastic pipe layer, middle reinforcement layer, and outer protective layer. Inner and outer layers are made of thermoplastic materials, and middle layer comprises of continuous fibre reinforced materials. RTP has to be manufactured by various thermoplastic materials - having varying thermal working limits – according to the working temperature at the final application.

RTP pipe

Showing resistance to heat and pressure of liquids, RTP Pipes are thermoplastic composite pipes for liquid transfer. While continuous fibre glass in the middle layer provides resistance against heat and pressure; protection for the continuous fibre glass layer, operating capability for the composite structure, high chemical resistance, convenience for assembling etc. features are gained with the thermoplastic layers on and under the fibre glass layer.

Polyurethane (Isolation Layer)

By means of the polyurethane layer in the middle of the geothermal pipe system, minimum heat loss (for heating systems) or gain (for cooling systems) is ensured while liquid transfer. Nevertheless, isolation layer can be constituted from rock wool, glass wool or other different materials based on project requirements. In Geothermal Pipe System, depending on customer needs special pipes with thicker isolation layers, rather than with standard thickness, can also be produced.

Casing pipe (HDPE)

The casing pipe is a protection layer made of polyethylene in order to keep the isolation material and the transporter (service) pipe away from ground water, humidity and mechanical damages.

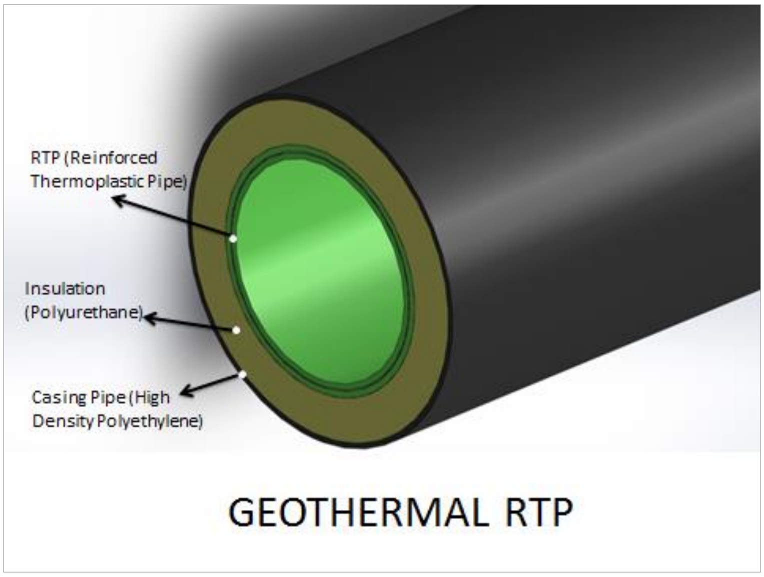


Figure 4.9: Schematic View of Geothermal RTP

RTP pipe features: technical features of PPR raw material

The thermoplastic raw material used in RTP Pipes can be chosen from different polymers (PPR, PPh, HDPE, PERT etc.) based on the project requirements. For Polypropylene Random (PPR) Copolymer, the features below have to be provided.

- **Standard**: TS EN ISO 15874-2.
- **MRS (the desired lowest resistance) value**: 8 MPa, at minimum
- **Additives:** no additives except antioxidants, UV-stabilizer and colorants
- **Density:** approximately ≥ 900 ± 5 kg/m3 when tested according to TS EN ISO 1183-1
- **MFR (Melting Flow Rate):** ≤ 0.5 g/10 min. when tested according to ISO 1133 (2.16 kg, 230°C)
- **Change ratio between MFR values:** ≤ 30% between the sample taken from the raw material and the RTP Pipe made of it
- **Colour:** Green, grey etc. If UV protection is required, they can be produced with UV resistance.
- **Diameters and Wall Thickness:** min. 90 mm - max. 315 mm
- **Length:** between 4 - 13.5 m (based on project needs). RTP Pipes can be produced for coiling up to 125 mm and coil length for this type is 200 m.
- **Pressure Resistance:** between PN15-PN200 (bars)
- **Heat Resistance:** heat resistance for RTP pipes is shown in the table below. Pressure resistance of RTP pipes decreases by heat increase.

Inner diameter	Weight	Pressure Class (PN) 20˚C, 20 years	Pressure Class (PN) 40˚C, 20 years	Pressure Class (PN) 60˚C, 10 years	Pressure Class (PN) 75˚C, 10 years	Pressure Class (PN) 95˚C, 5 years
70	2,62	50,0	36,5	25,0	18,0	10,0
68	3,00	100,0	73,0	50,0	36,0	20,0
67	3,37	150,0	109,5	75,0	54,0	30,0
65	3,75	200,0	146,0	72,0	72,0	40,0

Table 4.4: Properties for 90mm outside diameter pipe

In the R&D studies, RTPs and the production method of them will be developed. R&D studies for thermoplastic materials will be done in D2.26 “Report on eliminating disadvantages of conventional distribution systems”.

Waste Heat Recovery of SEAŞ thermal Power Plant

After the tendering process, the final design and calculations of the system will be conducted. According to the final design and specifications of the district heating component, manufacturing activities will start. Moreover, the district heating components will be manufactured and the implementation activities will take place. However there are many parameters that affect the plan of the implementation like shipping, civil works, connection of the pipes, insulation, etc. will take at least four months.

Once all the implementation activities finished, testing and commissioning activities will take place. Pressure, heat load and connection quality tests will be evaluated. The same activities will be done for the transmission line. After tendering processes of the distribution system finished, transmission line issues will start. After all the tendering processes of district heating finishes, design, calculation, manufacture, commissioning will be conducted in parallel.

5 Smart grid interventions and ICT

The energy monitoring is the first step towards building energy management. It creates an understanding of energy usage patterns and may reveal underlying issues that are often neglected by users, contributes to improve energy efficiency and reduce energy costs. The energy monitoring system is composed of several devices for monitoring and data acquisition that are listed below:

- Temperature sensors;
- Humidity sensors;
- Light sensors;
- Solar radiation sensors;
- Pressure sensors;
- Heat flow sensors;
- Reliable occupancy sensors.

Smart grid interventions give the clear picture of energy flow around the demo site. It will cover the real-time consumption measures of electricity and hot water from main lines to individual dwellings. The main goals are;

- Monitoring energy usage in real-time,
- Measurement and Verification of the ECMs according to the IPMVP
- Dynamic performance analysis of each dwelling,
- Fault and leakage detection and diagnostics
- Hourly, daily and weekly consumption forecasts
- Creating behavioural energy saving
- Sub-metering, condition monitoring and basic control on pilot 10 dwellings
- Alarm management according to the energy usage
- Monitoring PV generation
- Financial analysis on energy flow

Turkish demo site smart grid interventions will cover electricity consumption, heating usage by district heating system, indoor comfort and PV production. There are 4 different residential building types and 3 different building for public use. Each building has own design for smart grid interventions. Also, there several selected buildings as a sample to apply appliance-level monitoring and control.

The expectation from the selected samples, main concept will cover real-time electricity, heating consumption and indoor comfort parameters (temperature, humidity and illumination) of each dwelling where real-time means 15 minutes time intervals then using these data for creating awareness on tenants, behavioural change to increase energy efficient usage, real-time alarm management, neighbourhood benchmarks and ECMs saving verification according to the IPMVP methods. Multi-channel energy meters for electricity consumption measurement, hot water meters (calorimeters) for heating measurement, and wireless (RF based) indoor air quality sensors for indoor comfort measurements will be used for building-wide measurements. In addition to these, Modbus-to-GPRS, Modbus-to-Ethernet, M-Bus-to-Ethernet converters will be used for data transfer from end-devices to analytics server as an encrypted data package.

For the selected 5 buildings (3 duplex, 1 two-storey 1 three-storey) with 13 dwellings, in addition to the standard application above, we will apply plug-level (appliances level) monitoring and control. We will analyse these characteristics, take them as a sample for whole site and distribute these data for other dwellings according to the some specific properties that effect energy consumption directly. The control part gives us a sample application of whole smart grid implementation from electricity control to heating control.

In the end, the main aim will be to analyse behavioural patterns of building users and create behavioural savings on energy consumption.

For the other 3 buildings including 2 guesthouses and 1 conference building, we will apply system-level (lighting, plug-loads, heating, cooling, air conditioning, elevators, generators, UPS and zone level) monitoring. To create public awareness, we also apply LCD dashboard and touch screen kiosk in these public areas. Beside, local outdoor lighting will also be monitored from the main distribution panels to cover whole demo site in one smart grid platform.

Within the project, PV system will be monitored at inverter-level and compared with consumption. These measurements will be used for technical analysis, energy forecast and consumption optimization according to the pricing levels and financial analysis for past and future. All real-time data will be monitored via web browsers, mobile devices and on-site screens. Equipment, sensors and other device that will be used within the project are given below with specifications.

Equipment Visual	Type	Function	Technical Specification
	Multi-Channel Energy Meter	To Measure Electricity Consumption of Each Dwelling in a Phase Level	1. Active, Inductive and Capacitive Energy and Power measurement in real-time 2. Power Quality Parameters (Voltage, Current, Power Factor) 3. RS485 Modbus communication capability 4. Capable to use http – push method for data transfer 5. Computer based configuration 6. LCD screen to see instant measurement 7. At least 12 single phase channel which can read 3 phase as well 8. Integrated Ethernet gateway 9. Split-core CT for different level of current ratings 10. Integrated memory at least 100Mb to cover data loss
	Hot Water Meter	To Measure Hot Water (heating) Consumption of Each Dwelling	1. Water temperature and flow rate measurement in real-time 2. M-bus communication capability 3. If possible, integrated memory for data storage
	Gateway for Data Conversion and Transfer to WAN	To Gather Data from End Points/Sensors in Building	1. Capable to gather data both from energy meters and water meters in two-way 2. Sending output via GPRS or Local network concentrator 3. Capable to get data at least 24 devices
	Indoor Air Quality Sensor	To Measure the Air Quality in Dwellings	1. Temperature, Humidity, Noise, and Illumination measurement 2. Wireless data transfer in local area and push data to WAN via concentrator 3. Memory for storing the data with at least 100Mb capacity
	Plug Load Monitoring and Control	To Measure Plug Loads and Remote Control Consumption	1. Measure consumption 2. Wireless data gathering infrastructure 3. Remote on/off control capability
	Touch Screen Kiosk	To Create Awareness and Publish Energy Measurements over Saving	1. Capable to multi-touch 2. At least 41’ screen size 3. At least Windows XP 4-core processor with 2.5Ghz
	Electricity Panel for Equipment	To Install all Measurement and Communication Devices in a Well-designed Format	1. At least IP56 protection level 2. Lockable, metal format with warning signals 3. Well-designed equipment placement

Table 5.1: Specifications of equipment, sensors and other devices

On the demo site buildings are grouped in a spiral format including 6-10 buildings. Each group has its own electricity distribution box for whole building feed and outdoor lighting nearby. These distribution boxes are also measured with same meters to create hierarchical smart grid infrastructure. For the one upper level, it is also planned to make transformer level monitoring because demo site consist of 4 transformers.

On the software side, we are forming a secure data acquisition layer, which is directly connected to the end-devices and gathers data. Then, all these data logged in a database capable for real-time time series big data analytics in a NoSQL type. Data analytics infrastructure will use Machine Learning algorithms in analytics engine.

For the communication infrastructure, it will be decided later on because SEAS has not decided to use fibre cabling for whole site or not. If there is a possibility of fibre connection in each building we will use this infrastructure for more reliable data transfer. If there is no fibre implementation on site, we are planning to use RF for local network in a separated model according to the distances and then use GPRS for WAN integration.

Typical installation/connection diagram will be as follows:

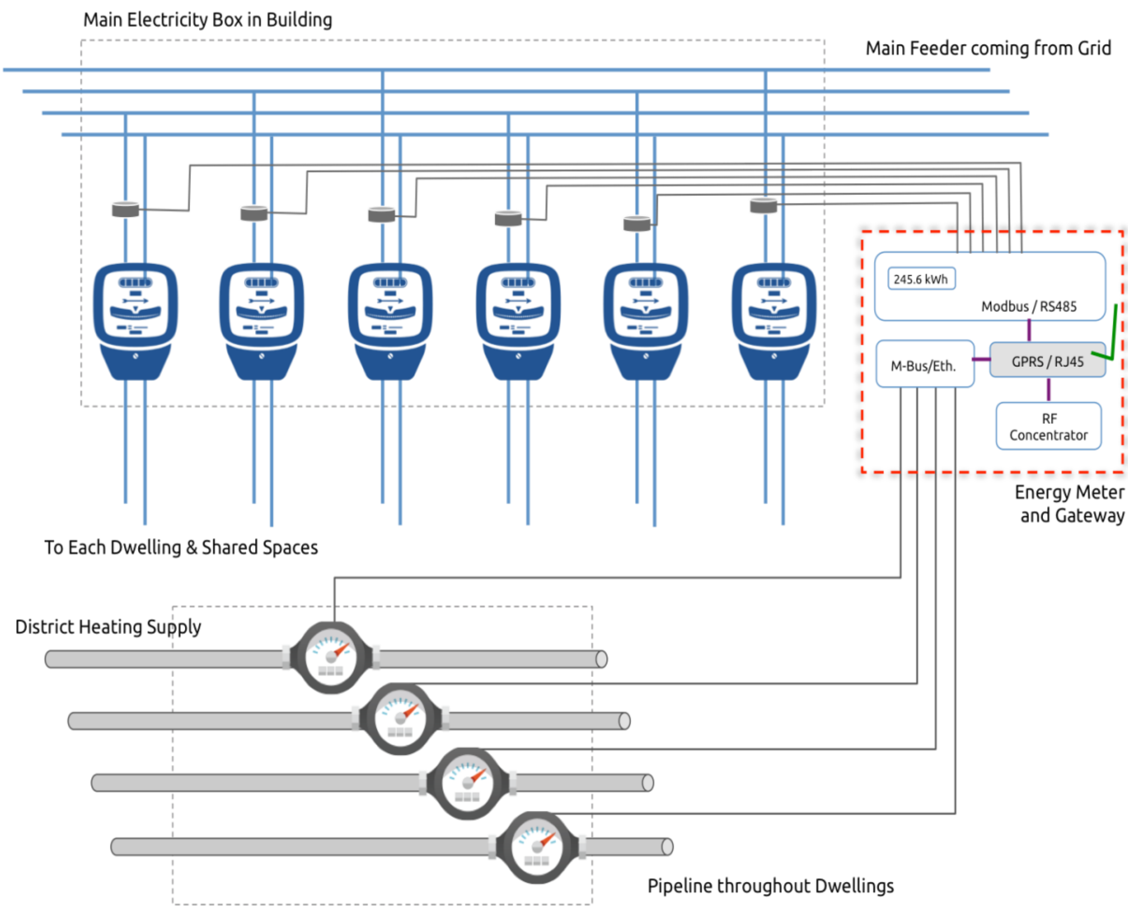


Figure 5.1: Typical installation, connection diagram

6 Green building certification

The demo site will be assessed under the BREEAM International New Construction 2013 [12] scheme. There is a client aspiration for the building to achieve a minimum BREEAM rating of “Good”.

A full Pre-Assessment was carried out, by the registered BREEAM International Assessors of DEM, on the current outline scheme to identify the changes required in specifications or designs required to achieve BREEAM certification at “Good” level. The pre-assessment report also includes details of why the project achieves certain credits and not others.

The residential units were assessed under the residential criteria. It is considered that the benefit of carrying out a fully certified assessment on single’s lodging, guest house and convention centre buildings is limited. This is due to their small size in comparison to the rest of the complex, and to the fact that construction has been substantially completed.

It is recommended to give consideration to carrying out a non-certified sustainability review on these units as an alternative approach, with full certification on the residential units. This would result in a report containing recommendations as to how the team can incorporate the highest standards of sustainability into the elements within the scope of the project based on the BREEAM targets (Building user guide, collection of recyclables, etc.). These strategies and recommendations can also be audited and reported.

Following the Review Meeting, it has been established that the Turkish demo site is currently expected to score 53.93%, which equates to a BREEAM rating of “Good”.

This BREEAM score is mainly due to the energy efficient retrofitting which enables the project to score high levels in the energy section of the assessment. Out of 23 possible points, 17 points can be targeted, which equals to 73.91% of this section. Also, the commissioning activities planned to be carried out at the completion of the project will help to achieve management points. With additional sustainable strategies such as bicycle paths, water use reduction, sustainable landscape design, collection of recyclables, reduction of pollutants etc. the project can achieve the “Good” rating.

A preliminary cost study was carried out to identify the required budget for these additional activities which are not included in the scope of CITyFiED. The results of the pre-assessment are based on several meetings held at the demo site and the summary of the results can be seen in the following table.

Overall building performance	
Building name	SOMA DEMO
Indicative BREEAM rating	Good
Indicative total score	53.93%
Min. standard level achieved	Very good

Table 6.1: BREEAM pre-assessment overall results

Environmental section	Nº credits available	Indicative Nº credits achieved	% credits achieved	Section weighting (user entry)	Section weighting (default)	Section weighting	Section score
Management	23	11	47.83%	-	12.00%	12.00%	5.74%
Health & Wellbeing	17	7	41.18%	-	14.00%	15.00%	6.18%
Health & Wellbeing - Hazards	0	0	0.00%	-	1.00%		
Energy	23	17	73.91%	-	19.00%	19.00%	14.04%
Transport	9	8	88.89%	-	8.00%	8.00%	7.11%
Water	7	5	71.43%	-	6.00%	6.00%	4.29%
Materials	11	0	0.00%	-	12.50%	12.50%	0.00%
Waste	6	4	66.67%	-	7.50%	7.50%	5.00%
Land use & Ecology	12	7	58.33%	-	10.00%	10.00%	5.83%
Pollution	7	3	42.86%	-	6.40%	10.00%	2.74%
Pollution – Surface water run-off	5	0	0.00%	-	3.60%		
Innovation	10	3	30.00%	10.00%	10.00%	10.00%	3.00%

Table 6.2: BREEAM pre-assessment environmental results

7 Public and private procurement processes

7.1 End-users acceptance

Energy related retrofitting and system changes are part of a wholescale retrofitting project consisting of such renovation in the dwellings like kitchens, bathrooms, electricity system changes and flooring. Due to almost 75% occupancy in the demosite, the construction activity has had to carefully time the interventions to cause minimum disruption to habitants. The tenants empty their appartments and move to empty ones.

The end users of the demo site are the personnel of SEAŞ. SEAŞ is charging the utility bills to the personnel and pay their salaries after reducing the energy bills. Thus the decrease in energy costs has an important impact in the tenants' acceptance of the renovations.

Since the beginning of the project, measuring end user acceptance has been a delicate issue. After the CITyFiED project was approved by the European Commission (EC), SEAŞ power plant was included in the scope of privatization by the Turkish government announced with the decision of the Higher Commission of the Privatization Agency on 7th August 2014 and published on the Official Gazette in 20 August 2014 [13]. There are two plants in SEAŞ thermal power plant, Soma-A and Soma-B Thermal power plants. The Privatization Agency's decision excludes the Soma-A Plant, which remains a public facility fundamentally engaged in research and development as well as the properties that are used by Soma-A plant which includes the lodgings on the demo site. The demo site buildings still belong to SEAŞ (which will become an entity of Elektrik Üretim A.Ş. (EÜAŞ) and publicly owned. The demo site will be heated using the waste heat from the power plant and the personnel will continue to live in the dwellings.

The numbers employed by SEAŞ will be considerably reduced after privatization. Some of the elderly personnel have retired and there are uncertainties surrounding the employment prospects of many. The project team was unable to conduct studies regarding user acceptance due to these present difficulties until a first stakeholder meeting was held on the 27th of February 2015, in the convention centre at the demo site. SEAŞ management, Manisa Municipality and the project team explained the project to the tenants and answered any questions they had in mind.

Most of the tenants expressed their positive feelings about the district heating system and use of waste heat of the plant. They are also aware that with the interventions their utility bills will be lower than before without their financial contribution.

Unfortunately, the local circumstances, confusion about the future of employment in the company makes it untenable presently to conduct a questionnaire about the energy consumption habits or other social information. SEAŞ management will conduct the questionnaire within the coming months and the results will be added to other deliverables.

As part of the BREEAM Green Building Certification a non technical user guide will be developped and distributed to the tenants aiming to recognise and encourage the provision of guidance for building users. They can understand and operate the building efficienctly. The user guide will contain the following information.

- Building Services Information
- Emergency Information
- Energy & Environmental Strategy
- Water Use
- Transport Facilities
- Materials & Waste Policy
- Re-fit/Re-arrangement Considerations
- Reporting Provision
- Training
- Links & References
- General

7.2 Licences and permits

There are different permits and licenses to be obtained for each intervention. SEAŞ as a public company being one of the key players in the industry is the owner of the demo site. Having only one owner at the demo site accelerates the decision making process.

7.2.1 Buildings retrofitting

The building retrofitting is being based on the strategies mentioned above, in section 3 “Building retrofitting technical solutions”, which are developed to improve the buildings' energy performance. Consequently, the specific codes and standards are applied as they were given in detail in D4.2 "Technical definition of the Turkish demo site (Soma, Turkey)".

Licencing

Building Code Law No: 3194 [14] dated 1985 indicate when a building permit is required to modify a building. In accordance with clause 21 any change related with a licenced premise is to be re-certified. There are some exceptions to this clause;

- If the gross area of independent parts and the nature of the building does not change.
- If the changes cannot be seen from outside like painting the walls, changing the tile and parquet of the floor, small changes in electrical and plumbing.
- If the changes does not affect the structure of the building.
- If the changes does not affect the carriers such as beams is not subject to licencing.

The owner of the building should apply to the Municipality for a consent showing the project of the modifications planned in the building. The Building Control Department of the Municipality will ask the project owner to show studies on 4 topics and may ask for additional information like performance tests, new design of the project if not satisfied;

- Earthquake resistance
- Cadastral extract
- Fire resistance
- Insulation

The licensing and permits of building modification controls are highly dependent on the local government's capacity.

According to Regulation on Energy Performance of Buildings dated December 2008, all existing buildings should have an Energy Performance Certificate by the end of 2017 [12]. In the Soma Demo site, this legal requirement will be met through actions carried out during the project.

Budget

As a public company, SEAŞ needs its investment budget to be approved by the Ministry of Energy and Natural Resources due to government regulations. The demo site has been going through deep retrofits during the last year not just for energy related issues but comfort related issues such as renovation of kitchens, bathrooms, the floorings, etc. SEAŞ has been reporting the CITyFiED related expenses to the Ministry.

The public tendering process needs to be concluded in order that work can start retrofitting the demo site. After this period, implementations will be done as described in section 3 "Building retrofitting technical solutions".

7.2.2 District heating renovation

Regarding pipes and fittings, costs of setting up a new production line for new piping systems are high; there is no possibility to buy the equipment. Instead of setting up new pilot production line, MIR would prefer operational leasing (renting) option. MIR will make production of District Heating system that will be developed by means of the R&D activities to be conducted within the project. A subcontractor will make production line and labour available for the production activities of pipe and fittings. Supervision activities will be done by MIR.

There are no licensing problems for the district heating system installation. Construction of the new transmission line is the responsibility for Manisa Metropolitan Municipality. SEAŞ, which is the owner of the demo site, will be applying to Manisa Metropolitan Municipality for connecting the district heating system.

The tendering process needs to be concluded in order to start working on district heating in the demo site. After this period, implementations will be carried out as described in section 4 “District heating system renovation strategies”.

7.2.3 Electrical generation

Licensing for power generating facilities and permits for grid connection differ greatly from country to country and even from region to region. Licensing may be required for plants over a certain capacity. In the case of licensing for power production, a whole set of rules may apply even including measurements regarding resource availability. It is very important to know local rules in detail, as in some cases specific restrictions may apply.

As a rule, a license must be obtained to perform energy market activities in Turkey. However, the new Electricity Market Law No. 6446 [15] (“Electricity Market Law”) sets forth certain exemptions for the license requirement in generation activities. Although the legal basis for license exempt generation activities was set forth in 2007, the scope of the exemption has been considerably increased in 2013 as explained below.

Pursuant to Article 14 of the Electricity Market Law, among others, generation facilities based on renewable energy resources with a maximum installed capacity of 1 MW are exempted from the requirement to obtain a license from the Energy Market Regulatory Authority (EMRA). The Council of Ministers has the authority to increase this 1 MW installed capacity limit to 5 MW; however, the Council of Ministers has not increased that limit yet.

On the other hand, onsite power generation is often regarded as for self- consumption, in which case a completely different set of rules and regulations may apply. Foremost, among these will be siting requirements, grid connection permits regarding grid quality and capacity analysis for the local grid. In the case of rooftop PV, structural requirements may result in a permitting process.

Pursuant to the License Exempt Generation Regulation2 and the Communiqué Concerning the Implementation of License Exempt Electricity Generation Regulation3, unlike the licensed electricity generation, there is no company formation requirement for license exempt electricity generation.

The same legal entity can operate more than one power plant without the need for establishing a separate special purpose vehicle (SPV) for each project, on the condition that;

- Each of such projects’ installed capacity cannot exceed 1 MW; and
- Each license exempt generation facility must be connected to a consumption unit (there is no minimum consumption amount requirement for the consumption units).

Connection Application

Under the “Unlicensed Electrical Power Production Market Regulation” [16] real or legal persons willing to produce electrical energy based on resources other than hydraulic resources apply directly to the Relevant Network Operator with Production With No Licence Connection

Application Form [17], Addendum 1 by attaching the following required information and documents to connection and system usage. Following must be presented during the applications;

- Land record, lease contract or document providing the usage rights for the location of the production facility.
- Facility total efficiency document of cogeneration facilities.
- Except production facilities based on biomass and gas from biomass (including landfill gas), wind and solar energy; a document showing the right to use renewable energy resources is obtained.
- The application fee document or receipt showing deposit is made to Network Operator's account.
- Single Line Diagram showing the technical specifications of the facility to be established.

Evaluation and finalization of the connection application

Applications will be evaluated within the first 20 days of the following month by the Relevant Network Operator.

Connection and System Usage

Under the Regulation general provisions of connection and system usage contracts signed with producers to be connected with Network shall be defined by taking Relevant Network Operator's opinion into consideration.

7.2.4 Smart grid interventions and ICT

In the implementation road map, independent power meters are planned for any measurement, which have no regulatory limitation. However, in order to increase the capability and efficiency of the infrastructure also the existing electricity meters will be used, which is sealed by electricity Distributor Company. In this way, the infrastructure will be suitable of legal remote metering called "OSOS" and specific reporting for that procedure will be provided. There are also specified data transfer protocols for communication part and some critical certification for the meter like CE, ISO etc., which should be followed.

From site assessment to commissioning, each step has to be led by an expert in order to create correct system planning and efficient process.

- **Before Installation:** after first walk through audit and gathering all site info by electrical and mechanical engineers, all the system diagrams were analysed to find data points and design end points and network structure. Each building has different amount of metering point so the selection of the metering equipment will be done accordingly then it affects the installation period and man-day values. Equipment models, providers and their shipment schedules will be organized considering the installation team and their needs.

- **During Installation:** all process will be implemented according to the system design and controlled by the field engineers. Each building need different amount of technician, equipment and time for installation, however every step has its own diagrams and checklists in order to decrease the risk of failure. Network controls and data transfer are another crucial point of installation. Ethernet and wireless communication will be used in a complimentary way. Hardware and software configurations and measurement comparison tests will be done.
- **After Installation:** each data point and equipment will be controlled according to field and database operation. Black-box and white-box testing, performance testing will be held on software side.

7.2.5 Green building certification

The BREEAM International 2013 scheme can be used to assess the environmental impacts arising as a result of an extensive range of building types and subtypes at the following stages:

- Design and Procurement Stage – leading to an Interim BREEAM Certificate.
- Post-Construction Stage – leading to a BREEAM Constructed Rating.

Design Stage

The Design and Procurement Stage Assessment and interim certified BREEAM rating confirms the building’s performance at the design stage of the life cycle. The certified BREEAM rating at this stage is an interim assessment based on the design and commitments made at this stage.

To complete an interim assessment the design must be advanced to a point where the relevant documented information is available to enable the BREEAM Assessor to evaluate and verify the building’s performance against the criteria defined on the scheme document. For the Demo site the Interim Design Stage Assessment can be completed after the detailed design of the energy efficient implementations and Ecologist’s reports are complete.

Post-Construction Stage

The Post-Construction Stage Assessment and BREEAM rating confirms the final “as constructed” performance of the building. A final Post-Construction Stage Assessment will be carried out after substantial completion of the building works and commissioning activities.

All certification is issued by the BRE based on the assessor’s analysis of evidence supplied by the project team. The assessor will recommend the points for acceptance to the BRE who may take an alternative view on the information provided, therefore, the assessor cannot guarantee the points will be achieved.

7.3 Selection of equipment and installers

Building retrofitting, solar thermal collectors, BIPV installations and heat distribution within the demo site construction procurements will be conducted by SEAŞ. Since SEAŞ is a publicly owned institution the "Public Procurement Law" No: 4734, dated 4 January 2002 [18], controlled by the Public Procurement Authority will apply. The Law can be summarized as follows.

Government procurement in Turkey is generally conducted through the issue of public tenders. Five main procurement procedures are applied in Turkey: (i) closed and sealed envelopes, (ii) selective limited tendering, (iii) public bidding, (iv) negotiated procurement and (v) direct competition procedure.

Closed and sealed envelope tendering is normally followed, but other procedures are used according to the value of procurement and/or the type of procurement Table 7.1. In the case of selective tendering, a company may be included in the pre-approved vendor list by developing a reputation as a quality, reliable and experienced supplier. Certain construction work up to TL 16 billion may be procured by the concerned Ministry using the so-called "force account commission" procedure [19] Table 7.1. The law provides an escape clause from the normal procurement procedures. According to Article 89, contracts may be awarded without competition if agencies are authorized by the Council of Ministers. Data are not available on the amount of procurement by procedure.

Procurement Procedure from "Public Procurement Law" No: 4734, dated 4 January 2002		
Method	Procedure	Instances when the method is applied
1. Closed and sealed envelopes (Article 36)	Written (closed and sealed envelopes)	Procedure normally followed
2. Selective limited tendering (Article 44)	Written (closed and sealed envelopes) offers from at least three candidates	Procurement of aircraft, warships, war ammunition, electronic equipment, military installations and supplies, weapon and supply systems, activities concerning defence industry, dams, power stations, irrigation systems, harbours, docks, airfields, railways, locomotives, highways, tunnels, bridges, fuel storage facilities, construction work of peculiar nature, works of art having esthetic and technical characteristics, plans for the city road nets, city maps, master and housing plans, water and sewerage systems and energy facilities
3. Public bidding (Article 45)	Oral offers'	Contracts up to TL 40 billion (or US$1.02 million in February 1998)
4. Negotiated procedure (Article 43, 49 and 51)	Oral offers from at least one candidate	Contracts up to TL 2.5 billion (or US$0.1 million in February 1998) or If closed and sealed envelopes procedure or selective tendering or public bidding fail; or for police or army requirements, urgent or secret works and a few other special instances (as defined in Article 51)

Procurement Procedure from "Public Procurement Law" No: 4734, dated 4 January 2002		
Method	Procedure	Instances when the method is applied
5. Direct competition procedure (Article 52)	Negotiation	Supervision of study, planning and project works, and works related to fine arts
6. Force account commission (Article 81 (a))	Written (closed and sealed envelopes)	Construction contracts for less than TL 16 billion. Laying ballast in railway construction and road construction materials; telegraph, telephone, and power transmission line construction; and certain construction work related to development of villages and military garrisons, or secret construction work, and a few other construction related works
7. Works for peculiar nature (Article 89)	Case-by-case procedure	When it is not possible to enforce the provisions of the law, the provisions may be disregarded by the Council of Ministers upon the proposal by the Ministry concerned. The procedures and rules are determined by the concerned administration and become final on approval of the Ministry concerned

Table 7.1: Key features of Turkey's procedures on government procurement

In general, the criteria followed in the award of tenders is that of the most attractive bid in terms of price, although the quality of equipment, services, delivery schedule, availability of spare parts and after-sale service, and previous experience with the suppliers all influence the decision. The availability of supplier credit may determine bid awards for some major procurement schemes. All credit offers must be screened by the under Secretariat of Treasury, which has responsibility for final credit decisions.

The authority that issues the invitation to tender is required to publish details about the award (such as whom the contract was awarded to, the nature of the work, value of the contract) in the Official Gazette. Parties may lodge complaints against the award of a contract with the issuing authority. However, if the issuing authority does not accept the complaint the complainant cannot lodge an appeal with the courts.

Since 2010 there is an internet portal called Electronic Public Procurement Platform (EKAP) [20] where tenders are more transparent and registered institutions can access to all the tenders around Turkey. SEAŞ uses the EKAP system, also provides information about the tenders from SEAŞ official web site <http://www.seas.gov.tr/> and EÜAŞ's web site <http://www.euas.gov.tr]. For tenders around 70 k € the call should be published for at least 7 days, for tenders around 560 k€ it should be published for 14 days.

7.3.1 Buildings retrofitting

Thermal insulation

The 5 cm thickness EPS (expanded polystyrene) foam will be carried out to the external walls and also the different insulation materials will be placed to the roof and ground floor to reduce heat losses. The details of these applications are given on deliverable D4.2 "Technical definition of the Turkish demo site (Soma, Turkey)". The equipment and the implementers for the insulation will be according to the given specifications.

0. Brick wall
1. Adhesives
2. Thermal Insulations (EPS foam)
3. Mechanical Fixing
4. Reinforced Layer: with glass fibre mesh
5. Primer Coat
6. Finishing Coat

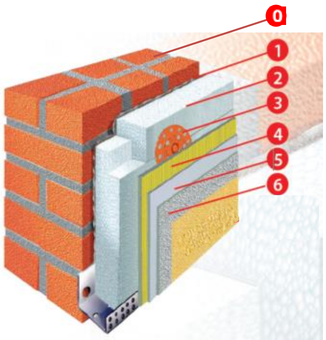


Figure 7.1: Section view of the insulation system

Figure 7.2: EPS foam implementation in Soma demo site

External Wall Insulation System	
Insulation Material	Expanded polystyrene
Insulation Thickness	5 cm
Thermal Conductivity	0,031 W/mK
U-value	0,42 W/m^{2}K

Table 7.2: Properties of the external wall insulation system

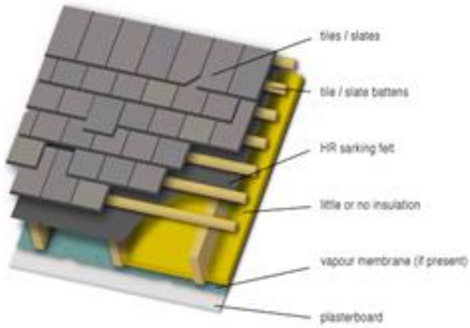


Figure 7.3: Roof section

Tiled Pitched Roof	
Insulation Material	Glass wool
Insulation Thickness	18 cm
Thermal Conductivity	0,035 W/mK
U-value	0,20 W/m^{2}K

Table 7.3: Properties of the roof insulation system

Installation of low temperature heating system

The panel system to be developed in D2.27 "Report on new efficient heating and cooling systems to improve the efficiency of energy generation systems" will be designed by MIR. Selection of the equipment and so on will be constituted as respect to the studies in D2.27. Also MIR will prepare the specifications about this system. After tendering process, supervision process will be completed by MIR.

For first two blocks, the calculations are made: sanitary systems drawn in 2D CAD program. After tendering process, production step comes to the point. The figure of the low temperature heating system equipment is given in the section 3 “Building retrofitting technical solutions”. The low temperature heating system equipment’s properties must meet the following details;

Definition	Properties
Material	Plaster, PEX pipe, EPS/XPS/Rock wool and glue
Plaster	Reinforced plaster plate
Thickness of plaster plate	15 mm
Thickness of insulation material	30 mm
Max. pressure value	6 bar
Temperature conditioning range	15-40 C
Fire safety	TS EN 13501-1, B-s1, d0
Pipe material	PEX pipe with oxygen barrier
Outer diameter	10 mm
Inner diameter	8 mm
Distance between pipes	55-75 mm

Table 7.4: LTHS panel properties

RTP Pipe Features

The thermoplastic raw material used in RTP Pipes can be chosen from different polymers (PPR, PPh, HDPE, PERT etc.) based on the project requirements. The pipes to be implemented on demo-site will consist of high density polyethylene. The properties are as follows;

Definition	Properties
Material	HDPE100
Density	>944 kg/m3
Colour	Black (Carbon black)>2.5% by mass (±0.5)
Elongation at break	>350%
Melting flow rate (MFR)	0.2≤MRF≤1.4 g/10min
Thermal stability	>20 minutes

Table 7.5: Casing pipe properties

Definition	Properties
Material	Rigid polyurethane foam
Average cell size	< 0.5 mm
Closed cell	> 88%
High temperature water adsorption	< 10% (according to TS EN 253)
Compressive strength	> 0.3 N/mm2
Axial shearing strength	> 0.12 N/mm2
Insulation life according to continuous service temperature	30 years in 120 C
Density	> 60 kg/m3

Table 7.6: Polyurethane properties

Pipe Dimension	Definition	Pressure Class
DN25	Ppr	PN20
DN32	Ppr	PN20
DN40	Ppr	PN20
DN50	Ppr	PN20
DN65	Ppr	PN20
DN80	Ppr	PN20
DN100	RTP	PN20
DN125	RTP	PN20
DN150	RTP	PN20
DN200	RTP	PN20
DN300	RTP	PN20

Table 7.7: Pipe properties

Installation of solar thermal systems

The solar thermal panels were installed and meet the hot water needs of the each dwelling partially.

Solar Thermal System Equipment (Number of Panels : 390)	
Vacuum Tube	Number : 24 Size: 47 x 1800 mm Frost Resistance: -25 ^{o}C Material : Selective copper surface
Boiler (Tank)	Number : 390 Hot water capacity : 150 lt Operating pressure resistance : Min 6 bar Internal Trunk: 2,5 mm Internal Bulge: 3 mm Outer body: 1 mm stainless steel with 50 mm polyurethane foam insulation
Expansion Tank	Number : 390 Material : Stainless metal sheet Volume : 5 lt

Table 7.8: Technical parameters of solar thermal system in Soma demo site

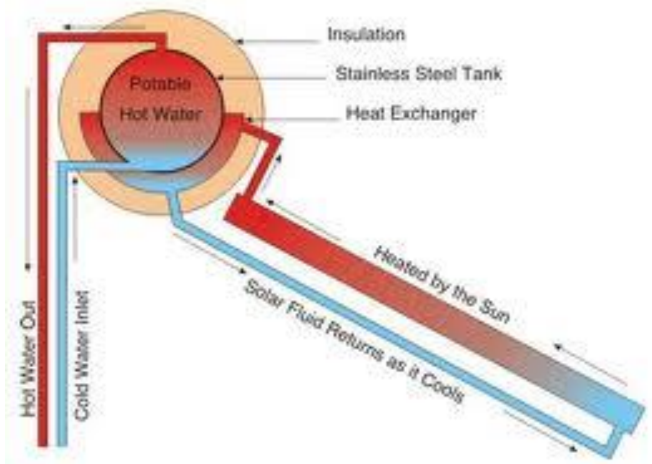


Figure 7.4: The view of established solar thermal panels in Soma demo site

Installation of solar photovoltaic systems

The solar photovoltaic systems will be installed on the roofs of the guesthouses and the convention centre to generate power.

Figure 7.5: Representative view of the PVs

Solar Photovoltaic System	
Size	1345 × 990 × 50 mm
Power	230 W

Table 7.9: Technical properties of the PVs

The public Turkish Electricity Distribution Company/Authority (TEDAŞ) has produced "type documents" for the selection and tendering of turn-key PV systems following the completion of the legislative framework pertaining to non-licensed PV system installations in Turkey. The legislative status of > 1 MWp solar PV power systems are completely different from those below this threshold where the former systems are required to go through licensing procedures. The type document [13] describes thoroughly the technical and legal requirements and the rules and procedures for the selection of technologies and vendors, installers and maintenance. Although the document has been written with < 30 kWp systems in mind, the major requirements fulfil all non-licensed installations. Briefly, the type tender gives details on:

- The design of the system as a whole and selection of all its components including
  - *DC system: PV panel and BOS elements etc.*
  - *Grounding*
  - *AC system*
- System performance
- Installation and field work
- Structural requirements from the building
- The sub-structure, carrying system of the PV system, its design characteristics and construction
- Labelling of various parts of the system
- Control, tests and commissioning
- Documentation

Procurement of the PV system: selection of vendors, installers and contracts

The PV system that will be installed in the demo site at Soma is expected to be 200 kWp. The installation will be one of the major elements of the demo site Smart Grid System and the only power generating component. The system will be financed by SEAŞ which will procure the system according to Public Procurement Regulation [18] governing public entities as described in above in section 6.3 "Selection of equipment and installers". PV systems are overwhelmingly installed by EPC (Engineering, Procurement, Construction) companies in Turkey as they are globally, and all tenders to select an EPC company capable of installing a PV system, including the preliminary design, sizing, purchasing of components, civil works, installation and commissioning of the system need work contracts an example of which is the the exhaustive document produced by TEDAŞ [21], the public Turkish Electricity Distribution Company/ Authority. As a rule of thumb the following example for the contract in the selection of the EPC company summarizes the requirements.

- **Scope of Work**

To design, supply, install and commission one, fixed (i.e. non-tracking) roof integrated photovoltaic system with energy storage on the selected roofs of demosite buildings at Soma, meeting all Industry, National by-laws, regulations, codes, standards and safety, etc.

SEAŞ relies on contractors to provide expert advice and guidance, thus if something is missing on the specifications or not included in the tender, it should be addressed at the job site meeting. Also if scope of work is added or deleted, an addendum will be issued by SEAŞ.

General Scope of Work can be said to be composed of - Designing, supplying and installing one net metered PV system including but not limited to:

- All works required for proper installation of Solar PV and energy storage system including necessary civil works for mounting structures of solar module, shall be done by the contractor.

The entire work shall be performed on turnkey basis thus including ;

- Submitting and obtaining approval of project plans with SEAŞ, relevant Distribution Network Operator (DNO) and TEDAŞ.

For the net metered installations, the contractor is to;

- Coordinate all metering and grid interconnection requirements with TEDAŞ and DNO;
- Prepare and submit all permits required, ie. electrical permit, building permit .
- Provide copies of the permit applications to the SEAŞ project manager;
- Shop drawings of equipment to be supplied to SEAŞ and DNO for approval;
- Complete DNO's Interconnection Request and Equipment Information Form;
- All work to comply with TEDAŞ/DNO requirements contained in the relevant Interconnection Guideline Document.
- Ensure the installation meets the installation requirements of the relevant Turkish Electrical Code and the equipment is certified to the relevant Code product standard, in addition to any other municipal and/or provincial construction and installation regulations that apply;
- All work to comply with all applicable safety codes and policies, PV Module Safety Standard, the Electrical Installation and Inspection Act and Code Regulations;

Except as expressly permitted by law, all work and electrical equipment to comply with all applicable codes/standards, poly-crystalline silicon terrestrial photovoltaic (PV) modules, approved by a recognized certification agency, or equivalent, with approval and work to meet industry best practices; meaning for the Contractor to;

- Ensure that all equipment is properly protected in such a manner that faults or other disturbances on the DNO system do not cause damage to the equipment;
- Ensure that the generation equipment operates within DNO's typical Distribution System operating and power quality conditions and is able to withstand abnormal conditions as outlined by the relevant section of TEDAŞ/DNO's Interconnection Guideline;
- Upon notification from DNO/SEAŞ complete a Net Metering Interconnection Agreement, including all relevant documents as listed in the TEDAŞ/DNO rules and regulation; i.e schedules, site plan, single Line Diagram.

Contractor is responsible for all electrical and control wiring and hardware as required and all wiring is to be neatly installed in proper conduit in accordance with the aforementioned codes and policies;

- Contractor to familiarize themselves with site specific working conditions;
- All wiring shall be done in conduits;
- Contractor is responsible for pointing out any possible asbestos that will affect the job. SEAŞ will be responsible for any necessary removal;
- Perform any wall and roof penetrations as required;
- Solar system to be ballasted, non-roof penetrating design, tilted at the optimum angle for the location;
- All water tightness and sealing work will be carried out by the Contractors relevantly certified roof integration personnel and tested for commissioning.
- All wiring and hardware from DNO supplied meter location
- Coordinate work with DNO supply service

All equipment installation locations to be verified by SEAŞ prior to installation;

- General aesthetics & cleanliness in regard to the installation of various systems shall have to be maintained in accordance with the aesthetics of the site;
- Install all equipment according to manufacturer's installation instructions;
- Coordinate work with SEAŞ to minimise disruption to existing building operations;
- Coordinate with SEAŞ the disconnection and re-connection of power supply;
- Supply, installation and labelling of inverters/chargers and manual disconnection device for isolation purposes (as per TEDAŞ/DNO Interconnection Guideline and subject to approval by TEDAŞ/DNO), etc.;

Contractor provides photovoltaic systems with the minimum peak capacity as specified;

The correct number of 230 watt PV modules are to be selected in liasion with SEAŞ;

Modules shall be ballast mounted on roof on a appropriately selected design to be integrated into the roof system, towards due south as much as practically possible. Stainless steel non-corrosive bolts and screws to be used on roof.

- Modules shall have a 25 year Linear Power Guarantee.
- Support structure design and foundation or fixation mounting arrangements should withstand horizontal wind speed up to 120 km/hr;
- A appropriately sized lithium-ion battery based energy storage system with a 6 kW utility interactive inverter/charger shall be supplied and installed in back-up generator room. Lithium-ion storage system and inverter/charger and controls shall be manufactured by well known approved international manufacturers.

Inverter/charger to be supplied with 240volt, 12 KVA transformers to connect single phase to three phase.

Inverter to be supplied with web connect option to allow for remote monitoring via internet. Internet connection to be supplied in electrical room by SEAŞ.

Each Inverter/charger shall be supplied and connected to PV modules in appropriate strings of relevant number of modules each, or approved alternative.

Lithium storage system will be programmed to cycle (charge/discharge) every day, and is not being used as only emergency power supply. Storage system sequences will be designed to maximize the use of solar energy within buildings and minimize grid interaction and demands (and need for net metering). Storage system might or might not be programmed for an emergency power supply mode.

SEAŞ will select the organization/firm/unit that will provide programming and commissioning services related to lithium-ion storage and inverter/charger system, including 4 sites visits in the first year of operation.

Contractor is responsible for :

- Tagging of all new electrical equipment;
- Disconnect and removal of all redundant wiring and conduit and be responsible for any damages to existing or new equipment;
- Be responsible for any cutting and patching;
- Provide qualified technician start-up reports and manuals. Following completed start-up, provide a trained technician to be present for commissioning of equipment in presence of SEAŞ and selected patner ;
- Provide copy of start-up report, operation and maintenance manuals; and
- Provide a minimum 10 year product warranty on materials to commence from date of commissioning and sign-off.

Annual output and performance of the system shall be demonstrated by submitting a RETScreen or PVSyst modeling output prior to installation.

References - Proponents shall provide an overview of their credentials related to the scope of work and any information which documents successful and reliable experience in past contracts related to the requirements of this Request for Quotation, including, but not limited to photovoltaic system design, supply and installation that have included energy storage and/or a net metering interconnection - PV system, energy storage and net metering experience do not necessarily need to be related to the same projects. Proponents shall provide a list of three (3) applicable client references that have contracted for photovoltaic supply and installation services offered by the proponent which are considered identical or similar to the requirements of this Request for Quotation.

The list should include the following information:

- Name and address;
- Telephone number and e-mail address; and
- A brief, written description of the specific services provided including the year.

The contractor is to quote on supplying all labour, material, tools, and necessary equipment to carry out the scope of work stated for SEAŞ with the relevant number.

The contract should also include al necessary supplementary Terms and Conditions including Operations and Maintenance clauses within its text.

7.3.2 District heating renovation

Pipes, pumps, heat meters and other equipment which will be used in the DH system shall be selected in accordance with related standards.

With this project, composite pipes are developed to implement in the demo site distribution line and transmission line. Calculations and test will be done after tendering process as described in section 4 “District heating system renovation strategies”.

Piping system

The heat that is extracted from plant cycle is delivered to dwellings via the main pump station which is located nearby the plant. Heat and pressure resisted pipes will use for transferring the surplus heat. The pipe line will be installed from central distribution unit located in demo-site to all buildings as following sizes;

Pipe Dimension	Pipe Length [m]
DN25	607
DN32	1,339
DN40	2,355
DN50	873
DN65	1,157
DN80	1,388
DN100	1,818
DN125	311
DN150	48
DN200	1,219
DN300	2,193

Table 7.10: Pipe dimension and lengths to be implemented

Tendering process will be done before production. Pipes to be implemented will be developed according to demo site area conditions and it will be produced by a related company. The cost of setting up new production line for new distribution system costs are pretty much, so there is no possibility to buy the equipment's. Instead of setting up new pilot production line, MIR would prefer Operational leasing (renting) option. MIR will make production of District Heating system that will be developed by means of the R&D activities to be conducted within the project. A subcontractor will make production line and labour available for the production activities of District Heating System (for pipe and fittings). Supervision of the each step will be completed by MIR.

7.3.3 Electrical generation

The only local distributed generation installation at the Turkish demo site will be the BIPV application for which all relevant information has been related through section 6.3.1 "Selection of equipment and installers: Building retrofitting under “Installation of Solar Photovoltaic Systems” description.

7.3.4 Smart grid interventions and ICT

Within smart grid interventions, there are three type of expertise area: electricity, heating and communication. Each part is also separated different segments according to the equipment types that we are going to use. We have our hardware suppliers for measuring devices energy analysers, hot water flow meters, wireless indoor sensors and other installation stuff (cables, panels etc.). Certified and experienced teams under the supervision of our senior engineers will implement each part.

Equipment has to be calibrated according to our need and adjusted to the desired sensitivity level. They have to include register maps to gather meaningful data of measurements. We will work with proven devices that we have already been using in our other applications.

As an output of the measurement, we need some specific parameters in order to get the KPIs, which are valuable for measurement and verification. The first step of the equipment selection depends on these output criteria. Then, the most important part is the financial constraints, which also affect installer selection and installation time. Equipment should be robust on field conditions and operates with minimum failure; Installers will be certified and have technical expertise on electricity and hot water meter installation.

In addition, equipment will meet the some standards like IEC 62056, 61970 (International Electrotechnical Commission) [22]. Architecture of data collection and network will also provide the defined conditions. Measurement and verification algorithms will be meet IPMVP protocol.

7.3.5 Green building certification

There are various key actions that should be incorporated at an early stage. These include actions which must be completed within certain time periods and general early actions to help maximise the BREEAM potential. Some of these actions require appointment of specialist consultants such as a Suitably Qualified Ecologist to conduct study regarding site ecology and develop long term plan to enhance the site ecology.

8 Planning

8.1 End-users commitments

The lodging buildings in the Turkish demo site are owned by SEAŞ which is a public entity. The majority of the tenants are employees of SEAŞ and have different tenure times in their lodgings. Their tenancy is also dependent on being employed by SEAŞ. As explained in section 6.1 "End-users acceptance" due to politico-judicial circumstances explained in the aforementioned section, actions related to end user/social acceptance have been delayed for the Turkish demo site.

The expected sequence of actions regarding end user acceptance is expected to be the following, the dates are tentative.

Deliverable related to end-user acceptance	Dates
Questionnaires collection	June 2015
Evaluation report	June 2015
Initial reactions to smart measurements at lodgings	June 2016
Final revaluation for user acceptance	Parallel to demo site monitoring schedule

Table 8.1: End-users commitment plan

Since the construction works started, 250 dwellings of the 346 have been occupied. The rest of the appartments are used for moving the tenants whose apartments are to be renovated and they move back to their original apartments after the renovation. The timing of the interventions are planned accordingly so that the tenants are not disturbed for a long time.

8.2 Buildings retrofitting

In below table, tentative retrofitting plan is given. Some of the dates given below about retrofitting time plan may change for different reasons during the tendering process.

Energy related retrofitting and system changes are part of a larger construction project consisting of renovations within the dwellings the tenants have to move out for the change of heating system, electrical system and relevant civil works for energy related retrofitting.

Due to the separation of the thermal plant and privatization of Soma-B plant there might be delays related with administrative issues. New engineers are hired for all the retrofitting implementations and CITyFiED project.

Tentative agenda for retrofitting for façade, lighting appliances and solar thermal collectors is given.

Retrofitting Plan for Façade	Dates	End Date
Tender document preparation and tendering process for solar thermal systems	Jan. 2014	March 2014
Installation of solar thermal systems	April 2014	Sept. 2014
Implementation of thermal insulation (7 blocks, single lodging, guest house facilities)	April 2014	Sept. 2014
Predesign and tender document preparation (71 blocks)	Sept. 2015	Dec. 2015
Tendering process for chosen blocks	Feb. 2016	April 2016
Implementation of thermal insulation	May 2016	Oct. 2016
Test and commissioning of the retrofitting	Nov. 2016	Dec. 2016
Energy related retrofitting and system changes of 200 dwellings	April 2014	April 2015
Energy related retrofitting and system changes of remaining dwellings	May 2015	April 2016
Replacement of the lighting bulbs for convention centre, guest house and single lodgings and 200 dwellings (system change will not be done)	May 2015	April 2016
Replacement of the lighting appliances (remaining dwellings)*	May 2015	April 2016

Table 8.2: Retrofitting time plan for façade retrofitting, solar thermal collectors, lighting.
(*)Lighting appliance installations are being done as part of building renovation activities

In below table, tentative retrofitting plan for low temperature heating system is given.

Retrofitting Plan for Heating System	Start Date	End Date
Predesign and tender document preparation	May 2015	Sept 2015
Tendering process for chosen blocks	Dec 2015	March 2016
Final design and calculations	April 2016	April 2016
Implementation for chosen 2 blocks	May 2016	June 2016
Tendering process for rest of chosen 10 blocks	August 2016	Sept 2016
Implementation for chosen 8 blocks	Oct 2016	Feb 2016
Test and commissioning of the system	March 2016	April 2016
Monitoring	April 2016	May 2017

Table 8.3: Retrofitting time plan for low temperature heating systems
(Source: MIR)

SEAŞ will be responsible for the tendering process and the time schedule may vary for different reasons.

8.3 District heating renovation

According to the new legislation in Turkey [23], Manisa Metropolitan Municipality will be responsible for district heating system and Manisa Metropolitan Municipality should take over responsibility from Soma Municipality. Handover agreement between Manisa Metropolitan Municipality and Soma Municipality has been signed in the mid of February 2015. After completion of handover agreement planning, designing and construction process of the new transmission line will be launched. Design of the new district heating distribution network is completed and after Manisa Metropolitan taking over the responsibility of district heating system tendering process for construction of distribution network will be launched.

Time schedule for the distribution system is below. Manisa Municipality will be responsible for the tendering process and the time schedule may vary due to different reasons. The handover agreement has been signed at the beginning of February 2015. Manisa Metropolitan Municipality have not allocated any budget for the project for 2015. But the Municipality is very excited about the project and want to start in 2015.

District Heating Plan	Start Date	End Date
Design and tender document preparation for distribution system	June 2014	March 2015
Tendering process of distribution system	March 2015	May 2015
Manufacturing activities of Distribution system	May 2015	July 2015
Implementation of Distribution system	Aug. 2015	Jan. 2016
Test and commissioning of distribution system	Feb. 2016	March 2016
Design and tender document preparation of transmission system	Nov. 2015	Oct. 2015
Tendering process of transmission system	Nov. 2015	Jan. 2015
Manufacturing activities of transmission system	Feb. 2016	May 2016
Implementation of transmission system	Feb. 2016	Aug. 2016
Test and commissioning of transmission system	Aug. 2016	Sept. 2016
Monitoring of total DH system	Oct. 2016	April 2018

Table 8.4: District heating plan for distribution and transmission system

Manisa Municipality will be responsible for the tendering process and the time schedule may vary due to different reasons.

8.4 Electrical generation

The planning process for power generating installations should include thorough consideration of equipment delivery timetables, time requirements for the licensing and permitting processes. The PV system and storage units are some of the most important elements of the onsite Smart Grid System. Although the BIPV system can be planned stand-alone and separate from the rest of the smart grid components, its design and implementation should in fact be very much in line with smart grid system planning schedule perhaps with a time shift. The following programme is therefore tentatively suggested to be in line with smart grid planning handled in the next section, 7.5 "Smart grid interventions and ICT".

PV Installation	Start Date	End Date
Connection Grid Application	July 2015	Feb 2016
Design and tender document preparation	July 2015	Dec. 2016
Tendering process of PV panels	Jan. 2016	March 2016
Implementation of BIPV system	April 2016	Oct. 2016
Test and commissioning of transmission system	Nov. 2016	Dec. 2016
Monitoring of total DH system	Jan. 2017	Dec. 2018

Table 8.5: BIPV installation plan

8.5 Smart grid interventions and ICT

Implementation plan started with tendering processes by providing inputs for the agreement. Because of partial tendering procedure, overall implementation plan will be finalized just after the last tendering period.

Considering that issue, our implementation will be separated into different time periods because we need 3 different expertise areas as it is mentioned in section 6.3.4 "Smart grid interventions and ICT". There 85 buildings on demo site with different characteristic which also give us standardization for each building type (~7 types). Our plan will be to cover similar building types for electricity, heating in parallel. After finishing end device integration then communication part will start to construct the robust and stable infrastructure according to the end devices conditions. The roughly schedule of the implementation plan is shown below.

Smart Grid Interventions	Start Date	End Date
Project design – Input for tendering processes	June 2015	Oct. 2015
Design stage site assessment	Oct. 2015	Dec. 2015
Overall final design of project and schedule	Jan. 2016	Aug. 2016
Construction stage preparation and Purchasing	July. 2016	Oct. 2016
Preparation of standardized metering panel	Sept. 2016	Oct. 2016
On-site Implementation	Oct. 2016	Dec. 2016
Test and Commissioning	Jan. 2017	Feb. 2017
Monitoring of whole site energy flow	Feb. 2017	Feb. 2016

Table 8.6: Smart Grid Interventions Plan

8.6 Green building certification

The BREEAM assessment is evidence based. Once the registration is complete, a report will be shared with the design team and project partners highlighting the party responsible for the production of evidence for each BREEAM issue pursued by the project.

Also, the required evidence is clearly presented against each of the issues within the Assessment Manual for the BREEAM scheme.

There are various key actions that should be incorporated at an early stage. These include actions which must be completed within certain time periods and general early actions to help maximise the BREEAM potential. Some of these actions require appointment of specialist consultants such as a Suitably Qualified Ecologist.

BREEAM Assessment Plan	Start Date	End Date
Project Registration	April 2015	April 2015
Review of Checklist A10 and Related Documents	April 2015	April 2015
Design Stage Document Preparation	April 2015	July 2015
Design Stage Assessment	July 2015	Aug 2015
Construction Stage Document Preparation	April 2015	March 2016
Construction Stage Assessment & Certification	April 2016	May2016

Table 8.7: BREEAM Assessment Plan

9 Conclusions

The aim of the intervention in the Turkish demo site is to accomplish the CITyFiED project objectives, which are to reduce the energy demand and greenhouse gas emissions and to increase the use of renewable energy sources by developing and implementing innovative technologies and methodologies for building renovation, smart grid and district heating networks and their interfaces with ICTs.

The retrofitting strategy in CITyFiED project is well beyond the requirements of Turkish regulations. To achieve these objectives, an intervention strategy has been defined, taking into account the following aspects:

- Buildings retrofitting - thermal insulation
- Replacement of existing lighting
- District heating through the use of the waste heat of the Soma Thermal Power Plant
- Low temperature heating/cooling systems for buildings
- On site building integrated photovoltaic electricity generation
- Smart grid interventions
- Green building certification

In addition to the retrofitting strategy, existing energy systems for the buildings will become more efficient and innovative, and concept solutions like radiant heating/cooling system will be tested in selected buildings. A new innovative piping system will be designed and tested to eliminate the heat loses.

Although SEAŞ is the owner of the demo site, the planning of the interventions (especially the ones related with retrofitting of the apartments) needs to take into account and be planned considering the comfort and occupancy of the tenants. The social acceptance of CITyFiED interventions by tenants employed by SEAŞ has been a delicate issue due to the privatization of the larger part of the SEAŞ power plant. The number of employees has been reduced and layoffs may continue into the near future.

Permits

SEAŞ and Manisa Municipality both public institutions are bound by Public Procurement Law No: 4734 [18].

As far as the retrofitting of the buildings are concerned Building Code Law No. 3194 [14] dated 1985 indicate when a building permit is required to modify a building. The licensing and permits of building modification controls are highly dependent on the local government's capacity. Soma Municipality does not require permitting due to the unavailability of required human resources.

According to the Electricity Market Law [15], among others, generation facilities based on renewable energy resources with a maximum installed capacity of 1 MW are exempt from the requirement to obtain a license from the Energy Market Regulatory Authority (EMRA). However, SEAŞ will have to apply to the Relevant Network Operator for a connection permit.

Planning

250 of the 346 dwellings are occupied at the moment. For the retrofitting of the electrical and heating systems, in principle, the families move to the empty apartments and they return after the renovation.

SEAŞ has installed the solar thermal collectors in 2014, along with the thermal insulation of some of the buildings. SEAŞ has a budget constraint approved by the Ministry of Energy and Natural Resources for 2015 and is planning to finish renovations related with energy inside the apartments and the district heating distribution system in 2015. Building insulation, BIPV installation and smart grid intervention investments are planned for 2016, although planning, design and tendering processes will be studied in 2015.

According to the new legislation in Turkey [23], Manisa Metropolitan Municipality will be responsible for district heating system and Manisa Metropolitan Municipality will take over responsibility from Soma Municipality. Handover agreement between Manisa Metropolitan Municipality and Soma Municipality has been signed in mid-February 2015.

The privatization process of SOMA thermal power plant has caused a lot of uncertainty in terms of time planning. The privatization has been completed and the construction work on the distribution system in the demo site area will start second part of 2015.

9.1 Expected benefits of the interventions

The expected benefits originated by the interventions described in this deliverable on the envelope and on the energy systems of the demo site can be grouped into three main categories:

- Energy saving: It is the amount of energy saved.
- CO_2 saving: It is the environmental benefit coming from energy saving.
- Costs saving: It is the quantification of the economic benefits related to the energy savings

Benefits of interventions are listed in the following table with saving values.

Intervention	Expected benefit
Implementation of thermal insulation	Energy Saving: 3,000,243 kWh/y
	CO_2 Saving: 999,4 tCO_2/year
	Costs Saving: 56,418 €/year
Replacement of the lighting appliances	Energy Saving: 393,522 kWh/y
	CO_2 Saving: 221 tCO_2/year

Intervention	Expected benefit
	Costs Saving: 43,175 €/year
Installation of solar photovoltaic systems	Energy Saving: 260,000 kWh/y
	CO_2 Saving: 183 tCO_2/year
	Costs Saving: 28,526 €/year
Installation of solar thermal systems	Energy Saving: 331,405 kWh/y
	CO_2 Saving: 110 tCO_2/year
	Costs Saving: 6,511 €/year
Energy consumption monitoring and control system	Energy Saving: 182,834 kWh/y
	CO_2 Saving: 92 tCO_2/year
	Costs Saving: 11,377 €/year
Installation of radiant heating and cooling systems	Energy Saving: 49,498 kWh/y
	CO_2 Saving: 16 tCO_2/year
	Costs Saving: 931 €/year
Waste heat recovery	Energy Saving: 1,356,895 kWh/y
	CO_2 Saving: 452 tCO_2/year
	Costs Saving: 25,516 €/year

Table 9.1: Expected benefits of the interventions

10 Annexes

Annex 1: Revised Plan of Low Temperature Heating System

Annex 2: Technical Specifications for Radiant Heating

Annex 3: Technical Specifications Solar Thermal Collectors

Annex 4: Progress Reports and Billings of Solar Thermal Collectors 1 (390 of the 518 collectors are related with demo site)

Annex 5: Project Approval Process for PV by TEDAŞ (Turkish Electrical Distribution Company)

Annex 6: Principles of BIPV Design and Calculation

Annex 7: Technical drawing of District Heating Transmission Pipeline

Annex 8: Technical drawing of District Heating Distribution Pipeline

Annex 9: Technical Specification of District Heating System

11 References

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