DIRECTION

Demonstration at European Level of Innovative and Replicable Effective Solutions for very Low Energy new Buildings

D1.3: Selection, description and performance values identification of suitable efficient equipment & RE production integrated solutions

WP1 , Task 1.2

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[1]PU = Public

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

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CO = Confidential, only for members of the consortium (including the Commission Services).

Table of Content

0 Executive Summary

This document describes the equipment and energy distribution and generation systems that have been selected to be incorporated in the three demonstration buildings (*Black Monolith, NuOffice Munich and Cartif III*). Key points analyzed are:

- Thermal equipment
- Optimisation of the use of heating/cooling distribution and terminal units, in order to define high efficiency equipment.
- Integrated building services
- Ventilation possibilities
- Lighting strategies
- Passive energy storage systems
- Integration of photovoltaic energy

Since the available information is not homogenous for the three buildings at the moment, this version serves as a first approach to the energy savings strategies to be adopted by each demonstrator. Since the buildings analysis has been performed using the construction projects as main source of information, all comments and suggestions expressed in this document are not definitive and further iterations with the buildings designers are needed to arrive to more solid conclusions and, therefore, to more accurate suggestions and optimization proposals.

This will be then summarized in the definitive version (M18) of this document.

1 NuOffice Munich, Germany

1.1 General Description

1.1.1 ORIGINAL DESIGN

Some of the most important concepts and techniques that are considered in the original building design are:

- There is a nearby connection to district heating. It makes sense to use it as heating source.
- The development plan considerably limits the visual and geometric appearance of the building.
- An external sunshade will need to be installed to reduce demands on the cooling technology.
- A ventilation system, which makes it possible to adjust the air exchange as needed, will provide ventilation to all zones of the building.
- Heating and cooling will be conducted via thermal activation of structural parts, which guarantees the lowest temperatures for heating and highest temperatures for cooling in the building.
- An innovative approach will be taken to heating the building via an absorption heat pump supplied by district heating.

1.1.2 MUNICH WEATHER

One of the most important aspects to be considered in an energy efficient design is the local weather.

Munich has a continental weather strongly modified by the proximity of the Alps.

During summertime the mean temperature will be around 24ºC. In winter it is quite cold, with an average temperature around -2ºC. Depending on the Föhn wind, warmer temperatures can be reached in any year period.

Design HVAC conditions suggested by ASHRAE are:

- Elevation: 529 m
- Winter Dry bulb temperature: -15.4ºC
- Summer Dry Bulb /Wet Bulb temperatures: 29/18.7 ºC
- Maximum WB: 19.6ºC. So, to obtain a water temperature of 27-29ºC is quite simple with a cooling tower.

- Maximum Dew Point: 17.1ºC. This is an important data because will limit surfaces temperatures above 19ºC at least.

1.2 HVAC System

1.2.1 General Description

The HVAC installation is now being analyzed. For better understanding in this document it has been grouped in several issues. First the HVAC systems will be studied and then the cooling and heating generation.

1.2.2 Cooling and Heating Systems

Heating and cooling Distribution. Thermal Slabs

It is commonly said that thermal slabs have a self-regulating effect, despite of their huge thermal inertia. This asset is based on the characteristics of the radiation part of the heat transfer between the slab and the spaces close to it. Heat transfer by radiation grows as the fourth power of the absolute temperature, so that a small variation of the spaces temperature has to modify noticeably the total heat transfer rate, tending to return to the former thermal equilibrium. We think this effect is negligible, because the temperature of the slab surface is very close to spaces temperature and the radiation part of the total heat transfer is therefore rather small. So much so that expressions for total heat transfer in European Norms depend only on the difference between slab surface and space temperatures, just as if there were only a convective heat transfer; the radiation part is taken into account by increasing the convective coefficient. There is no term for the fourth power of the temperature and there is no expected noticeable self-regulating effect. Temperature at slab surface varies very slowly because of the big thermal inertia of the slab, so the operative temperature in the liveable spaces will move into a relatively broad range, according to the variation of thermal gains or losses. This is the reason for some of our following comments.

- The design documentation describes that they will use the ceiling to cool and heat the spaces. We understand that instead of ceilings they are talking about the slabs.
- We saw in sections drawings that there is technical floor. So the main part of the heat transfer will be between the slab and the spaces below it, although there will be also a certain heat flow between the slab and the upper spaces.
- Whenever thermal slabs are used is very important to consider that this is a very inertial system. Thus, the HVAC system and its control must be designed considering that it has a very slow answer. Actually, we have seen on the design documentation an answering heat estimation for the slab around 12 hours. This means that the system is not able to respond to demand variations along one day. Our experience with similar solutions will recommend using the fresh air to cover the dynamic part of the demand.

The idea would be to install a "double system". The slabs will cover the basis of the demand, which represents most of the energy demand, while the air shall answer to variations on it. Unfortunately, the all-air systems are intended only for ventilation and for limitation of humidity, and they cannot be used to help the slab to handle thermal loads.

- We are especially worried about spring and autumn periods. Those days when the building will demand heat on the early mornings and cool on the afternoon will present certain problems with the system designed. That could be solved by using the air and keeping the slab in a neutral point, but it is not possible with the current design.
- Inertia can cause another kind of problems. We know that in Munich weather change easily and fast. We can have fast storms or rains. Those changes cannot be controlled by the thermal slab. Again, the ventilation system could handle the fast changes of outdoor weather.

Additional Electric Heaters

- The design documentations include the possible installation of additional electric heaters to rise the temperature up to 26ºC. Talking about a near zero building, it seems this heating temperature should not be reachable, in order to reduce energy consumption. In any case, we need more details about these heaters. They should be rejected if were Joule-effect heaters.

Ventilation

- The ventilation system may be also used for cooling purposes. We would like to review how much cooling loads are covered by ventilation airflow. But we do not have data about those.
- The most important limitation of the thermal slabs is the same that every radiant cooling system. The temperature shall be above dew point. In Munich the outside dew point can reach up to 17ºC. Therefore, indoor dew point could reach up to 19ºC easily. The ventilation system should be able to dehumidify the air in order to cover the latent loads and avoid condensations.
- What is the cooling capacity for those thermal slabs? We have not found any simulation about it. We think it could be around 40 W/m2, based on our experience in this kind of systems. This amount must be intended as a maximum, because it could be lower depending on the indoor dry bulb temperature set point and the maximum possible dew point.
- The ventilation air can provide a limited cooling. There is no air flow rate control for each room that may be used to regulate the provided cooling to the room. Air supply

conditions must be fixed, primarily, in order to limit indoor dew point. Secondarily, a lower temperature could be chosen to supply additional cooling for the rooms, but it is very difficult to set properly this temperature, because the occupation and the sunlight can vary from a room to another one at the same time. The AHU supply temperature should be studied. We have experience in those situations and it is very important to define very well the control strategy. That is the best way to reduce energy consumption and increase free-cooling hours.

Using Groundwater for Heating And Cooling

- As the tender design says, a flow rate of 15 l/s can be achieved. They only considered 10 l/s after few studies.
- COOLING
    - Maximum temperature difference 6ºC
    - Maximum return temperature: 20ºC
    - Maximum power: Between 190 and 315kW.
    - As this power is not large enough they designed an air cooled chiller to satisfy the loads not met.
- HEATING
    - Maximum temperature difference 5ºC
    - Maximum return temperature: 5ºC
    - Maximum power: Between 125 and 315kW.
    - As this is not enough power the district heating is used directly to cover the loads not met.

1.2.3 Heating and Cooling Generation

Heating Generation

- An absorption chiller will be installed. It will use the district heating water as heat source, while the chilled water will be delivered to the ground or the servers, depending on the demand.
- It will be a heat pump driven by the district heating (COP around 0,7). The return temperature for the district heating must be below 50ºC. Therefore the heat pump shall be designed to work with such conditions. Looking at the technical data provided on the tender design we saw a return temperature of 59ºC. This temperature is, apparently, too high for the district heating requirements and perhaps it should be reviewed.

- The warm water from the absorption chiller will be used to heat up the slabs. The temperatures used will be a 27-33ºC.

Cooling Generation

- The ground water is the main source for chilled water for the slabs, due to ground water temperature is suitable per seto chill the slabs water for this use, without any need of additional chilling.
- The following areas are currently planned for special use:

Fitness and training area	70kW
Server rooms (as described in C.3.3)	80kW Cooling for computers in interior rooms
	150 kW. Additional air cooled chiller.

1.2.4 Optimizations and Suggestions

- If necessary, deliver portable heating equipment based on PCM (phase change material).
- It is necessary to study carefully how to set the slabs water temperature according to weather forecasts, and how to set the air supply temperature according to actual outdoor weather and existing indoor conditions. The objective must be to ensure an indoor dew point below slab surface temperature, in one hand, and to reduce the range of variation of indoor temperature as much as possible; and, at the same time, maximizing the energy savings.

1.3 Renewable Energy

1.3.1 General Description

The building will use ground water heat and solar energy.

1.3.2 Renewable Energy #1

At this stage, apparently, it is no worth increasing the current use of renewable energy, so we do not develop this point.

1.3.3 Optimizations and Suggestions

See the comment above.

1.4 Lighting System

1.4.1 General Description

There are ceiling-mounted lighting or suspended lighting design concept for the design of the lighting designer. To provide a highly energy-efficient lighting safe, the landlord waives the oversizing of the lighting, which will usually compensate for the aging of the lamps. The tenant can compensate for this aging of the lamp by a more frequent replacement of bulbs or tenant's desk lamp. Thus a significantly reduced power consumption can be expected. All lamps are equipped in the main areas with occupancy sensors and daylight control, which has a low fuel consumption and thus lower costs for the meter result. In toilets and archives in the presence detector rental units will be installed.

Lighting of common areas in the stairways is like the overall visual concept. Here is placed in the entrance and atrium area on a high-quality and mood lighting value.

1.4.2 Lighting Consumption

As it is said, all lamps are equipped in the main areas with occupancy sensors and daylight control, which has low fuel consumption and thus lower costs for the meter result. Make sense but we need more information about lights, density.

1.4.3 Optimizations and Suggestions

Day lighting simulation or studies should be done to allow a further analysis.

The use of mirrors or any other reflective system to gain day lighting is a possibility which may be evaluated.

2 Cartif II building, Valladolid (Spain)

2.1 General Description

CARTIF III building is located in Valladolid, in the centre of Spain, under a Mediterranean Continental Climate.

CARTIF III building was designed to have several industrial activities zones and some offices for R&D tasks of CARTIF Foundation. So, there are four industrial areas of 3100 m2 and an office area of 935 m2.

The building has basement, ground floor and first floor, but not into whole plant, some of the industrial zones were designed as cathedral ceiling or double height.

It has been designed as a very low energy building, which will integrate a lot of solutions for saving energy and to improve the overall energy efficiency.

The envelope has been designed to minimize thermal energy and light electrical demand through a special concept (glass wall and louvers blinds) that allows an important use of daylight with high solar gain and so to reduce thermal requirements. Also high efficiency lighting equipment will be used on the building.

There will be integrated a polygeneration renewable energy facility, designed as a combination of thermal plants (using a geothermal and biomass integrated systems) that will ensure high efficiency, energy balances between winter and summer periods (by means of the use of the ground storage capacity) and zero CO2 emissions.

A PV plant will be installed in order to supply an important portion of the total electricity consumption.

And of course there will operate an advanced building management system (BMS) that will optimize energy uses by means of an efficient distribution and final use of the overall energy involved in each system and process.

2.2 HVAC System

2.2.1 General Description

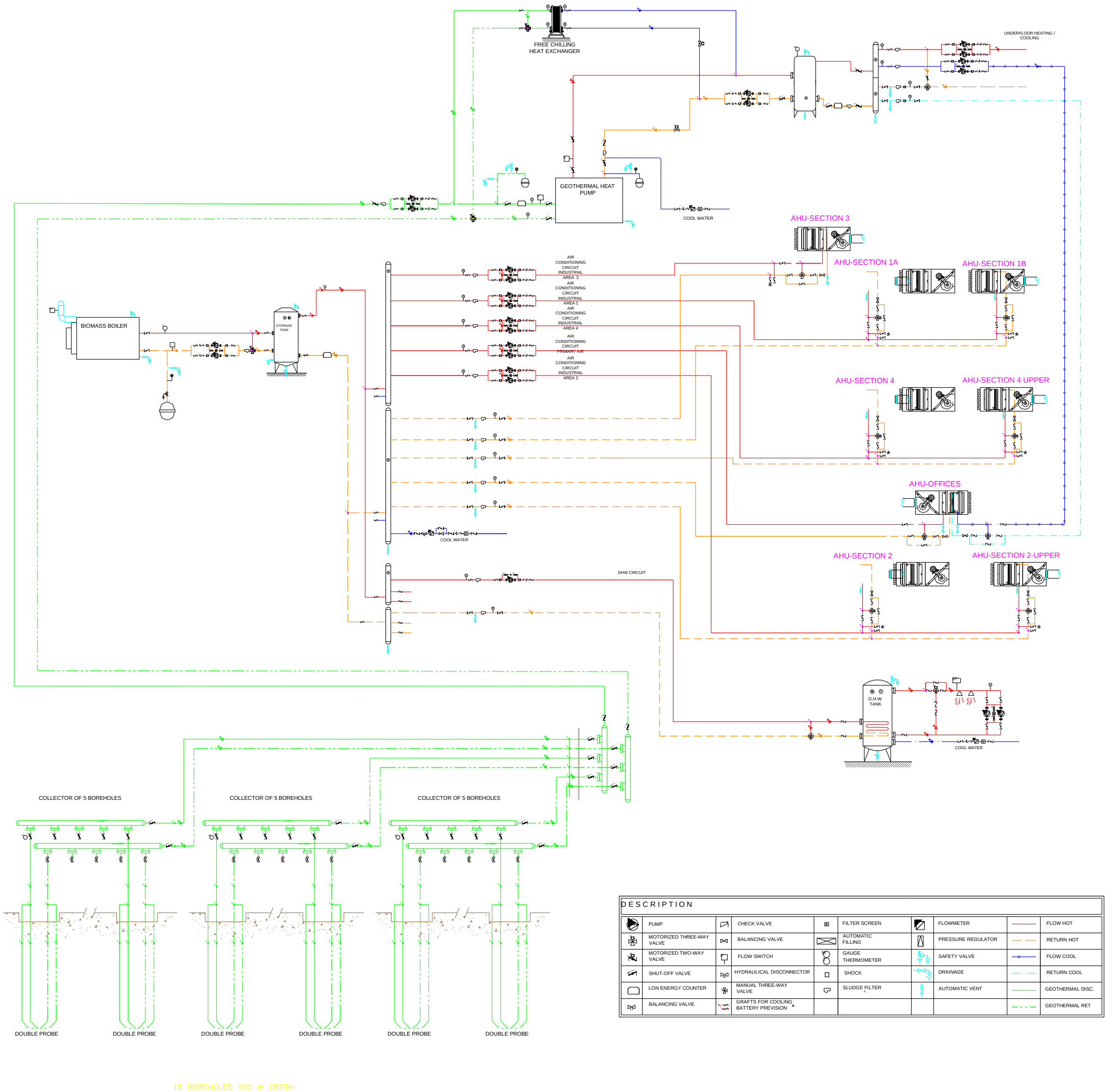
The HVAC System for the building Cartif III is entirely based on renewable energy production to provide the energy needs. The energies sources are geothermal and biomass, achieving a significant reduction of CO2 emissions.

The source of energy production for office area will be geothermal, based on the use of ground heat. The geothermal installation is composed by a geothermal heat pump unit with seasonal performance, which will allow balancing the energy absorbed from and dumped to the ground so the annual thermal need to heat this area is null.

All the necessary thermal energy for the industrial buildings and the DHW will be provided by a biomass boiler with very high performance (> 90%), with the added value of having zero CO2 emissions.

The distribution of heating and cooling in the office area is through an underfloor heating and cooling system supplemented by a system of air diffusion with air handling unit. In the industrial area, the heating system selected is through air handling units.

The following figure shows the flow diagram of thermal facilities in Cartif III:



2.2.2 Cooling and Heating Systems

In the industrial areas, there are only heating systems. This system is composed by air handling units (AHU). These units have a heat recovery device, free cooling system and their heating coils fuelled by biomass boiler. Each industrial area is heating by one unit except the main industrial area, which due to its size there are two units.

These equipment are located on the roof of the building, pushing the air through circular ducts and doing the air diffusion with jet nozzles.

The main devices of the air handling units are filters, heating coil, free cooling system, adiabatic wetting and heat recovery system.

There is a free-cooling system for the entire building, it will allow a considerable reduction in cooling requirements for the industrial zones. In summer, it will be only used free cooling due to the combining of Valladolid´s climate conditions, work schedule and the height.

Other energetic saving measure implemented in these systems is heat recovery in the air handling units. They are high energy efficiency.

Other advantage of this air conditioning system is that it also ensures ventilation rate required by the Regulations.

The air conditioning for **offices** is through an under-floor system both for heating and for cooling. With this system it achieves a high level of comfort. Produced heat is uniform and pleasing, because it doesn't produce air currents and it is completely silent. This facility will be complemented with an air handling unit, providing 20% heat demand and 30% cooling demand.

Each under-floor circuit will be regulated through a temperature sensor corresponding to each floor section. Different sections have been defined depending on its orientation.

To ensure the required ventilation within the offices, it will install an air-handling unit with cooling and heating coils, free cooling device, energy recovery, adiabatic wetting and filters. As for industrial areas, the free cooling will involve a reduction in cooling requirements.

The air diffusion is through rotary diffusers and grilles and the flow of each room is regulated through variable flow gates.

The distribution of cold and heat to different areas of the building will be done by circuits departing from the production central. The circuits are divided according to the use and orientation of each zone:

- From biomass boiler, six circuits: office´s UHA, Industrial area 1´s UHAs, Industrial area 3´s UHA, Industrial area 2 ´s UHAs, Industrial area 4´s UHA and DHW.

From Geothermal heat pump, two circuits: one for under-floor and the other one, Offices' UHA.

2.2.3 Heating and Cooling Generation

In Cartif III, the heating and cooling generation systems are based entirely on renewable energy, geothermal and biomass. There aren't any non-renewable generation systems in the building, for this reason, the generation systems are explained in the followings section.

2.2.4 Optimizations and Suggestions

As HVAC system optimization, it has been proposed the use of variable flow ventilators in industrial areas UHA. Thus the air flow will vary according to the needs of both thermal and ventilation. Without variable flow ventilators, UHAs will drive total flow rate at all times, this is high energy consumption due to the large volume to move within each industrial area. The nozzles support this flow variation within a set range with a minimum flow.

Apart from a decrease in electric consumption of the fans, thermal consumption will also decrease because the flow to heat is lower.

2.3 Renewable Energy

2.3.1 General Description

As mentioned above, the thermal production in the building is made entirely by renewable energy, geothermal and biomass. Each one of these systems is designed for supplying the energy required to different areas of the building. The biomass will heat the industrial zones and DHW. The geothermal heat and cool the office areas.

The biomass facility consists of main equipment that is the boiler and the fuel used are pellets and woodchips.

By the other side, the geothermal facility will have like main equipment a heat pump brine-to-water with a closed circuit through which circulate brine with vertical boreholes.

Now it will be described in greater detail each of renewable energies designed.

2.3.2 Renewable Energy #1

The Geothermal facility provides cooling/heating both under-floor and office air handling unit by the energy extracted from the ground.

Geothermal energy is an excellent solution for energy efficiency, due to its effectiveness and efficiency. It is a system that be able to extract renewable energy from soil.

An air conditioning system using geothermal energy is more energy efficient than an air conditioning system that exchange heat with air or water. The exchange with the ground is much more advantageous because the temperature of the ground is stable along the year, about 16 º C.

A geothermal heat pump system presents important advantages over traditional heat pumps air-to-air or air-water, which they use as heat source ambient air. Its efficiency is higher because the annual uniformity in soil temperature involves performances of cycle substantially higher, in both cooling mode and heating mode, this leads to a drastic reduction in the quantity of primary energy consumed and as result in CO2 emissions.

The system has also other important advantages, such as reduced noise, eliminating the aesthetic impact of air chillers units on roofs or "split" in facades, condensate removal and better maintenance and durability of components by lower thermal oscillations to which they are subjected.

The initial investment for this type of heat pump is usually higher than the cost of air-air facilities, mainly due to the cost of the heat exchanger buried, but payback is between 3 and 5 five years. But on the other hand, the operations costs are low, as geothermal heat pump systems typically have lower energy and maintenance costs than outdoor air systems.

Other advantage is the possibility of free chilling, that is, if there is an additional heat exchanger between the water loop and the building distribution system, the heat pump unit can be by-passed if the temperature level of the geothermal source is sufficient to provide the cooling demanded by the building.

It is designed a system compounds by a heat pump brine-to-water and a closed vertical circuit ground heat exchanger. With this type of exchanger, a very constant temperature heat source is obtained, and the required ground area is very reduced.

Geothermal system yields or extracts heat from the ground, according to needs of heating or cooling, through a set of collectors buried by which circulates a water-glycol solution. For cooling during the summer, geothermal system transfers excess heat from the inside of the building to the underground. Moreover, during the winter the geothermal equipment will be permitted heating a building with the reverse process: extracting heat from the soil to transmit to the building through the collectors.

The generator will supply the energy required to air condition the offices and cooling/heating coils of offices primary air handling unit.

The generator equipment is a high efficiency reversible brine-to-water heat pump with a rated heating output 101.5 kW and cooling 77 kW. This equipment has a COP (coefficient of performance) of 4.35 and an EER of 3.81.

The geothermal heat pump is equipped with regulation equipment that adjusts power consumption according to load variations. And it will be located on the basement.

The soil composition has a great influence on its thermal properties and on the overall performances. The thermal diffusivity of the soil (thermal conductivity divided by the product of the density and specific heat) is the predominant factor of the heat transfer in the ground.

There are 15 vertical boreholes buried 100 meters depth with double U-tubes probes, and they are separated up to 5 meters between them. When installing double probes, it obtains a performance 30-40% higher due to be working with a double flow (equal to meters drilled).

Probes were filled with brine as antifreeze in a closed loop. This limits the problems of dirt in the exchanger and avoids possible freezing problems in the equipment.

To make better use of geothermal energy and achieving greater energy reduction it will install a 44kW power exchanger for chilling free, using in this way the geothermal free energy from the ground.

The geothermal system will provide office's thermal requirements (40kW cold and 51kW heat). It will be a source of heat and cold to the office area during the winter and summer, expecting annual energy savings of 20-30% compared to an air to water exchange system.

2.3.3 Renewable Energy #2. Biomass.

The biomass is a renewable energy source based on the production of energy from a biofuel. From the point of view of energy efficiency, biomass is characterized by having a low carbon content, a high oxygen and volatiles content. These volatile compounds (formed by long chains of type C_nH_m, and presence of CO_2, CO and H_2) have high calorific value. In general the calorific value of the biomass can range between 3000 - 3500 kcal / kg.

From the environmental point of view, the energy use of biomass does not contribute to the increase in greenhouse gases because the balance of CO_2 emissions into the atmosphere is zero. The amount of CO_2 generated in the combustion of the biomass is reabsorbed by photosynthesis in plants growth for their production and, therefore, it does not increase the amount of CO_2 present in the atmosphere. On the contrary, in the case of fossil fuels, the carbon is released into the atmosphere which is fixed to the earth for millions of years.

These characteristics and the low sulphur content make biomass a good choice for improving the energy efficiency of the building.

The biomass boiler has a heat output of 220 kW, fuelled by pellets and woodchips. This equipment will be able to provide the thermal energy needs of industrial areas and the DHW production.

The biomass boiler has the following features:

- Boiler for wood pellets (diameter 6 mm) and woodchips (until 100mm length) and with a maxima humidity 40%.
- Worm screw feeding.
- Nominal heat output: 220kW
- Performance: 88-90.6% kW.

The storage silo of pellets and woodchips will be located next to the boiler room, sized properly to allow unloading a pneumatic truck.

The biomass system will provide thermal requirements of industrial area (155kW). The CO_2 emissions will be reduced to zero.

2.3.4 Optimizations and Suggestions

As optimizations and suggestions to this building according to renewable energies, we study two particular:

- A 45kWp photovoltaic plant. There is enough free space on the roof of the building for an installation of this type. This will help a lot to achieve the objective of 60kW/m2yr because this system will make a contribution of 15 kW/m2yr.
- Another possible improvement, that has been studied, is the energy efficiency of an absorption chiller. This equipment would use as heat source a solar installation of heat pipe solar collectors placed on the roof and as the cold source, soil.

This option was rejected because it needs a large area for the placement of solar panels and many boreholes more. This installation was very expensive in proportion to the savings obtained. It would also prevent the placement of the PV plant.

2.4 Other Energy Systems

2.4.1 General Description

Other energy systems in the building to consider are the lighting. This facility involves a high consumption in all the buildings. Therefore it is important to achieve a low-energy building, to make actions with regard to this point. So lighting of offices and industrial area are high efficiency lights. In the Industrial zones, the lights used are the type of sodium vapour.

This type of lighting has a much lower consumption relative to other lights on the market. In addition to selecting low consumption lights, it is also installed control devices that vary depending on the intensity of daylight.

Lightings are grouped by area of use and proximity to windows, so that the lights vary in intensity depending on the natural light that enters the room.

3 Black Monolith, Bolzano (Italy)

3.1 General Description

The building to be analysed in this chapter is the Black Monolith of the New Technology Park placed in Bolzano. Adjacent to this new building there are two historical industrial buildings, BZ1 and BZ2, and one smaller existing building denominated BZ3.

Only the L-shape new building, the Black Monolith, is the object of the Direction project. This building contains offices, conference halls, bar, cafeteria, and the general entrance and information.

3.2 HVAC System

3.2.1 General Description

There is not a full description about HVAC systems but a short one.

We have found a very simple layout of the heating and cooling generation and systems.

There is also a very short descriptions of the systems used but they are not detailed defined and where are they applied.

3.2.2 Cooling and Heating Systems

Several systems are presented as possible solutions:

- Radiant ceiling panels are used in the offices areas. This solution could be good enough for those offices with low cooling loads, but it could present a problem with the ventilation system. As the ventilation is not very well controlled (windows can be opened), and the outside dew point in Bolzano becomes high in summer, possible water condensation could appear in the cool surfaces. We understood that the windows will not open if outside dew point is above 17ºC but if a summer storm is occurring the dew point rise is quite fast and might not be controlled fast enough.
- During the day, mechanical ventilation is available. There are 8 AHUs denominated UTA-A1 to UTA-A4, UTA-I1, UTA-E1, UTA-U2 and UTA-U3. UTA-A1 to UTA-A4 is for the auditoriums, UTA-I1 for the entrance hall, UTA-E1 for the expo, and UTA-U2 and UTA-U3 for the offices. The AHUs for conference halls, entrance, and foyer are of the all-air type (both external and circulation part). UTA-A1, UTA-A2, UTA-A3, and UTA-A4 (conference halls for 260 and 150 people, foyer, and small conference hall for 70 plus 40 people, respectively) are located in BZ1 and are composed of a heat exchanger of counterflow type, mixing chamber, double-stage filter, coils with hot and chilled water. Supply and return ducts are equipped with silencers. The quantity of air is regulated by an air quality sensor on the return duct. The air is used to control ventilation, humidity,

and temperature. In winter, free-cooling is used if the enthalpy of the outdoor air is lower than the circulated air. In the conference halls, the air is injected by nozzles and sucked in through grilles in the ceiling. In the foyer zone, the air is injected through nozzles where there is no suspended ceiling, otherwise through outlet vents in the ceiling. The return air is sucked in at the wall. UTA-I1 is equal, the air injection occurs through outlet vents. UTA-E1 is for the expo area. It is located on the basement of the Black Monolith in a technical room. It uses the energy accumulated by the solar-thermal equipment to cool and dry the air. Radiant ceiling panels perform the temperature control. The air is injected through linear outlet vents. UTA-U2 and UTA-U3 are located on the basement of the existing BZ1 building. The central unit is equal to that of the other AHUs. The air is for ventilation purposes, while the radiant ceiling panels control the temperature. In summer, the flow rate guarantees humidity control. In winter, that flow rate is reduced to the minimum foreseen by law. Every zone is equipped with a temperature and humidity sensor. In summer, when humidity rises over a threshold, before closing the chilled water supply valves, the system verifies that all temperature setpoints are maintained and changes the chilled water supply temperature by at most 2 K. If afterwards some zones cannot satisfy the sensible load, that temperature is brought back to design conditions, and only then the chilled water supply valves are closed in the zones where the humidity has reached the threshold.

- Conference room. In such case AHU is defined. There are the AHUs UTA-A1 to UTA-A4 for this purpose. We think it as good solution.

It is described that every AHU will have heat recovery systems. A minimum efficiency of 50% is defined. We recommend increasing this efficiency. Modern heat exchangers (counterflow type) reach up to 80% its efficiency.

A desiccant evaporative cooling (DEC) is employed in summer in the AHU E1 for the expo area. General working: First, the external air is dehumidified thanks to a concentrated lithium chloride solution that binds the water content in the air, thus getting diluted. The now dry external air is cooled by evaporation. In a separate process, the saturated salt solution is regenerated by heating it up to 55-70°C and extracting the water vapour. The heat source are the solar collectors. The regeneration is time-independent from the absorption.

The volume of supply air requested in the technical specifications for the Black Monolith is about 6,000 cubic meters per hour. At the current stage we don’t have reliable numbers on psychometrics or solar heat needs. The planned final area for the solar collector field is 150 m2. In the tendering documents for the upcoming tender, 40 m2 (20 collectors with 2 m2 each) are already foreseen. The description of the solar collectors is only qualitative. The rest of the collectors will be inserted in a future tender depending on the requirements of the building owner and the DIRECTION project. In the documentation on the AHU E1, the calculations were made by the design team with a solar collector field with 31 kW installed power (water temperatures 70/60°C).

This system should be studied carefully in order to maximize solar cooling efficiency.

3.2.3 Heating and Cooling Generation

The main idea for heating and cooling generation is to use solar thermal collector and ground water as heat source or sink coupled to heat pumps.

The idea is quite good but further details are required:

- Amount of heat need and provided by solar collector.
- Water conditions (temperature, flow, conditions, etc.)
- Detailed demand simulation of the building in order to be able if it can be satisfied by those renewable sources.

On the other hand we think that this type of building will have simultaneously demand of heating and cooling. Therefore it is recommended to add possible heat recovery to the layout diagram.

We think there could be some problems with the layout presented. We understand it is a very simplified version but it seems that whenever the solar water temperature is above the ground there is a circulation of such water that will heat the ground. We understand we are losing energy and certain modifications should be added to the diagram.

3.2.4 Optimizations and Suggestions

Develop desiccant cooling system and use.

Increase heat recovery in AHUs.

Use heat recovery in heating and cooling generation.

3.3 Lighting System

3.3.1 General Description

Daylighting solutions are detailed in the Deliverable D.1.1.

The artificial lighting solutions are:

- Offices: background lighting with fluorescent lights and task lighting with LEDs. We think this is a good understanding and practice. According to EN 12464-1:2011 background lighting may be reduced down to 150 lux. Currently, for the areas adjacent to the workplaces, 350 lux are prescribed. No dimming is defined, but hand operated switches. We think it is a good solution.
- Corridors, entrance and halls. Those will have fluorescent lamps with dimming systems. Is a good option if those lamps are last generation fluorescent type (TL5 type or similar).

- Conference rooms. General illumination based on fluorescent lamps (we assume with dimming systems). Stage illumination based on LEDs. It's a good solution.

3.3.2 Lighting Consumption

Simulations were performed in Daysim with hourly natural light data from a meteo file. Daysim calculates how much artificial light is needed to reach the lux prescribed, differentiated by hour and zone. In the Trnsys model, the hourly data from Daysim are used as input, differentiated by floor. Thus, for each floor, hourly internal gains and electrical consumption due to illumination are available.

3.3.3 Optimizations and Suggestions

Use last generation fluorescent lamps.

Install dimming systems in conference rooms.

3.4 Renewable Energy

3.4.1 General Description

There are two renewable energy installations considered in this building: PV solar panels and solar thermal collectors.

3.4.2 Solar PV Panels

After a simplified simulation it is estimated that the energy consumption becomes as big as 82,72kWh/m2year. As the goal of this project is to reduce it down to 60, we will need certain production of electricity. This is delivered by a 245.75kWp Solar PV field placed on the roof.

The PV field was designed to maximize total electricity production instead of production per kWp. Thus, it was proposed to install panels having the same inclination as the roof, that is, two degrees. The integration in the façade was discarded due to an unsatisfying cost-benefit ratio. The PV field is not simulated dynamically for now. From the tendering documents, the panels have to consist of monocrystalline silicon modules. They have an aluminium frame and are covered in front with tempered glass. The peak power has to be at least 333 Wp (surface area 1559 x 1046 mm), with a nominal efficiency of at least 80% for 20 years.

We might suggest reviewing this PV field size once new detailed simulations are defined.

3.4.3 Solar Thermal Collectors

Those are used as heat source for the heat pumps in winter and to regenerate the desiccant cooling wheel. Further details about simulation and main field characteristics are required.

3.4.4 Optimizations and Suggestions

Further details about simulation and main field characteristics are required.