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# Introduction

*[The development of Solar Process Heat projects requires a duly assessment of both the conventional heat production and distribution system as well as of the heat consuming processes. Aiming an optimal design of the system, a thorough exploitation of waste heat recovery measures is due, after which the most suitable solar integration point and solar technology is to be selected. Upon identification of the effective heat demands at power, energy, temperature, and load profile levels, the most suitable solar thermal technology and thermal storage options might be analysed towards the definition of an optimal Solar Process Heat design suiting the end-user demands. This is followed by the tendering process.]*

*[The introduction should include basic end-user information, and be summarized in the following table:]*

*End User Information*

|  |  |
| --- | --- |
| **Location** |  |
| **Contact Person** |  |
| **Branch** |  |
| **Products** |  |
| **Annual Production** | South Façade  Total |
| **Operation Period** |  |
| **Main Heating/Cooling Requirements** |  |
| **Main Processes** |  |
| **Number of Employees** |  |

*[Furthermore, the introduction should include already information related with solar system installation requirements:*

* *Available area(s), location, inclination and orientation*
* *Rooftop type and resistance (minimum 25 – 40 kg/m2)*
* *Access to water and electricity infrastructure*
* *Existing solar field and components*
* *Existing (unused?) thermal storage]*

|  |  |
| --- | --- |
| **CSH system supplier** |  |
| **Gross area of solar collectors (m2)** |  |
| **Installed cost of CSH system ($)** |  |
| **Estimated Process Heat Demands (Liters/day)** |  |
| **Estimated Annual Energy savings (kWh/y)** | South Façade  Total |
| **Estimated Annual cost savings ($/y)** |  |
| **Payback period (years)** |  |
| **Total avoided CO2/y due to CSH (kg)** |  |
| **System working days per year** |  |
| **Storage Tank Size (Liters)** |  |
| **Estimated Delivery Temperature (°C)** |  |

# Overview of Current Systems in Place

*[Aiming at an identification of effective heat demands and corresponding temperature levels, an overview of heating/cooling production systems and consuming processes must be included in the project.*

*Such information enables an identification of potential efficiency improvements and/or heat recovery possibilities, to be adopted (at the same or at a later time), thus avoiding a possible solar system over dimensioning.*

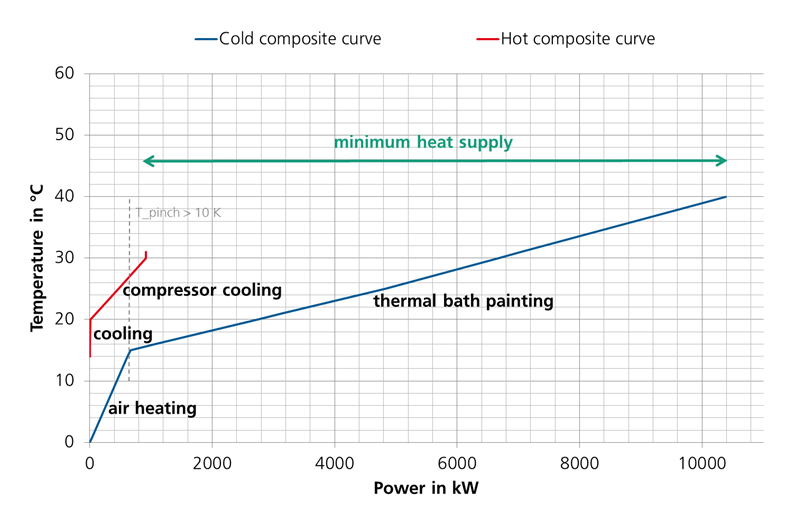
*The analysis of process characteristics and heat distribution network are usually to be based on a site visit with local technician and includes information on:*

* *Temperature levels, condition of heat distribution network*
* *Open / closed processes, direct / indirect heat integration, heat integration at process level or supply level (heat distribution network)*
* *Process-schemes, load profiles, installation of measuring equipment*
* *Process optimization and energy efficiency measures [1]*
* *Processes state-of-the-art? Future plans?*

*For each process, the goal is to determine the effective thermal energy consumption and to identify waste heat recovery potentials, by gathering information on:*

* *input of energy*
* *output of energy*
* *input of raw material*
* *output of processed materials*
* *input of process media*
* *output of waste streams*
* *inlet and outlet properties of streams, as: material, temperatures, mass flow rates, pressures (if relevant)*
* *operating schedules*

*In order to determine the actual, effective heat demand of industrial processes, heating and cooling streams of the different processes have to be evaluated and their heat recovery potential assessed by means of a Pinch analysis.*

**

* *Identification of heat, cold and material streams in the company*
* *Identification of energy efficiency potential*
* *Identification of potential streams for solar process heat integration]*

# Solar Process Heat System Sizing

*[With the detailed process requirements and heat generation characteristics, approximate estimations for potential solar thermal heat integration to the industrial process can be derived.*

*Furthermore information is needed on the solar resources of the evaluated location (DNI, GHI).]*

## Process Heat Demands

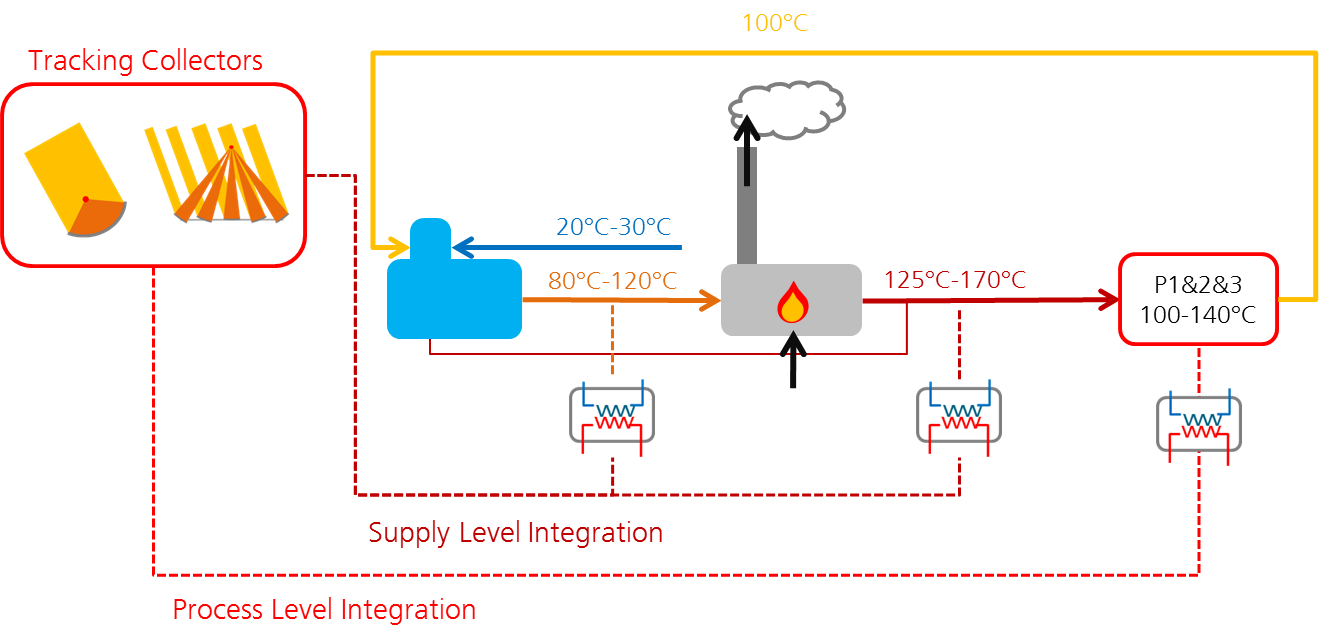
*[Identify:*

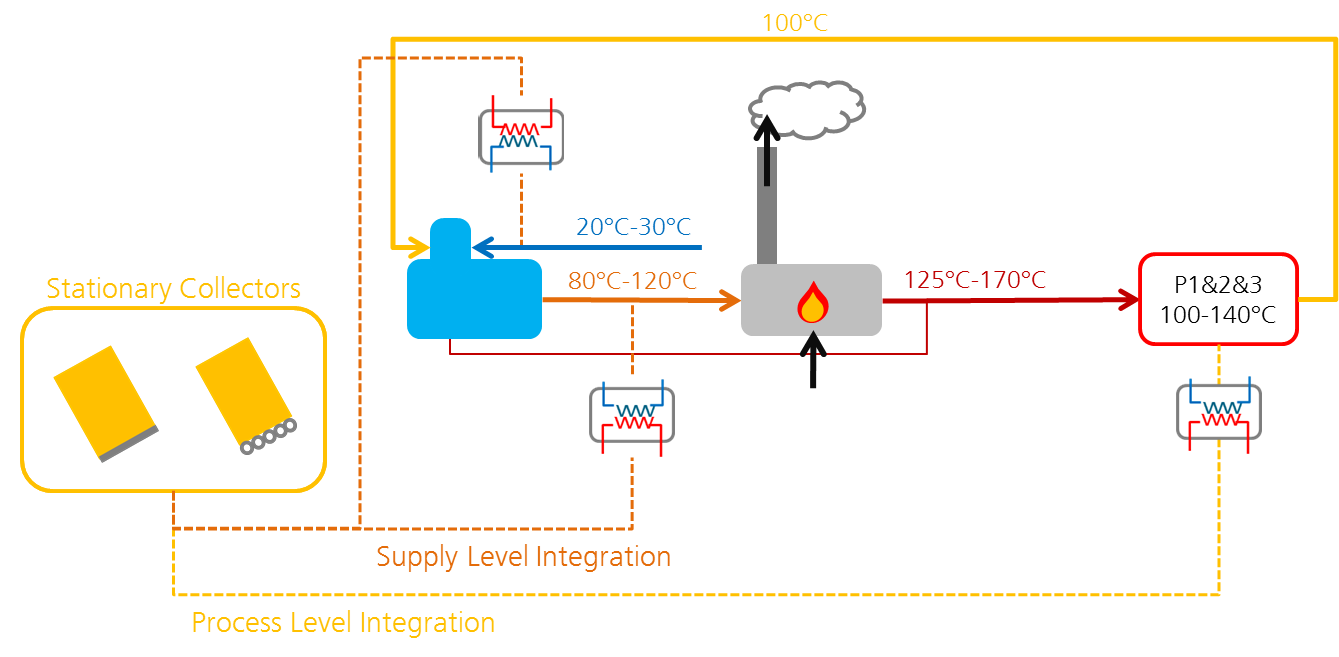
*Temperature level*

*Power demand based on energy efficiency measures*

*Consideration of process schedules (day/night operation)*

*Suitable integration point:*



*]*

*[The following table presents the thermal heating and cooling loads description. This table must be filled and clearly presented. Occupancy of the Facility should be presented also in this sub-section.]*

*Description of the Appliances in the Facility*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description of thermal Loads in the Facility** | **Power (Watts Thermal)** | **X** | **Hrs/day** | **=** | **Wh/day** |
|  |  | **X** |  | **=** |  |
|  |  | **X** |  | **=** |  |
|  |  | **X** |  | **=** |  |
|  |  | **X** |  | **=** |  |
|  |  | **X** |  | **=** |  |
|  | **Total loads Wh/day Thermal**  **=** | | | | |
|  |  | | | | |

*[Add additional rows for additional appliances as needed]*

*[The below table must be filled according to clearly made assumptions]*

*Total Daily Power Demands*

|  |  |
| --- | --- |
| **Correction Factor** |  |
| **Total Average Daily Loads** |  |

*Location Temperature*

|  |  |
| --- | --- |
| **Location** |  |
| **Latitude** |  |
| **Longitude** |  |
| **Cold Water Temperature (°C)** |  |

*[Temperatures must correspond to regions for the Lebanon model energy building code]*

## Site Analysis

*[Information about space availability (outside area, rooftop etc.) should be clearly mentioned in this sub-section. Possible orientation of collectors, shading/blocking issues and longitude/latitude information should be detailed for site evaluation based on solar angle and shading calculation]*

## Meteorological Analysis

*[This sub-section should include on-site description of all the different factors that affect the sun power the CSH module will be exposed to. Some examples of these factors are the location of the CSH array, roof area & orientation (Google Earth, Roof Ray), roof slope of the building, exact shading (depending on the geography of the site, neighboring buildings and self-shading by the architectural form), roof conditions and special mounting system. Other factors that affect the output of the solar collector are the local landscape features that shade the collector daily or seasonally, and local weather conditions (foggy mornings or cloudy afternoons, for example), as these factors also can affect the collector's optimal orientation]*

*[Ideally hourly values for ambient temperature, DNI, GHI and humidity should be given for one representative year. Preferably, sources of weather data should be Meteonorm or Solargis]*

*[This sub-section should also present the monthly and yearly averages for the direct normal irradiation values. References of Solar Data shall be mentioned]*

*Solar Irradiation Data*

|  |  |
| --- | --- |
| **Month** | **Average Direct Normal Irradiation (kWh/m2)** |
| January |  |
| February |  |
| **Average** |  |

*[Add additional rows for all months of the year. The normal irradiation to be used is only the one provided in annex; tilted irradiation should be calculated according to the conversion table also in annex. Graph of annual irradiation on site must be included in this sub-section]*

## Sizing the Solar Field

*[The sizing of the solar field depends on the storage size and solar multiple. A techno-economical optimization process should be completed where it is important to prove that the sizing of the solar field will not exceed the profitable size for the facility]*

*[The selection of solar collector array for a given project may be based on any number of factors, including the physical characteristics (dimension and weight), warranties, efficiency, reliability and reputation of the manufacturer, manufacturer certification to quality standards, module warranty and design qualification, customer satisfaction and field results, costs and availability]*

*[To properly size a solar water-heating system, the most important is to determine the total collector area and the storage volume needed to meet 90 to 100 percent of the facility's hot water needs during the summer]*

*[The first step is calculating the energy needed to heat the water to the desired temperature]*

*[Standby heat loss factor from storage should be calculated based on referenced figures related to the materials used for the storage tank using the following formula:*

*Where:*

* + *: Energy lost due to heat transfer through the tank (Wh)*
  + *: U-value of the tank’s walls (W/m2.K)*
  + *: Surface Area of the storage tank (m2)*
  + *: Temperature difference between stored fluid and the ambient (K)]*

*[Determining penalty factors that affect the energy delivered by the solar collector is to be clearly mentioned such as system factor, tilt factor and orientation factor. System factor depends on the system configuration (direct system with no heat exchanger, indirect system with heat exchanger or other)]*

*[Knowing the Solar irradiation, Efficiency of the collector, Temperature Difference, Volume of water and storage losses, the solar collector active area can be calculated using the following formula:*

*Where:*

* + *Q: Solar irradiation (kWh/m2)*
  + *Qloss: Energy lost due to heat transfer through the tank (kWh)*
  + *ρ: Density of water (kg/liter)*
  + *V: Volume of water (liter)*
  + *C: Specific Heat (kJ/kg.K) = 4.1784 kJ/kg.K*
  + *ηc: Efficiency of the collector (%)*
  + Δ*T: Temperature Difference (K)*
  + *A: solar collector active area (m2)]*

*[The table below includes most of important technical required values for the sizing of the PV array and must be filled]*

*Array Sizing information*

|  |  |
| --- | --- |
| **Energy needed to heat the fluid (kWh)** |  |
| **Heat Loss from storage** |  |
| **Tilt Factor** |  |
| **Orientation Factor** |  |
| **% of Annual Hot Water energy needs provided** |  |
| **Thermal Performance Rating** |  |
| **Total Area (m2)** |  |
| **Number of Collectors** |  |
| **Solar Fraction** |  |

## Sizing the Storage tank and heat exchanger

*[The sizing of the storage tank depends on the solar field area and the night operation. A techno-economical optimization process should be completed where it is considered important to prove that the sizing of the storage tank will not exceed the profitable size for the facility]*

*[If the plant will be operating at night time, the tank should be sized accordingly based on the number of operating hours and the load during these hours. The maximum should be in accordance with the capacity of the installed solar field in order to avoid oversizing of the tank. In order to size the tank based on the facility’s load, it is recommended to adopt the following minimum size criteria technic:*

1. *25L/m2 of collectors for systems with a good match between load and resource profiles. (more than 85% of the load is during the operating hours of the plant with peak loads around noon)*
2. *50L/m2 of collectors for systems with a reasonable match between load and resource profiles. (more than 60% of the load is during the operating hours of the plant with peak loads around noon)*
3. *75L/m2 of collectors for systems with a reasonable match between load and resource profiles. (less than 60% of the load is during the operating hours of the plant with peak loads around noon)]*

## Pump Sizing

*[The pump is needed to push enough heat transfer fluid through the solar collectors to efficiently remove the heat that the sun is depositing in them. Small flows will cause the collectors to run hotter and less efficiently, and high flows will be wasting money on bigger pipes and pumps than the system needs and using more pump power than what is needed. Ideally, a variable speed pump should be used in order to follow the minimum/maximum mass flow of the heat transfer fluid.*

*The steps involved in the pump sizing are:*

1. *Calculate the flow that the collectors need.*
2. *Measure the vertical distance between the highest and lowest points in the fluid loop.*
3. *Calculate the pressure drop and flow velocity for the plumbing system.*
4. *Select a pump that provides, the flow, the vertical lift calculated, and can handle the pressure drop calculated.]*

## Summary of Solar Water Heating System Components

*[Use manufacturer’s specifications to fill in the CSH system components blocks]*

*[The specifications of all the system components should be summarized in this section through the available tables below]*

*[All the technical data should be supported by data sheets from the* *manufacturers in the appendices]*

*[The technical specification of the components depend on the definition, by the end-user, of the following technical conditions:*

* *Load media quality: mineral content and corrosion potential of (feed) water or load side media circulating within solar system related heat exchangers and/or thermal storage volumes;*
* *Load side pressure: pressure on the load side hydraulic circuit. Moreover, concrete technical specifications of each component depend on the equipment and technical solution proposed in the offer, namely regarding:*
* *Solar HTF properties;*
* *Maximum pressure foreseen in the solar loop;*
* *Minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Compatibility of materials regarding galvanic corrosion potentials;*
* *The solar loop HTF mass flow rate and head losses;*
* *Minimum and maximum temperatures foreseen for the load side;*
* *Maximum pressure foreseen for the load side;*
* *Solar collector stagnation temperature;*
* *Solar loop installation layout, piping lengths, accessories and diameters, all of them to be explicitly presented in the offer.]*

### Solar Collectors

*[The Solar collector should present the following characteristics:*

* *Glazed protection over the absorber surface ;*
* *Withstand a maximum pressure of at least 1,5 times the maximum pressure foreseen in the solar loop ;*
* *Certification according to the best certification scheme/standard applicable in Lebanon;*
* *Inner hydraulic circuit must be compatible with the foreseen HTF ;*
* *Hydraulic connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials.]*

*[Solar collector specifications and information will be summarized in the following table]*

*Solar Collector Information*

|  |  |  |  |
| --- | --- | --- | --- |
| **Manufacturer** |  | **Azimuth** |  |
| **Type/Model** |  | **Circulating fluid** |  |
| **Length** |  | **Efficiency (%)** |  |
| **Width** |  | **Weight** |  |
| **Number of collectors** |  | **Gross area (m2)** |  |
| **Irradiation (active surface)** |  | **Active area (m2)** |  |
| **Tilt angle** |  | **Collector Box** |  |
| **Absorber Materials** |  | **Cost (USD)** |  |

### Solar HTF

*[The Solar collector should present the following characteristics:*

* *Compatibility with all the hydraulic circuit components and piping foreseen to the solar loop;*
* *Withstands the minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Withstands the maximum pressure foreseen for the solar loop;]*

*Heat Transfer Fluid Information*

|  |  |  |  |
| --- | --- | --- | --- |
| **Manufacturer** |  | **Minimum Operating Temperature (˚C)** |  |
| **Type** |  | **Maximum Operating Temperature (˚C)** |  |
| **Composition** |  | **Heat Exchanger** | Yes/No |
| **Capacity (L)** |  | **Cost (USD)** |  |

### Storage Tank

*[The Storage tank should present the following characteristics*:

* *Material foreseen for the thermal insulation of the thermal storage must present the features described for the thermal insulation of the remaining solar loop ;*
* *Thermal storage hydraulic connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials;*
* *Withstands the minimum and maximum temperatures foreseen for the operation of the load side;*
* *Withstands the maximum pressure foreseen for the operation of the load side;*
* *Enable the implementation of the system layout and operation conditions presented in 3.1]*

*Storage Tank Information*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Number of tanks used** |  |
| **Capacity (L)** |  |
| **Efficiency (%)** |  |
| **Insulation Material** |  |
| **U-value of Insulation Material** |  |
| **Thickness of Material** |  |
| **Heat Exchanger** | Yes/No |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple insulation layers]*

### Solar Controller

*[The solar controller should present the following characteristics*:

* *Comprise all the hardware, software and sensors defined for the implementation and functionality of the solar loop control system ;*
* *Enable the implementations and functionality of the solar loop control system ;*
* *Include a centralized local visualization of the current values of all the control variables and control set point parameters.]*

*Solar Controller Information*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Input Voltage (V)** |  |
| **Rated Power (W)** |  |
| **Cost (USD)** |  |

### Pumps

*[The pump should present the following characteristics*:

* *Pump material must be compatible with the foreseen HTF;*
* *Pump connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials;*
* *Assure the head foreseen to the solar loop HTF mass flow rate and head losses;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Withstand the maximum pressure foreseen for the solar loop;*
* *Compatible with the implementation and functionality of the solar loop control system;]*

*Pumps Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Number of pumps used** |  |
| **Power (W)** |  |
| **Input Voltage (V)** |  |
| **Life time** |  |
| **Efficiency (%)** |  |
| **Cost (USD)** |  |

### Heat exchangers

*[The heat exchanger should present the following characteristics*:

* *Material must be compatible with the foreseen Solar HTF and with the Load media quality;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop and load sides;*
* *Withstand the maximum pressure foreseen for the solar loop and load sides;*
* *Present a minimum effectiveness  > 0,6 under nominal operation conditions;*
* *The heat exchanger connected to the solar loop (solar loop / TES) must present a minimum heat transfer power (under nominal operation conditions) of HX,solar = 750/ [W/m2collector];*
* *Heat exchanger nominal conditions are those defined for mass flows and temperatures in the system simulation conditions presented in Section 3;]*

*Heat Exchanger Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Number of Heat Exchangers Used** |  |
| **Life time** |  |
| **Efficiency (%)** |  |
| **Cost (USD)** |  |

### Piping and accessories

*[Piping and accessories should present the following characteristics*:

* *Compatibility of materials with the foreseen HTF;*
* *Compatibility with all solar loop component connections, regarding galvanic corrosion potentials;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Withstand the maximum pressure and temperature foreseen for the solar loop under solar collector stagnation temperature conditions;*
* *Diameters will ensure maximum internal flow velocities Vin < 1,5 m/s for indoor paths and Vout < 2,0 m/s for outdoor paths;*

*Piping and Accessories Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Operating Temperature Range** |  |
| **Operating Pressure Range** |  |
| **Life time** |  |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple piping and accessories types]*

### Cut-off valves

*[Cut-off valves should present the following characteristics*:

* *Compatibility of materials with the foreseen HTF;*
* *Valve connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials and diameter;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Withstand the maximum pressure foreseen for the solar loop;]*

*Cut-Off Valves Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Operating Temperature Range** |  |
| **Operating Pressure Range** |  |
| **Life time** |  |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple cut-off valve types]*

### Three-way valves

*[Three-way valves should present the following characteristics*:

* *Compatibility of materials with the foreseen HTF;*
* *Valve connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials and diameter;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Withstand the maximum pressure foreseen for the solar loop;*
* *Compatible with the implementation and functionality of the solar loop control system;]*

*Three-way Valves Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Operating Temperature Range** |  |
| **Operating Pressure Range** |  |
| **Life time** |  |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple three-way valve types]*

### Safety valves

*[Safety valves should present the following characteristics*:

* *Compatibility of materials with the foreseen HTF;*
* *Valve connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials and diameter;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop;*
* *Must be selected according to the maximum pressure foreseen for the solar loop;*
* *Connected to due sewage system complying with the safety and environmental standards applicable at the country of the application to the foreseen Solar HTF;*

*Safety Valves Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Operating Temperature Range** |  |
| **Operating Pressure Range** |  |
| **Life time** |  |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple safety valve types]*

### Expansion vessel

*[Expansion vessels should present the following characteristics*:

* *Compatibility of materials with the foreseen HTF ;*
* *Connections must be compatible with all connecting piping and/or accessories of the solar loop, regarding galvanic corrosion potentials and diameter;*
* *Withstand the minimum and maximum temperatures foreseen for the operation of the solar loop ;*
* *Must be selected according to the maximum pressure foreseen for the solar loop ;*
* *Connected to due sewage system complying with the safety and environmental standards applicable at the country of the application to the foreseen Solar HTF;]*

*Expansion Vessel Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Operating Temperature Range** |  |
| **Operating Pressure Range** |  |
| **Life time** |  |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple expansion vessel types]*

### Thermal insulation

*[Material used for thermal insulation should present the following characteristics*:

* *Present a thermal conductivity <= 0.04 W/m. K;*
* *Moisture compatibility under the foreseeable condensation conditions in the solar loop;*
* *Compliance with the fire hazard regulations applicable in the location of the application;*
* *Weather proof and compatibility with the foreseeable condensation conditions in the solar loop;*
* *Ensure due mechanical protection of the insulation against « normal » external agents : haze, UV, animals;*

*Thermal Insulation Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **U-value** |  |
| **Thickness** |  |
| **Life time** |  |
| **Cost (USD)** |  |

*[Add rows as much as needed in case of multiple insulation layers]*

### Mechanical Drawings and Connections

*[Mechanical Drawings and Connections must be attached to the proposal in this sub-section]*

*[Real drawings must be clear to check the global view of installation of the real system]*

### Technical drawings clarify the content

*[Example:*



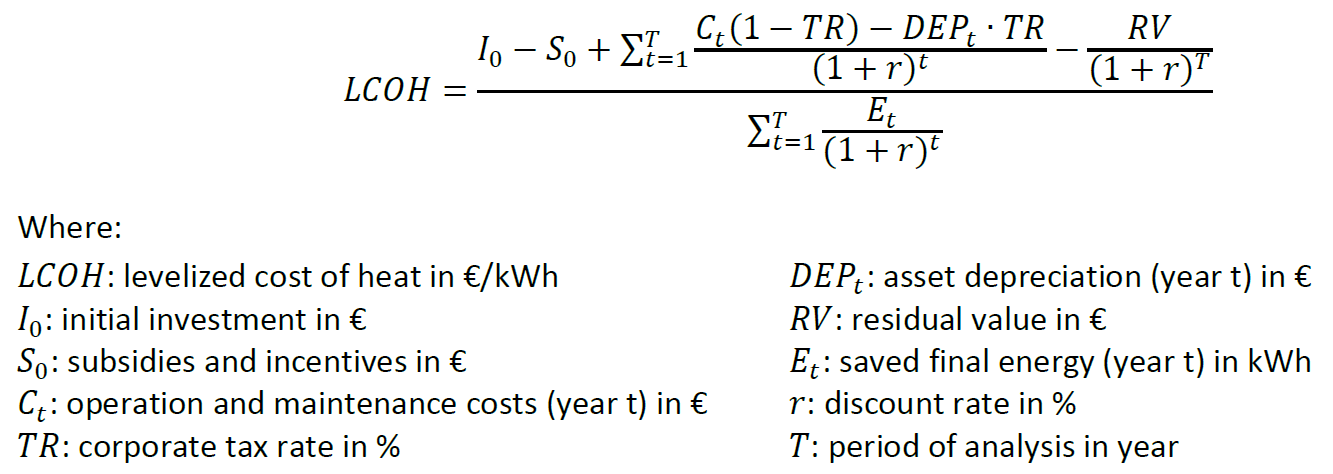
Figure 23: Schematic system layout

Table 9: Summary of operation strategy

|  |  |
| --- | --- |
| ***Operation mode*** | ***Condition*** |
| Solar pump (P1/P2) is activated | Tcol,out (TS2) > TSTO,lower + 10°C |
| Solar pump (P1/P2) is stopped | Tcol,out (TS2) < TSTO,lower + 5°C |
| Solar pump (P3/P4) is activated | Tcol,out (TS2) > TSTO,lower + 10°C |
| Solar pump (P3/P4) is stopped | Tcol,out (TS2) < TSTO,lower + 5°C |
| Solar pump (P1/P2) controls collector outlet temperature | Tcol,out (TS2) = 90 °C |
| Solar pump (P3/P4) controls collector outlet temperature | Tcol,out (TS2) = 90 °C |
| Mixing valve (MV1) controls temperature behind STO1 | TTS3 = 65°C |

## Financial Analysis

*[Cost figure to compare energy produced with solar thermal collectors to conventional heat sources is LCOH (Levelized costs of heat). The LCOH is calculated with the following formula [2]:*



*[The detailed financial proposal of all the products of the CSH system must be provided in the below table format]*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ref. No.** | **Item** | **Item Description** | **Quantity** | **Amount Needed (USD)** |
| **1** | Solar Collectors |  |  |  |
| **2** | Heat Transfer Fluid |  |  |  |
| **3** | Storage Tank |  |  |  |
| **4** | Controller |  |  |  |
| **5** | Pump |  |  |  |
| **6** | Heat Exchanger |  |  |  |
| **7** | Pipes |  |  |  |
| **8** | Cut-Off Valves |  |  |  |
| **9** | Three-Way Valves |  |  |  |
| **10** | Safety Valves |  |  |  |
| **11** | Expansion Vessel |  |  |  |
| **12** | Thermal Insulation |  |  |  |
| **13** | Flow Meter |  |  |  |
| **14** | Mounting Structure |  |  |  |
| **15** | Data logger |  |  |  |
| **16** | Accessories |  |  |  |
| **17** | Installation |  |  |  |
| **18** | VAT |  |  |  |
|  | **Total Amount of the SWH system (USD)** | |  |  |
|  | **LCOH** | |  |  |

*[Add additional rows for more detailed accessories items]*

*[Details on system life and maintenance are to be mentioned in this section such as expectancy, yearly degradation factor, yearly maintenance cost, etc…]*

*[In order to compare the different SWH system options and to determine the most cost-effective system designs and to give the client a global view of the advantages and benefits of his investment in such projects, the life cycle cost analysis of the SWH system should be provided in this section showing the total cost of ownership for this renewable action including energy cost, replacement cost and maintenance cost over the lifetime of the system]*

*[Three different parts must be studied to achieve a complete and clear financial analysis: the first one about all the parameters to take into consideration in the life cycle cost analysis, the second about the cash out-flows and the third discussing the cash in-flows]*

*[All the information to be provided for the financial analysis must be clear, comprehensible and detailed]*

*[The net cumulative savings will be the essential data for concluding on the profitability and the return on investment. The following tables should be used in such analysis and more detailed tables can be provided according to the contractor or consultant detailed analysis:*

*Yearly Cost Savings*

|  |  |  |
| --- | --- | --- |
| **Month** | **Energy Savings (kWh)** | **Cost Savings (USD)** |
| January |  |  |
| February |  |  |
| **Year** |  |  |

*[Energy and Cost Savings must be detailed]*

*Net Cumulative Savings*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Year** | **Cash Out-Flows** | **Cash In-Flows** | **Total Cash Flow** | **Total Cumulative Cash Flow** |
| Year 1 |  |  |  |  |
| Year 2 |  |  |  |  |
| **Net Present Value (NPV)** | |  | **IRR** |  |

*[In this section all the financial details should be included and justified]*

## Green House Gas Emissions Reduction

*[This section is dedicated to the environmental part of the project to be implemented. The calculation of the avoided green house gas emissions must be provided and detailed]*

## Post-Installation Measurements

*[Most important data to be noted when measurements will be done after installation of the solar water heating system is the Monthly Total Energy Saved in addition to the hot water temperature in winter and summer, etc…]*

*[It is crucial to keep monitoring the temperature and mass flows at the collector outlets as well as monitoring the storage level]*

## Tendering

*[The Tender must be clear from the technical (e.g. connection of components), conceptual (design layout) and material (connection and/or interface accessories) points of view:*

* *must define who is responsible for what;*
* *establishes the border for technical description of services:*
  + *Customer side: definition of existing facilities / equipment, objectives to be achieved with purchase of services, expected impacts;*
  + *Supplier side; definition of technical requirements of the supply.*

*The tender might adopt one of two approaches:*

* *Internal engineering: the end-user already has an engineered solution, described in the tender / the supplier only has to offer specific components / services ;*
* *External engineering: the customer only has a definition of the requirements / the supplier has to provide a technical solution (including engineering) as well the components / services enabling its implementation.*

*In the current case, as system integration, layout and operation are already pre-defined, the Tender might be defined after one of the following approaches:*

* *A - Fixed area / storage volume : the tender is based on a pre-defined solar field area and storage volume (from the economic optimization presented in Section 3) ;*
* *B – Fixed solar yield: the tender is based on a minimum solar yield.*

*The contents of a Call for Tenders depend greatly on the scope of services procured. A general structure might follow the following contents:*

1. *Introduction: Identification of the customer and general objectives and framework of the Call (fixed solar field area and thermal storage volume or fixed yield);*
2. *Technical Description: objectives, identification of the interface, identification of the scope of supply, identification of all relevant technical constraints and requirements, Site constraints for installation (distances, location of interface points, foreseeable location of components, etc.); Load media quality (mineral content and corrosion potential of (feed) water or load side media circulating within solar system related heat exchangers and/or thermal storage volumes); Load side pressure (pressure on the load side hydraulic circuit);*
3. *Description of items: technical description of all the items to be included in the proposal (component and/or service related technical characteristics, conformity/standardization criteria, dimensioning, material properties/specification, reference component / service – when allowed)*
4. *List of items and map of quantities*
5. *Supplier access conditions*
6. *List of documentation/information to include in the offer]*

## Conclusion

*[The conclusion of the CSH study proposal must include the following:*

* *Summary of recommendations, estimated annual kWh produced, estimated cost savings, projected investment cost and payback period in the table format below:*

*Summary Table of the proposed SWH system*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***SWH System Description*** | ***Energy Savings (kWh/year)*** | ***Cost Savings ($/year)*** | ***Implementation Cost*** | ***Payback Period*** | ***tCO2 reduced*** |
|  |  |  |  |  |  |

* *ESCO’s or Solar Energy Company’s recommended action plan and implementation schedule*
* *Statement by the client on which recommendations will be implemented and timeframe for implementation]*

## Appendices

*[Information of significant importance, which cannot be presented as a part of the text report (because of number of pages, quality of presentation, etc.) shall be presented as appendices]*

*[The appendices should include:*

* *Details of all products specifications (Collector’s Certificate of Compliance from the IRI must be provided)*
* *Details on simulation tools employed and calculations method*
* *Construction and physical characteristics and warranties conditions for concerned products]*

## General Notes

*[Documentation – All numbers related to the results should be supported by information showing how they were derived. This includes all energy produced; cost savings, investment and payback information]*

*[Mathematical accuracy – All calculations in the report should be checked for mathematical accuracy]*

*[SI units must be used in all parts of the report]*

*[Grammar and style – The report should be written in proper prose. The language should be clear, concise and understandable]*

*[All graphs and plots should be properly labelled and show the dates and conditions when the data was taken]*

**ANNEX**

1. **Solar Irradiation Data (DNI) per climatic zone according to TSBL**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Average Daily Direct Normal Irradiation (Wh/m2)** | | | | |
| **Zone** | **Coastal (Beirut)** | **Coastal (Bayssour)** | **Western Mid-Mountain** | **Inland** | **High Mountain** |
| January | 2981.7 | 3737.0 | 3714 | 4445 | 2963.4 |
| February | 3364.5 | 3369.6 | 3357.6 | 4190.2 | 3352.3 |
| March | 4587.2 | 3672.3 | 3666.3 | 4579.6 | 3663.5 |
| April | 4761 | 4761.3 | 4760.3 | 4760 | 3807.9 |
| May | 4829.7 | 4827.8 | 4832.2 | 4834.1 | 4834.1 |
| June | 6740.1 | 7698.8 | 6744.6 | 7712.1 | 7712.1 |
| July | 6586.6 | 7523.5 | 7532.6 | 7536.7 | 7536.7 |
| August | 7240.3 | 7239.0 | 7242.2 | 8149.2 | 7243.8 |
| September | 6960.9 | 6964.4 | 6956.2 | 7821.5 | 6952.4 |
| October | 4959 | 4965.9 | 4949.9 | 4942.9 | 4119.2 |
| November | 4514.7 | 4524.4 | 3751.5 | 5241.2 | 3743.9 |
| December | 3529.8 | 3539.6 | 2813.3 | 3507.1 | 2805.7 |
| **Average** | 5094.9 | 5242.5 | 5034.7 | 5647.1 | 4900 |

*LCEC recommends the use of Bayssour irradiation data for areas above 200m of altitude in Climatic Zone 1.*

* 1. ***Climatic Zone 1: Coastal***

|  |  |  |
| --- | --- | --- |
| **Mohafaza** | **Qadaa** | **Real-estate District** |
| Beirut | Beirut | All |
| Mount Leb | Baabda | Chiyah; Furn Ech-Chebbak; Haret Hreik; Laylaki; Bourj El-Brajneh; Tahouitat El Ghadir; Baabda; Hadath Beyrouth; Boutchay; Merdache; zire; Kfar Chima; Ouadi Chahrour Es-Souf; Ouadi Chahrour El Aaou; Haret Es-Sit; Bsaba Baabda; Chouit; Aaraiya |
| Mount Leb | El Metn | Bourj Hammoud; Sinn El-Fil; Jdaidet El-Matn; Baouchariat ; Deir mar Roukoz; Dekouanet; Mkalles; Antelias; Menqlet Mezher; Jall Ed-Did; Naqqach; Aamaret Chalhoub; Zalqa; Byaqout; Mazraat El-Hdaira; dbaye; Haret El-Ballane; Mazraat Deir Aaoukar; Mansouriyet El-Matn; El-Dechouniyeh; Fanar; kafra ain saade; Roumieh; Bqennaya; Majzoub; Bsalim; Nabay; Mtayleb; Beit El-Kekko; Qornet Chehouane; Beit Ech-Chaar; Dik El-Mehdi; Zouk El-Kharab; Aain Aar; Mazraat Yachouaa; Deir Tamich; Zakrit; Deir Mar Aabda el Mcha; Beit Chabab; bherzoq; frayke; Hbous; Qornet El-Hamra; Jouret El-Ballout; Qennabet Broummana; Beit Meri |
| Mount Leb | Chouf | Damour; Naamat; Mechref; Chhim; mazboud; Dalhoun; Chammis Ech-Chouf; Ketermaya; El-Maaniyeh; Ouadi Abou Youssef; Sibline; Bourjein; Barja; Bkechtine Ouel Mcheiaa;Baassir;Debbiyeh; Benouati Ech-Chouf; El Jiyeh; Jadra; Chmaarine; Dahr Ech-Chouf; Aalmane Ech-Chouf; Jmeiliyeh; Rmeilet Ech-Chouf; Majdalouna; El-Wardaniyeh; Joun; mghayriye ech chouf; Deir El-Moukhalles; reiaa; Bkifa Ech-Chouf; Mazmoura; Kfar Faqoud; Deir Baba; Sirjbal; GHabet Jaafar; Kfar Him; Ouadi Ed-Deir; Dmit; Bqaiaa Ech-Chouf; Moughayret Ech-Chouf; Deir Dourit; Ouadi bnehlay; El-Jahliyeh |
| Mount Leb | Aley | Chouaifat Amroussyat; Chouaifat Qobbat; Choueifat El-Oumara; Deir Qoubel; Aaramoun Aaley; Aain Drafil; Sirhmoul; Baaouerta; Bchamoun; Daqqoun; Aain Aanoub; Blaybel; Houmal; Bdadoun; Bsous; rjoum; Aaytat; Aaley Bsatine; Aabey; Kfar Matta |
| Mount Leb | Kasrouane | jounieh kaslik; Zouk Mkayel; Jounie Ghadir; Zouk Mousbeh; Jounie Haret Sakhr; Sahel Aalma; Ouata Sillam; Kfar Yassine; Tabarja; Adma Oua Dafine; Safra Kesrouane; Bouar; kfar shihham; Bqaq Ed-Dine; Kharayeb Nahr Ibrahim; Balloune; Souhailet El; Faouka; Aain Er-Rihane; Jaaita; Aintoura Kesrouane; Mazraat Er-Ras; Ghazir; Bourj El-Ftouh; Chnanaair; Batha; Ghidras; Deir Baqlouch; Harissa Kesrouane; Nammoura; Kesrouane; Daraaoun; Maaysra Kesrouane; Bizhel; Zaitoun |
| Mount Leb | Jubail | Jbayl; Mastita; Qartaboun; Blat Jbeil; edde jbail; Aamchit; Halate; Hasrayel; Rihanet Jbayl; Jeoddayel Jbayl; Nahr Ibrahim; Mounsef; Berbara Jbayl; kfar kidde; Aalita; Bchille Jbayl; Zibdine Jbayl; Brayj Jbayl; Behdaydat; Ramout; Saqiet El-Khayt; Kfar Qouas; Fatre; Kfoun; Bintaael; Beit Habbaq; kafr; jlisse; mhammara bejje; Ghalboun; Chamate; Hbaline; Bmehrayn; Hboub; Hsarat; Kfar Mashoun; Aain Kfaa; Ghofrine; Maad; Gharzouz; Chikhane; Chmout; Bekhaaz; Fghal |
| North | Tripoli | All |
| North | Koura | All |
| North | Zgharta | Zgharta; Aardat; Kfardlaqous; Rachaaine; Qarah Bach; Kfarhata Zgharta; Arde; Asnoun; Mazraat Ajbeaa; Mejdlaiya Zgharta; Hariq Zgharta; Aalma; Mazraat Jnaid; Deir Jdeide; khaldiye; Iaal; Kfarhoura; Kfarzaina; Kfarchakhna; Bsebaal; Sakhra; Houakir; Kfaryachit; Morh Kfarsghab; Bchannine; Bnechaai; Aarjis; Daraiya Zgharta; Kfarfou; Ras Kifa; karm sadde; Tallet Zgharta; Sebaal Zgharta; Danha; Aachach; Miriata; Hailan; Boussit; Mzraat Kefraya; Hraiqis |
| North | Batroun | Litige; Batroun; Rachana; Thoum; Kfar Aabida; Koubba; Selaata; Heri; Chikka;  Dahr Abi Yaghi; Toula El-Batroun; Daraya El-Batroun; AAbdelli; Jrabta El-Batroun; Chibtine; Deir Kfifane; Sghar; Deir Mar Youssef Jrabt; Mrah Ez Ziyat; Ghouma; Kfifane; Jrane El-Batroun; Smar Jbayl; Kfar Hatna; Zane; Ftahat El-Batroun; Kour; Basbina; Aartiz; Harbouna; Mrah Chdid; Kfarb Shlaimane; Edde El-Batroun; Sourat El-Batroun; Bijdarfil; Ijdabra; Helta; Aabrine; Kfar Hay; Jebla; Rachkida; Boqsmaiya; Daael; Kfar Khollos; Qatnaaoun; Ras Nahhach; Ouajh El-Hajjar; Hamat |
| North | Akkar | Litige; Halba; Cheikh Mohammad; nfisse; Idbil; Kroum El-Aarab; Cheikh Taba  Es-Sahl; Cheikh Taba; Jdidet Ej-Joumeh; Zouarib; Majdel Akkar Minyara; Hakour; Karm Aasfour; Mazraat Beit Ghattas; Qantarat Aakkar; Machha; Hayzouq; Aarqa; Souaisset Aakkar; Ilat; Bqerzla; Deir Dalloum; Zouk-El-Hosmieh; Zouq El-Hbalsa; Dahr Laissine; Kfar Harra; balde; Zouq El-Hadara; Zouq El-Moqachrine; Jebrayel; Mar Touma; Hedd; Tikrit; Tallet Chattaha; Beit Mellat; Beino; Aayoun Aakkar; Qboula; Chaqdouf; Borj Aakkar; Tall Aabbas El-Gharbi; Tall Aabbas Ech-Charqi; Koueikhat; Khreibet Ej-Jindi; Saadine; Haouchab; Hayssa; Hokr Etti; Chir mairine; Darine; sammouniye; massaoudiye; Tall Meaayan Tall Kiri; Qaabrine; Kfar Melki Aakkar; tall bireh; Tall Hmayra; Hokr Jouret Srar; Barcha; Qleiaat Aakkar; Kneisset Aakkar; Tall Sebaal; aabboudiye; Mighraq Aakkar; Hokr Ed-Dahri; Marlaya; Melhem; Kharnoubet Aakkar; Semmaqli; Mqaiteaa; Janine; Aamaret Aakkar; Cheikh Zennad; Qoubber Chamra; sammaqiye; AAridet Cheikh Zennad; Bebnine; Mhammaret; Rmoul; Sayssouq; Berqayel; Bzal; Kloud El-Bakia; Dinbou; Chane; Houaich; Sfaynet El-Qaitaa; Qabaait; Habchit; Homeira; Qardaf; Jdeidet El-Qaitaa;  Aayoun El-Ghizlane; Majdala; rahbe; Ouadi El-Jamous; Beit El-Haouch; Fraydes Aakkar; Khirbet Daoud Aakkar; daghle; Aamriyet Aakkar; Kafr; Bsatine Aakkar; Aain Ez-Zeit; Kouachra; Khirbet Char; dibbabiye; Berbara Aakkar; Aain Tinta; Baghdadi; Deir Jannine; douair aadouiye; Noura Et-Tahta; Sfinet Ed-Draib; Aamaret El-Baykat; Msalla; Qachlaq; Ouadi El-Haour; Charbila; Tleil; mzeihme; Haytla; knisse; Rihaniyet Aakkar; Saidnaya; Hmaiss Aakkar; Srar; El-Ghozaili; El-Armeh |
| North | Minieh-Danie | Beddaoui; Deir Aammar; bourj el yahoudieh; Nabi Youcheaa; Minie; rihaniet-minieh; Zouq Bhannine; Btermaz; Harf Es-Sayad; Harf Es-Sayad; Beit Zoud; Mrah Es-Srayj; Debaael; Qarhaiya; Aazqai; Aasaymout; Kfar Chellane; Kfar Habou; Deir Nbouh; Merkebta; Raouda-Aadoua; Tourbol; Bakhaaoun |
| South | Saida | All |
| South | Sour | All |
| South | Jezzine | Kfar Falous; A'ain El-Mir; Mrah El-Hbasse; Bayssour Jezzine; haytoule ; Lebaa ;  mharbiye; Ouadi El-Laymoun; Sfaray; hassaniye; Karkha; Choualiq Jezzine;  Ouadi Baanqoudaine; Mjaydel Jezzine; Dahr Ed-Deir; Jensnaya; Rimat; Kfar Jarra; Anane; baanoub; Jernaya |
| Nabatiye | Nabatiye | All |
| Nabatiye | Bint Jubail | All |
| Nabatiye | Marjaayoun | All |
|  |  |  |

* 1. ***Climatic Zone 2: Western Mid-Mountain***

|  |  |  |
| --- | --- | --- |
| **Mohafaza** | **Qadaa** | **Real-estate District** |
| Mount Lebanon | Baabda | Baalchmay; Aain Mouaffaq; Rouaysset El-Ballout; Mzairaa Baabda; El Halaliyeh haret hamze, kahlounieh; Qtale baabda, deir mar youhanna; Ras El-Href; Deir Khouna; El-Abadiyeh; Qrayet Baabda; Chmeisset Baabda; Ras El Matn; Qobbayaa; Qordata; El-Ksaibeh; Deir El-harf; Zandouqa; Kneisset Baabda; El-Erbaniyeh; dlaybeh; Salima Baabda; Hasbaiya El-Matn; Qalaat Baabda; chbaniyeh; Khreibet Baabda; Bmaryam; Btekhnay; Btibyat; Qornayel; Jouar El-Haouz; Bzebdine; Arsoun; Jouret Arsoun |
| Mount Lebanon | El Metn | Bikfaya; Mhaidset Matn; Ouadi Chahine; Aain El-Qach; Mar Boutros Karm; Bhersaf; mayassa; ain el kharroubeh; Himlaya; aain Aalaq; aatchaneh; Aain Et-Teffaha; Sfeilet Bikfaya; Abou Mizane; Deir Chamra; Jouar El-Matn; Chrine; Broummana El-Matn; Masqa; Aayoun El-Matn; Mar Chaya et Mzakki; Baabdat; Dahr Es-Souane El-Matn; Qannebet; Salima; Bsifrine; aain ezzeitouneh; Khillet El-Mtain; Bnabil; Aain es-Sofsaf El-Matn; Ouata El-Mrouj; Mrouj; Marjaba; Aain Es-Sindiane; Zaraaoun; Qaaqour; Khinchara; Choueir; Bteghrine; Douar El-Matn; Chouaya El-Matn; Aayroun; Zighrine El-Matn; Aain El-Qabu; Kfar Aaqab; Mar Moussa Ed-Douar; Machraah El-Matn; Ouadi El-Karm El-Matn; Zabbougha; Kfar Tay El-Matn |
| Mount Lebanon | Chouf | Daraiya Ech-Chouf; Aanout; Debbiyeh; mtallet ech chouf, bzina; Mazraat Es-Dahr; Khirbet Bisri; El-Jleiliyeh; Zaarouriyeh; Bsaba Ech-Chouf; Beit Ed-Dine; Deir El-Qamar; Kfar Hamal; El-Samkanieh; Kfar Qatra; Maasser Beit Ed-Dine; Bchtfine; Kneisset Ech-Chouf; Aammiq Ech-Chouf; deir koucheh; Mazraat Ed-Douair; Ouadi Es-Sitt; Majdel El-Meouch; Faouarat Jaafar; Biret Ech-Chouf; Chourit; Kfar hay; Kfar Niss; Brih; El-Werhaniyeh; Fraudis Ech-Chouf; Aain Zhalta; Baaqline; Aainbal; Aathrine; gharifeh Hasrout; Moukhtara; botmeh; Aain Qania; Jdeidet Ech-Chouf; Niha El-Chouf; Aain Ouzain; Baadarane; Khereibet Ech-Chouf; Aammatour; Kahlouniet Ech-Chouf; Haret Jandal; Mazraat Ech-Chouf; Kfar Nabrakh; Mristi; Batloun; Maasser Ech-Chouf; Jbaa Ech-Chouf; Bater; Barouk; Bayqoun |
| Mount Lebanon | Aley | Aaley; El-Kamatiyeh; aain erroumaneh aaley; Bmakine; Bkhichtay; Ghaboune; aain el jdideh aaley; Behouara; Souq El-Gharb; Bteezanieh; El-Rejmeh; Keyfoun; Chimlane; Kfar Aamay; Bayssour Aaley; Douair El-Roummane; Rouayssat En-Naamane; Mejdlaiya; Aaynab; Chartoun; bou zrideh; Dfoun; Richmaiya; Aain Traz; Selfaya; Rimhala; Binnay; Aain Ksour; Jisr El Qadi; Bhamdoun El-Mhatta; Bhamdoun Ed-Dayaa; Chanay; Btalloun; Majdel Baana; Saoufar; Aain El Halazoun; Bedghan Oua Ouadi Bedg Bedghan Oua Ouadi Bedg; Homs Oua Hama; Mansouriyet Bhamdoun; Mchekhti; Charoun; Btater; Ighmid; EL-Azouniyeh; El-Mechrefeh; Habramoun; Bserrine; El-Ramliyeh; Maasrati; Mazraat En-Nahr Aaley; Mrayjat Aaley |
| Mount Lebanon | Kasrouane | Litige; Aajaltoun; Daraiya Kesrouane; Jdaidet Ghazir; Ghosta; Maarab; Dlebta; Aaramoun Kesrouane; Kfour Kesrouane; Ghidras; Harharaya; Bzoummar; souhoum el ghineh, aain abeaal; Hsayn; Hayata; Chahtoul; zaaitre; Jouret E-Tourmos; Jouret Mhad; Aazra ouel Aazr; jaayel ghbaleh, mashhat; Jouret Bedrane; El-Mradiyeh; Nahr Ed-Dahab; yahchouch; Eghbeh; Rayfoun; Qleiaat Kesrouane; Mazraat Mrah El-Mir; Aachqout; Faytroun; Beqaata Aachqout; Raachine; Kfar Dibiane; Beqaata Kanaan; Kfar Tay Kesrouane; Kfar Tay Kesrouane; Bqaatouta; Ouata El-Jaouz; Mayrouba; aain el delbeh kesrwan; Mghayer; Chouane |
| Mount Lebanon | Jubail | Ehmej; Almate El-Chemaliat; Mazraat El-Maaden; Almate El-Jenoubiat; Tourzaiya; Ferhet; Michmich Jbayl; Souanet Jbayl; aain el delbeh jbeil; Frat; Kfar Baal; Hjoula; Aain Jrain; Hsoun; Mechane; Lehfed; Habil; Jouret El-Qattine; Birket Hjoula; Adonis Jbayl; Ras Osta; Bichtlida; Haqel; Kharbet Jbayl; Qottara Jbayl; Sebrine; Aabaydat; Mayfouq; Bayzoun; Qartaba; janneh; Lassa; Qorqraiya; Boulhos; Qahmez; Saqi Richmaya; Jaj; Tartij |
| North | Zgharta | Beslouqit; Aintourine; Aarbet Qozhaiya; Toula Zgharta ; Mazraat Et-Teffah ; Bhairet Toula; Ayto; Miziara; Seraal; Ijbaa |
| North | Batroun | Masrah; Douq; Mar Mama; Mehmarch; Aalali; Racha; Mrah El-Hajj; Assia; Nahla; Douma; Bcheaali; Beit Chlala; Deir Mar Youhanna; Bechtoudar; Kfar Hilda; Kfour El-Aarbi; Ram El-Batroun; Hadtoun; Tannourine Et-Tahta; Hardine; Beit Kassab; Deir Billa; Niha El-Batroun |
| North | Akkar | Daouret Aakkar; Aaiyat; Aain Yaaqoub; Bezbina; Aakkar El-Aatiqa; Beit Younes; Sadaqa Hrar; Khreibet Aakkar; Qraiyat; Beit Ayoub; Michmich Aakkar; Qornet Aakkar; Fnaydeq; Tshea; Menneaa; Cheikhlar; Rmah; Kfar Noun; bardeh, beit jaalouk; Khirbet Er Remmane; Sindianet Zeidane; Mounjez; Qsair Aakkar; Biret Aakkar; Aaouaainat Aakkar; Khalsa; Machta Hammoud; Mazraet-El-Nahrieh; Qbaiyat Aakkar; Aandqet; Dayret Nahr El-Kabir; Aamayer; Hnaider; Kneisset Hnaider; Mazareaa Jabal Akroum; Qarha Aakkar |
| North | Bcharre | Qnayouer; Billa; Aabdine; Tourza; Qnat; Mazraat Bani Saab; Berhalioun; Ouadi Qannoubine; Mazraat Aassaf; Blaouza; Moghr El-Ahoual; Metrit; Beit Menzer |
| North | Minieh-Danieh | Sir; Aassoun; Mazraat Ketrane; qattine-md; Bqarsouna; El-Hazmieh; tarane; Mimrine; haql el aazimeh; Beit El-Faqs; Mrah Es-Sfire; aain ettineh-md; Kharnoub; sfireh; Qarsaita; Izal; Qemmamine; Karm El-Mohr; Qraine; Hawara; Beit Haouik; Jayroun; Aaymar; Zaghartaghrine; Behouaita; Kahf El-Malloul; Jarjour; Bechehhara; Qarne; Mazraat El-Kreme; Kfar Bibnine |
| South | Jezzine | Jezzine; Wadi Jezzine; Qabaa Jezzine; qaytouleh, mrah bou chdid, tayoun; Bkassine; homsiyeh; Aaray; Sabbah; Haytoura; El-Ghabbatieh; Benouati Jezzine; Maknounet Jezzine; Btedine El-Leqch; Roummanet; machmoucheh; Midane Jezzine; Jabal Toura; kfar houne, mazrat btediniye, mza; Harf Jezzine; Baba; Zhilta; Bhannine; Aazour; Taaid; Bisri; Mazraat Er-Rouhbane; Saydoun; Roum; Hidab; Deir El Qattine; Sanaya; Mazraat El-Mathane; Srayri; Aaramta; Mlikh; Rihane Jezzine; Mazraat; Qatrani; Louayzet Jezzine; Mazraat Khallet Khazen; Mazraat Qrouh; Mazraat Zighrine Jezzi; Chbail; mazrat louzid (awzieh); Soujoud; aaychiyeh, mazrat souwairi; mazrat wazaiyyeh; wardiyeh; Mazraat El-Aarqoub; El-Mahmoudiyeh; Jarmaq; Mazraat Daraya; El-Demachkiyeh; Mazraat Tamra; Bouslaya |
| Nabatiye | Hasbaiya | Hasbaiya; Abou Qamha; Aain Jarfa; Fardis Hasbaiya; Rachaiya El-Foukhar; Kfar Hamam; hebbarieh; Chouaya Hasbaiya; Aain Qinia; Meimes; Chebaa; marj ezzouhour (hawsh qinnabe); Kaoukaba Hasbaiya; Salaiyeb; Bourghos; Meri; Kfar Chouba; Khalouet Hasbaiya; Kfayr Ez-Zait; majidieh, khirbet doueir hasbayya; dellafeh; Khreibet Hasbaiya |

* 1. ***Climatic Zone 3: Inland***

|  |  |  |
| --- | --- | --- |
| **Mohafaza** | **Qadaa** | **Real-estate District** |
| Bekaa | Zahle | All |
| Bekaa | West Bekaa | All |
| Bekaa | Baalbek | Baalbek; Aain Bourday; Douris; Iaat; Aadous; Haouche El-Tal Safyat; Taibet Baalbek; Majdaloun; Haouche Barada; maqneh; haouch El-Dehab; saaideh; Jebaa; Kfar Dane; Hadath Baalbek; Ras Baalbek Es-Sahel; Fekehe; Aain Baalbek; Bajjaje; Nabi Osmane; Ras Baalbek Ech-Charqi; Al-Labouat; Zabboud; Qaa Baalbek; Deir Mar Maroun Baalbek; Moqraq; Qaa Wadi El-Khanzir; Qaa Baayoun; Sbouba; Al-Qa Jouar Mekie; Chaat; Qarha Baalbek; Ram Baalbek; Youmine; Deir El-Ahmar; Kneisset Baalbek; Bechouat; Riha; Dar El-Ouassaa; Btedaai; Bednayel Baalbak; Qsarnaba; Temnine El-Faouqa; Beit Chama; Haouch Er-Rafqa; Misraya; Slouqi; Temnine Et-Tahta; Kfar Dabach; Chmistar; Haouch En-Nabi Chite; Haouch Snaid; Taraiya; Serraaine Et-Tahta; Talia; Hizzine; Khodr Baalbek; Nabi Chit; Jenta; Kharayeb El-Hermel; Yahfoufa; Haour Taala; Brital; Khreibet Baalbek; Bouday; Chlifa |
| Bekaa | Hermel | Hermel; Ras Baalbek Wadi Faara |
| Bekaa | Rachiaya | Rachaiya el wadi; Aaqabet Rachaya; Bakkifac Rachaya; Dahr El-Ahmar; Beit Lahia; Tannoura; Kfar Denis; mhaydseh rachaya; Kaoukaba Bou Arab; Aain Rouha; Khirbet Rouha; Kfar Lichki; Rafid Rachaiya; hawsh qinnabe, mazraat jaafar; Biret Rachaiya; Aain Aarab Rachaiya; Aain Aata; Majdel Balhis; Mdoukha; Yanta; Aayta El-Foukhar Nabi Safa |

* 1. ***Climatic Zone 4: High Mountain***

|  |  |  |
| --- | --- | --- |
| **Mohafaza** | **Qadaa** | **Real-estate District** |
| Mount Lebanon | Baabda | Hammana; Khalouat Baabda; Falougha; Kfar Selouane; Tarchich |
| Mount Lebanon | El Metn | Mtain; Mchikha; Aintoura El-Matn; Majdel tarchich; Baskinta; Kfar Tay El-Matn |
| Mount Lebanon | Aley | Aain Dara; Bmahray |
| Mount Lebanon | Kasrouane | Hrajel; Faraya; Mchaa Kfar Dibiane; Mchaa Faraya; Mchaa El Ftouh |
| Mount Lebanon | Jubail | Mar Sarkis; aain el ghouaybe; Mazraat Es Siyad; Hdeine; Seraaiita; Ghabat; mghayre jbayl; Yanouh Jbayl; Majdel El-Aqoura; Laqlouq; Afqa Jbayl; Aaqoura; Aarab El-Lahib; Hema Mar Maroun Aannaya; Hema Er-Rehban; Aarasta |
| North | Zgharta | Ehden; Kfarsghab |
| North | Batroun | Chatine; Ouata Houb; Tannourine El-Faouqa |
| North | Bcharre | mchaa ej jibbeh; bcharre; hadath ej jebbeh; Bane; Breissat; Dimane; Hasroun; Hadchit; Bazaaoun; Bqerqacha; Bqaa Kafra |
| North | Minieh-Danieh | Bqaa Sefrine; Bechnnata; Mrebbine |
| Bekaa | Baalbek | Aamchki; nahleh baalbek; Aain Es-Siyaa Chadoura; Aarsal; Halbata; Harabta; Nabha Ed-Damdoum; Barqa; Aaynata Baalbek; yammoune; Mazraat beit Mchaik; Maaraboun; Ham; Aain El-Barnaya; chaaibe; Nabi Chbay; Aain Ej-Jaouz Baalbek; Tfail; Ouadi El-Aaoss |
| Bekaa | Hermel | mchaa marjhine, saaidiy; Zighrine; Charbine El-Hermel; Ras Baalbek El Gharbi; Ouadi Faara; Hermel Jbab; Maaysra El-Hermel |
| Bekaa | Rachiaya | Rachaiya el wadi; Aayha; Kfar Qouq; Bakka; Yanta; Deir El-Aachayer; Selsata; Helouet Rachaiya |

***\*Source: TSBL – Climatic Zoning 2005.***

1. **Tilt Angle Conversion Table**

*Transposition Factors for Beirut (Lebanon)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tilt** | **Azimuth** | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **June** | **July** | **Aug.** | **Sep.** | **Oct.** | **Nov.** | **Dec.** | **Year** |
| 0° | +/- 0° | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 15°  15°  15°  15° | +/- 0°  +/- 30°  +/- 60°  +/- 90° | 1.24  1.20  1.11  0.99 | 1.19  1.16  1.08  0.99 | 1.11  1.09  1.05  0.99 | 1.04  1.04  1.02  0.99 | 1.01  1.00  1.00  0.99 | 0.98  0.98  0.99  0.99 | 0.99  0.99  0.99  0.99 | 1.03  1.03  1.01  0.99 | 1.10  1.08  1.04  0.99 | 1.18  1.15  1.08  0.99 | 1.25  1.21  1.12  0.99 | 1.30  1.25  1.14  0.99 | 1.08  1.07  1.03  0.99 |
| 30°  30°  30°  30° | +/- 0°  +/- 30°  +/- 60°  +/- 90° | 1.41  1.35  1.17  0.96 | 1.31  1.26  1.12  0.95 | 1.17  1.13  1.06  0.95 | 1.03  1.02  1.00  0.94 | 0.96  0.96  0.96  0.94 | 0.91  0.92  0.94  0.94 | 0.93  0.94  0.95  0.94 | 1.01  1.01  0.99  0.94 | 1.13  1.10  1.04  0.94 | 1.29  1.24  1.11  0.95 | 1.43  1.36  1.18  0.95 | 1.52  1.44  1.23  0.96 | 1.10  1.08  1.03  0.94 |
| 45°  45°  45°  45° | +/- 0°  +/- 30°  +/- 60°  +/- 90° | 1.51  1.42  1.18  0.90 | 1.36  1.29  1.11  0.89 | 1.16  1.12  1.02  0.88 | 0.97  0.97  0.94  0.88 | 0.87  0.88  0.89  0.86 | 0.80  0.82  0.86  0.86 | 0.82  0.84  0.87  0.86 | 0.93  0.94  0.92  0.87 | 1.10  1.07  1.00  0.88 | 1.32  1.26  1.10  0.89 | 1.53  1.44  1.19  0.89 | 1.66  1.55  1.25  0.91 | 1.07  1.05  0.98  0.88 |
| 60°  60°  60°  60° | +/- 0°  +/- 30°  +/- 60°  +/- 90° | 1.53  1.41  1.14  0.83 | 1.34  1.25  1.05  0.81 | 1.09  1.04  0.94  0.80 | 0.86  0.86  0.85  0.79 | 0.73  0.75  0.78  0.77 | 0.65  0.69  0.75  0.77 | 0.68  0.71  0.76  0.77 | 0.81  0.82  0.83  0.78 | 1.02  0.99  0.91  0.79 | 1.29  1.21  1.04  0.81 | 1.55  1.43  1.14  0.82 | 1.70  1.56  1.22  0.84 | 0.98  0.96  0.90  0.79 |
| 90°  90°  90°  90° | +/- 0°  +/- 30°  +/- 60°  +/- 90° | 1.31  1.18  0.90  0.62 | 1.08  0.98  0.80  0.60 | 0.78  0.75  0.68  0.57 | 0.53  0.57  0.60  0.57 | 0.37  0.44  0.53  0.54 | 0.29  0.38  0.50  0.54 | 0.31  0.40  0.50  0.53 | 0.45  0.51  0.57  0.56 | 0.69  0.68  0.65  0.56 | 1.00  0.92  0.78  0.59 | 1.31  1.17  0.89  0.59 | 1.50  1.34  0.98  0.62 | 0.66  0.67  0.64  0.56 |
| **Tracking**  **Tracking** | 2-axis  Axis=latit. | 1.76  1.69 | 1.63  1.60 | 1.46  1.46 | 1.36  1.34 | 1.35  1.29 | 1.36  1.28 | 1.36  1.28 | 1.41  1.38 | 1.45  1.44 | 1.65  1.64 | 1.81  1.74 | 1.94  1.83 | 1.48  1.83 |

***\*Source: PVSyst Software.***