

*Introduction:*

*The National Energy Efficiency and Renewable Energy Action (NEEREA) is a national financing mechanism dedicated to the financing of loans in energy efficiency, renewable energy, and green buildings. NEEREA is a joint initiative between the Central Bank of Lebanon (BDL) and the Ministry of Energy and Water (MEW). NEEREA receives the technical support of the United Nations Development Programme (UNDP) through funding by the Global Environment Facility (GEF).*

*The Technical Support Unit to the Central Bank of Lebanon (BDL) at LCEC is dedicated to offer BDL technical assistance to evaluate the eligibility of submitted loans to benefit from the EU-funded subsidy. This task is financed by the European Union (EU).*

*Important Notes:*

***1. All sentences written in italic format in these Guidelines are for instructions purposes only. These sentences should be removed from the technical feasibility study.***

*2. This guide is for instructional purposes. It is designed to help potential beneficiaries and contractors in preparing comprehensive technical reports and proposals about solar water heating systems installation.*

*3. This guide is a mandatory requirement towards facilitating the green loan applications and ensures sufficient and proper technical and financial analysis.*

*4. This guide is prepared by the Lebanese Center for Energy Conservation- Technical Support Unit to the Central Bank of Lebanon, and is available for public use.*

*5. This guide is divided into 10 sections that would ideally be available in the submitted technical report of a loan application. The last section offers general notes on the format of the report.*

*6. For questions, clarifications, or suggestions, please contact the LCEC: 01-569101 or by email:* [*energy@lcec.org.lb*](mailto:energy@lcecp.org.lb)

|  |
| --- |
| ***Evaluation of projects requesting financing of Solar Water Heating Systems under NEEREA will be based on these issued SWH Guidelines. Contractors are entailed to abide by the requirements set in these guidelines and must submit the technical reports following the steps and regulations clearly identified.*** |

# Solar Water Heating Study Content

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## Introduction

*[This section should include the objective of the proposed SWH system installation, the financial criteria and technical/operational limitations, the conclusions on the technical study and economic evaluation of the project, a summary of recommended energy conservation measures, annual energy savings and cost savings using in a table format]*

A detailed summary of the proposed project is provided in this section in the table here below:

*[Supplier’s Signature] [Client’s Signature]*

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

1. Overview of Current Systems in Place

*[This section should include dates of preliminary study or audit and data collected from facility or building owner. A general description of the relation between the existing appliances at the facility and the PV system to be installed is required]*

1. Solar Water Heating System Sizing

*[Multiple factors play an important role in determining the SWH system size (budget, shading, roof space, electricity need, etc…)]*

*[Before installing a solar water-heating system, the site's solar resource must be considered first, since the efficiency and design of a solar water-heating system depend on how much of the sun's energy reaches the building site. Furthermore, sizing the system properly is a must to ensure that it meets the hot-water needs of the facility]*

*[In addition to solar collectors, a number of other components are required in any SWH system to conduct, control, distribute, and store the energy produced by the collector. The specific components required depend on the functional and operational requirements for the system. The major components for SWH system are solar collector, storage tank (heat exchanger), pump, controller, flow meter, data logger and auxiliary energy source, where the pump and controller are used only in active systems.*

* *Solar collector: the solar collector used for converting sunlight into thermal energy.*
* *Storage tank (heat exchanger): storage tank is used to store the hot water for future use. It can contain the heat exchanger where heat is exchanged from the circulating fluid to the cold water, or the heat exchanger can be a separate part.*
* *Pump: it is used to circulate water and/or heating fluid in the active SWH system.*
* *Controller: Turns the pump on when the water in the collector is warmer than the water in the tank and it turns the pump off when the temperature difference is small.*
* *Flow meter: it is used to measure the flow rate of hot water.*
* *Data logger: it is used to record the data measured by the flow meter and all other sensors/transducers used in the system.*
* *Auxiliary energy sources: oil boiler, electric resistance….*

*[An accurate system of the customer’s needs is the starting point for specifying, designing and installing SWH systems. Developing and planning SWH projects requires an understanding of the customer’s expectations from both financial and energy perspectives]*

*[The following sub-sections must be followed, described and completed to achieve a full technical SWH project proposal. All the tables in these sub-sections are not shown as examples, they must be filled and completed in such technical feasibility studies and should include these minimum required information and details needed to assess the SWH systems]*

4.1 Hot Water Demands

*[The first step in designing a SWH system is to estimate the hot water consumption]*

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

*Hot Water Demand*

|  |  |  |  |
| --- | --- | --- | --- |
| **Hot Water Use** | **Average Liters per Usage/person** | **Number of persons** | **Estimation of daily hot water use (Liters)** |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| **Total daily Demand (Liters)** | | |  |

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

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

*Location Temperature*

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

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

4.2 Site Analysis

*[Information about physical structure and layout of the roof space should be clearly mentioned in this sub-section. Suitability of the site for SWH system and availability of surface area must be justified since geographic orientation and collector tilt can affect the amount of solar radiation the system receives]*

4.3 Meteorological Analysis

*[This sub-section should include on-site description of all the different factors that affect the sun power to which the solar collector will be exposed to. Some examples of these factors are the location of the solar collector 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]*

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

*Solar Irradiation Data*

|  |  |
| --- | --- |
| **Month** | **Average Daily 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]*

*[Tilt angle should be specified and justified in this sub-section. Although the optimal tilt angle for the collector is an angle equal to the latitude, mounting the collector flat on an angled roof will not result in a big decrease in system performance and is often desirable for aesthetic reasons. However, the roof angle must be taken into account when sizing the system]*

4.4 Sizing the Solar Collector Array

*[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 between 1.12 and 1.20 depending on the type of tank insulation that should be mentioned]*

*[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, and Volume of water, the solar collector active area can be calculated using the following formula:*



*Where:*

* + *Q: Solar irradiation (kWh/m2)*
  + *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]*

*Collector Sizing information*

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

*[If the solar fraction is less than 0.65, the collector array is undersized. Consider either adding another collector or using a different model/size collector]*

4.5 Sizing the Storage tank (heat exchanger)

*[The size of the storage tank is directly related to the daily and peak hot water consumption and solar collector area]*

*[For active solar water-heating systems, the size of the solar storage tank increases with the size of the collector—typically 1.5 gallons per square foot of collector. This helps prevent the system from overheating when the demand for hot water is low. That is between 60 and 80 liters for every m2 of collector area]*

*[The average tank capacity is approximated to be 50 L/member in the Lebanese family]*

4.6 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.*

*The steps involved in the pump sizing are:*

1. *Calculate the flow that the collectors need.*
2. *Measure the vertical distance between the top of the collector and the tank water level.*
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.]*

4.7 Summary of Solar Water Heating System Components

*[Use manufacturer’s specifications to fill in the PV 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]*

* + 1. Solar Collectors

*[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)** |  |

*[The efficiency curve test must be provided in this sub-section]*

*[Solar collectors should be compliant with the NL EN 12975-1 and NL EN 12975-2 National Standards]*

* + 1. Storage Tank

*[Storage Tank specifications and information will be summarized in the following table]*

*Storage Tank Information*

|  |  |  |  |
| --- | --- | --- | --- |
| **Manufacturer** |  | **Efficiency (%)** |  |
| **Type** |  | **Insulation** |  |
| **Number of tanks used** |  | **Heat Exchanger** | Yes/No |
| **Capacity (L)** |  | **Cost (USD)** |  |
| **Water Flow Mechanism** | |  | |

* + 1. Solar Controller

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

*Solar Controller Information*

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

* + 1. Pumps

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

*Pumps Specifications*

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

* + 1. Additional Equipments

*Data logger Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type** |  |
| **Internal memory size** |  |
| **Input Voltage (V)** |  |
| **Cost (USD)** |  |

|  |  |  |  |
| --- | --- | --- | --- |
| **Auxiliary Heating Specifications** | | **Flow Meter Specifications** | |
| **Manufacturer** |  | **Manufacturer** |  |
| **Type** |  | **Type** |  |
| **Nominal Output** |  | **Impulse Rate** |  |
| **Efficiency (%)** |  | **Cost (USD)** |  |
| **Cost (USD)** |  |  |  |

* + 1. Mounting Structure

*[Mounting materials should be specified and detailed in this sub-section]*

*[The foundation for the array should be designed to meet the wind load requirements of the region]*

*[SWH system must be Water, Wind and Corrosion resistant and if possible a data logger is to be included to measure and record system performance parameters]*

* + 1. 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]*

5. Financial Analysis

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ref. No.** | **Item** | **Item Description** | **Quantity** | **Amount Needed (USD)** |
| **1** | Solar Collectors |  |  |  |
| **2** | Storage Tank |  |  |  |
| **3** | Pump |  |  |  |
| **4** | Controller |  |  |  |
| **5** | Flow Meter |  |  |  |
| **6** | Mounting Structure |  |  |  |
| **7** | Data logger |  |  |  |
| **8** | Accessories |  |  |  |
| **9** | Installation |  |  |  |
| **10** | VAT |  |  |  |
|  | **Total Amount of the SWH system (USD)** | |  |  |

*[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]*

6. 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]*

7. 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…]*

8. Conclusion

*[The conclusion of the SWH 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]*

9. 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]*

10. 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 per climatic zone according to TSBL**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Average Daily Global Horizontal Irradiation (Wh/m2)** | | | | |
| **Zone** | **Coastal (Beirut)** | **Coastal (Bayssour)** | **Western Mid-Mountain** | **Inland** | **High Mountain** |
| January | 2387.6 | 2503.6 | 2471.8 | 2522.2 | 2357.3 |
| February | 3195.8 | 3208.1 | 3165.9 | 3282.2 | 3153.3 |
| March | 4898.1 | 4777.7 | 4734.8 | 4861.2 | 4718.4 |
| April | 6012 | 6018.3 | 5991.8 | 5979.5 | 5817.1 |
| May | 6837 | 6833.2 | 6834.1 | 6837.6 | 6837.6 |
| June | 7192 | 7209.7 | 7192.7 | 7211.3 | 7211.3 |
| July | 7010.4 | 7024 | 7032.8 | 7037.5 | 7037.5 |
| August | 6343.7 | 6353.2 | 6337.4 | 6405.2 | 6327.6 |
| September | 5374.6 | 5389.1 | 5362 | 5466.1 | 5347.2 |
| October | 3873.5 | 3896.9 | 3851.8 | 3828.4 | 3750.2 |
| November | 2757.2 | 2770.7 | 2669.5 | 2765.4 | 2656.3 |
| December | 2273.4 | 2287.3 | 2162.4 | 2241.2 | 2149.2 |
| **Average** | 4854.6 | 4864.1 | 4825.6 | 4877.6 | 4788.4 |

*LCEC recommend 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***

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| **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***

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| **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***

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| **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.***