

*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).*

*As part of the contract signed between the BDL and the LCEC under the name "Technical Support Consultancy Services Agreement in Energy Efficiency and Renewable Energy", 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 under NEEREA.*

*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. The present report contains part of the Deliverable D4d-IV from project CEDRO IV, Guidelines on Ground Source Heat Pump*

*5. The Annex has been elaborated based on the reference: LCEC Guidelines on Preparing Technical Proposals for Solar Water Heating Systems (SWH) Applications*

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|  |
| --- |
| ***Evaluation of projects requesting financing of Ground Source Heat Pumps under NEEREA will be based on these issued GSHP 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.*** |

## Ground Source Heat Pumps Guideline Content

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## Ground Source Heat Pumps guideline Content

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## Introduction

*[This section should include the objective of the proposed GSHP system installation, the financial criteria and technical/operational limitations, the conclusions on the technical study and economic evaluation of the project, annual energy savings and cost savings 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]*

|  |  |
| --- | --- |
| **GSHP system supplier** |  |
| **Indoor area to be covered** |  |
| **Installed cost of GSHP system ($)** |  |
| **Estimated energy consumption heating (kWh/y)** | South Façade  Total |
| **COP according EN 14511, heating** |  |
| **Estimated energy consumption cooling (kWh/y)** |  |
| **COP (also known as EER[[1]](#footnote-1)) according EN14511, cooling** |  |
| **Estimated energy consumption sanitary hot water (kWh/y) (kWh/y)** |  |
| **COP according EN14511, sanitary hot water** |  |
| **Estimated Annual Energy savings (kWh/y)** |  |
| **Estimated Annual cost savings ($/y)** |  |
| **Payback period (years)** |  |
| **Total avoided CO2/y due to GSHP (kg)** |  |
| **System working days per year** |  |

* 1. Overview of Preliminary Study of GSHP Appliance

*[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 GSHP system to be installed is required]*

* 1. Ground Source Heat Pump System Sizing

*[Multiple factors play an important role in determining the GSHP system size (indoor area to be heated or cooled, sanitary hot water demand, budget, outdoor area available for underground heat exchanger, electricity power available, etc…)]*

*[Before installing a GSHP system, the heating, cooling and sanitary hot water demands must be considered first, since the efficiency and design of a GSHP system depends on the thermal insulation of the building to be heated or cooled. Furthermore, sizing the system properly is a must to ensure that it meets the thermal energy needs of the facility]*

*[In addition to GSHP, a number of other components are required to ensure the energy efficiency of the system, like underground heat exchanger, control system and the distribution of the thermal energy to the building, among others. The specific components required depend on the functional and operational requirements for the system. The major components for GSHP system are heat pumps, underground heat exchanger, storage tank (sanitary hot water), buffer tanks (heat, cool), pumps, control system, energy meters (electricity, thermal energy) and data logger.*

* *Heat pumps: the unit used to drive underground thermal energy to the building.*
* *Underground heat exchanger: boreholes, horizontal heat exchangers or any other device that could be used to extract or inject thermal energy from / to the underground.*
* *Plates heat exchanger: heat exchanger which uses metal plates where fluids are exposed to much larger surface area.*
* *Storage tank (sanitary hot water): storage tank is used to store the sanitary hot water for future use. It can contain the heat exchanger where heat is exchanged from the heat pump to the cold water, or it could be a tank-in-tank system)*
* *Buffer tanks (heat, cool): store water to reduce the starting and stopping of the system, while maintaining a reserve of thermal energy that enables providing the service of heating and cooling during periods when the compressors are shutdown.*
* *Pump: it is used to circulate water and/or heating fluid in the active GSHP system.*
* *Control unit: takes care of the whole GSHP system. It is usually integrated in the heat pump machine.*
* *Energy meters (electricity, thermal energy): are used to measure the energy efficiency of the whole GSHP system. To be used when the energy efficiency of the whole GSHP system is to be monitored.*
* *Data logger: it is used to record the data measured by the energy meters.*
* *Auxiliary Elements: such as manifolds, expansion, pressure safety, two and three-ways valves or filters and others for safety and long term sustainability.*

*[An accurate system of the customer’s needs is the starting point for specifying, designing and installing GSHP systems. Developing and planning GSHP 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 GSHP 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 GSHP systems]*

* + 1. **Energy Demand**
       1. ***Heating and / or Cooling Demand***

*[Information about heating or cooling loads that are using water as thermal fluid, specified monthly and in a round year basis (kW)]*

*Heating and cooling demand*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| Cooling demand (kWh/month) |  |  |  |  |  |  |  |  |  |  |  |  |
| Heating demand (kWh/month) |  |  |  |  |  |  |  |  |  |  |  |  |

* + - 1. ***Hot Water (for sanitary use) Demand***

*[Estimate the hot water consumption]*

*[The below table must be filled according to clearly made assumptions, specified monthly and in a round year basis]*

*Monthly Hot Water Demand (litres)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Hot Water Use | Average litres per person | Number of persons | Average daily hot water demand (litres/day) | | | | | | | | | | | |
| **01** | **02** | **03** | **04** | **05** | **06** | **07** | **08** | **09** | **10** | **11** | **12** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total daily Hot Water Demand (litres/day) | | |  |  |  |  |  |  |  |  |  |  |  |  |

*[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]*

* + - * 1. ***Hot Water (for Sanitary use) energy demand (kWh)***

*[Once the total daily demands have been stated, the thermal energy (kWh) to cover should be calculated and indicated]*

*[Knowing the Temperature Difference and Volume of water, the thermal power requirements can be calculated using the following formula:*

*Where:*

* + *ESHW: Energy demand hot water for sanitary use (kWh/day)*
  + *ρ: Density of water (kg/liter)*
  + *V: Volume of water required (liter/month)*
  + *c: Specific Heat (kJ/kg·K) = 4.1784 kJ/kg·K*
  + *η: Efficiency of the storage tank (%)*
  + Δ*T: Temperature Difference (K)]*

*[As an example, a house which uses 2.400 l in the month of April which heats the water 35ºC (from 10ºC to 45ºC) and a tank efficiency of 90% will require 108.32 kWh/month to cover the demand]*

*[The monthly thermal power demand should be calculated]*

*Monthly Hot Water Demand (litres)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| Hot water for sanitary use demand (kWh/month) |  |  |  |  |  |  |  |  |  |  |  |  |

* + - 1. ***Total Underground Energy Demand***

*[The total demand should be calculated]*

*[For small projects (i.e. < 12 kW) losses related to the distribution and storage are negligible. However, for projects of higher thermal power, the loss factor to the heating and cooling demand as well to the hot water demand should be added to calculate the final underground demands]*

*[Compressor demand cool and Compressor demand heat (points 2 and 5) refers to the Power required by the compressor which is the result (cooling or heating demand / COP). As a reference a COP of 4,34 could be considered.]*

*[Hot water demand comprises the demand for heating and the demand for hot water for sanitary uses]*

*[Total cooling demand (point 3) is the result of the total cooling demand plus the compressors demand for cooling]*

*[Total hot water demand (point6) is the result of the total cooling demand minus the compressors demand for hot water]*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Month | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| 1 | Cooling demand (kWh) |  |  |  |  |  |  |  |  |  |  |  |  |
| 2 | Compressor demand cool (kWh) |  |  |  |  |  |  |  |  |  |  |  |  |
| 3 | **Total cooling demand (kWh) (1+2)** |  |  |  |  |  |  |  |  |  |  |  |  |
| 4 | Hot water demand (kWh) |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 | Compressor demand heat (kWh) |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 | **Total hot water demand (kWh) (4-5)** |  |  |  |  |  |  |  |  |  |  |  |  |
| 7 | Total (from/to ground) (kWh) (3+6) |  |  |  |  |  |  |  |  |  |  |  |  |

*[The result of the heating demand minus the cooling demand. When (+) it refers to heat extracted from the ground, when (-) it refers to heat injected into the ground.]*

* + 1. **Heat Pump Selection**

*[Once heat, cool and sanitary hot water demands are stated, appropriate heat pump should be selected)*

*[The heat pump is responsible for extracting heat from the ground heat exchanger to the distribution grid or vice versa.]*

*[To determine the size of the needed pump of the system, the maximum demand must be identified. When buffer tanks are available, as general rule, a compressor should not start more than three times per hour]*

*[For direct use (without buffer tanks), the input rating of the heat pump should be same as the loads to allow for safe and efficient operation]*

*[All features concerning the specific site and GSHP project must be detailed and provided in this sub-section; such as buffer tanks operation, remote control operation, load transfer switch, etc.]*

*[The following table should be filled considering the heat pumps size]*

*Heat pump important information*

|  |  |
| --- | --- |
| **Number of heat pumps** |  |
| **Heat pumps configuration (master-slaves)[[2]](#footnote-2)** |  |
| **Number of compressors per heat pump** |  |
| **Rated output per heat pump (kW) (for operating conditions)** |  |
| **COPEN 14511 (in cooling operating conditions)** |  |
| **COPEN 14511 (in heating operating conditions)** |  |
| **Rated voltage (V)** |  |
| **Refrigerant circuit type** |  |
| **Refrigerant circuit volume** |  |

* + 1. **Underground Heat Exchanger**

*[The selection of type of heat exchanger to be used for a given project may be based on any number of factors, including the ground composition, availability of outdoor space for vertical or horizontal methodology, costs and availability]*

*[In case a thermal response test TRT has been performed to assess the ground characteristics, the details should be included here]*

*[To properly size an underground heat exchanger the thermal energy extraction / injection round the year and the stability of the non-disturbed ground temperature in a medium term basis (not less than 25 years) should be taken into consideration]*

*Underground Heat Exchanger information*

|  |  |
| --- | --- |
| **Outdoor area available (m2)** |  |
| **Bore holes: number and length (m)** |  |
| **Horizontal exchanger: area (m2)** |  |
| **Total thermal power of underground exchanger (W)** |  |
| **Yearly hours of operation** |  |
| **Energy to be extracted (kWh/y)** |  |
| **Energy to be injected (kWh/y)** |  |
| **Balance (extracted versus injected) (%)** |  |
| **Underground exchanger manufacturer/contractor** |  |
| **Expected lifetime with undisturbed underground Tº** |  |

* + 1. **Sizing the Storage tank (sanitary hot water)**

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

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

* + 1. **Buffer tanks / heating and cooling**

*[The buffer tanks are needed to reduce the number of starts of compressor’s heat pump and enlarge his lifetime. Heat pumps having variable speed (inverter type) can avoid the use of such buffer tanks]*

*[Usually, a volume of 15 to 20 liters capacity per each KW of compressor’s capacity should be considered]*

* + 1. **Recirculation pump Sizing**

*[The pump is needed to push enough heat transfer fluid through the underground heat exchanger to the heat pump, and from the heat pump to the buffer tanks or heat/cool distribution system. The steps involved in the pump sizing are:*

1. *Calculate the flow that the water velocity, according heat pump manufacturer’s instructions.*
2. *Calculate the pressure drop and flow velocity for the plumbing system.*
3. *Select a pump(s) that provides, the flow, the vertical lift calculated, and can handle the pressure drop calculated.*
4. *Select a pump(s) of the maximum energy efficiency class]*
   * 1. **Summary of Ground Source Heat Pump System Components**

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

#### Heat Pump

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

*Heat pump Information*

|  |  |  |  |
| --- | --- | --- | --- |
| **Manufacturer** |  | **COP cool mode (also known as EER)** |  |
| **Type/Model** |  | **Type of refrigerant gas** |  |
| **Power output heat** |  | **Dimensions** |  |
| **Power output cool** |  | **Weight** |  |
| **COP heat mode** |  | **Warranty (years)** |  |
|  |  | **Cost (USD)** |  |

*[Heat Pumps COP and EER should be stated according EN 14511 norm. Energy Label according Regulation (EU) No 811/2013* *should be also fulfilled.]*

#### Underground Heat Exchanger

*[Underground Heat Exchanger specifications and information will be summarized in the following table]*

*Underground Heat Exchanger*

|  |  |
| --- | --- |
| **Manufacturer/Contractor** |  |
| **Type: Vertical or Horizontal** |  |
| **Total thermal power** |  |
| **Cost (USD)** |  |

#### 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** | |  | |

#### Buffer Tanks

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

*Buffer Tanks Information*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Capacity** |  |
| **Maximum working temperature** |  |
| **Minimum working temperature** |  |
| **Cost (USD)** |  |

#### Recirculation 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)** |  |

#### Additional Equipment’s

*[Additional equipment, if any, should be specified and detailed in this sub-section]*

*Additional Equipment’s Specifications*

|  |  |
| --- | --- |
| **Manufacturer** |  |
| **Type / Model** |  |
| **Function** |  |
| **Cost (USD)** |  |

*[Use an individual table customised according specifications for each additional equipment]*

#### Electrical, Hydraulic & Mechanical Drawings and Connections

*[Electrical, Hydraulic & 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]*

* 1. 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** | Heat Pump |  |  |  |
| **2** | Underground Heat Exchanger |  |  |  |
| **3** | Pump(s) |  |  |  |
| **4** | Controller |  |  |  |
| **5** | Sanitary and buffer tanks |  |  |  |
| **6** | Flow Meter |  |  |  |
| **7** | Data logger |  |  |  |
| **8** | Accessories |  |  |  |
| **9** | Installation |  |  |  |
| **10** | VAT |  |  |  |
|  | **Total Amount of the GSHP 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 GSHP 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 GSHP 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]*

* 1. 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]*

* 1. 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…]*

* 1. Conclusion

*[The conclusion of the GSHP 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 GSHP system*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***GSHP 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]*

* 1. 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]*
  1. 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]*

1. *EER is equivalent to the COP in cooling mode* [↑](#footnote-ref-1)
2. *In case of projects with heat pumps working in cascade configuration (more than one heat pump installed in the same GSHP system)* [↑](#footnote-ref-2)