******

*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).*

*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 heat pump 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 is a result of task 2.a.1. “Preparation of NEEREA guidelines for heat pump projects” of the project “The climate change mitigation strategy in Lebanon: the role of renewable energies and energy efficiency measures - PHASE 1”co-financed by the Italian Ministry for the Environment Land and Sea (IMELS) and LCEC. It presents the main contents of deliverables D.2.a.1.A “Guidelines for projects proposal” and D.2.a.1.B “Project proposal templates” prepared by Politechnico Milano – Department of Energy.*

*5. This guideline will be updated constantly, kindly always refer to the latest version.*

*6. For questions, clarifications, or suggestions, please contact the LCEC: 01-569101 or by email:*

*energy@lcec.org.lb*

|  |
| --- |
| ***Evaluation of projects requesting financing of Air to Water Heat Pump Applications under NEEREA will be based on these issued 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.*** |

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Nomenclature

COP: Coefficient of Performance (for heat pump in heating mode)

D.B.: Dry Bulb temperature

DHW: Domestic Hot Water (sanitary use)

EER: Energy Efficiency Ratio (for heat pump in cooling mode)

ESCO: Energy Service COmpany

HP: Heat Pump

W.B.: Wet Bulb temperature

y: year

# Introduction

[This section should include the objective of the proposed HP 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]*

|  |  |
| --- | --- |
| **Type of facility (e.g. residential building, office, hotel)** |  |
| **Location** |  |
| **Occupancy (number of persons)** |  |
| **Indoor area to be covered (m2)** |  |
| **Indoor volume to be covered (m3)** |  |
| **HP system supplier** |  |
| **Use of the HP system (e.g. heating, cooling, DHW)[[1]](#footnote-2)**  |  |
| **Heating/cooling devices (e.g. radiators, heating floor, fan-coil)** |  |
| **Rated power output per heat pump (kW) (declare the operating conditions)** |  |
| **Installed cost of HP system (*USD* )** |  |
| **Estimated annual energy consumption heating (kWh/y)** |  |
| **COP according EN 14511 (heating mode)** |  |
| **Estimated annual energy consumption cooling (kWh/y)** |  |
| **EER**[[2]](#footnote-3) **according EN14511 (cooling mode)** |  |
| **Estimated annual energy consumption domestic hot water (kWh/y)** |  |
| **COP according EN14511 (DHW mode)** |  |
| **Estimated annual energy savings (kWh/y)** |  |
| **Estimated annual cost savings (*USD* /y)** |  |
| **Simple payback period (years)** |  |
| **Total avoided CO2/y due to HP (kg)** |  |
| **System working days per year** |  |

# Overview of preliminary study of HP appliance

[This section should include dates of preliminary study or audit and data collected from facility or building owner. A general description of the HP system to be installed is required].

*[In case of building retrofit, describe the relation between the existing appliances for heating/cooling/DHW at the building and the HP system to be installed, and specify which parts will be replaced by the new HP system. Specify the rated power output of the existing generation systems].*

# Heat Pump system sizing

[Multiple factors play an important role in determining the HP system size (e.g. type of HP (air to water, water to water), heat source temperature, heat sink temperature, indoor area to be heated or cooled, sanitary hot water energy need, budget, and electricity power available)].

*[Energy efficiency actions can involve the entire building. For example, improving the home insulation decreases the required thermal capacity of the heat pump, and accordingly lowers the building energy demand. This would allow to install a smaller HP unit and, consequently, to save money upfront and over the long-term].*

[The first step to design a HP system is the definition of boundary and design conditions and the evaluation of the heating, cooling and domestic hot water energy needs, since the efficiency and design of a HP system is a function of the capacity ratio].

[In addition to the actual HP appliance, other components are required to ensure the energy efficiency of the system. The specific components required depend on the functional and operational requirements for the system. The main components of a HP system are: heat pumps, 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 heat from a lower temperature heat source to a higher temperature heat sink.*
* *Storage tank for sanitary hot water: storage tank is used to store the sanitary hot water for future use.*
* *Buffer tank (hot, cold): store water to reduce the on/off cycles 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 HP system.*
* *Control unit: takes care of the whole HP system. It could be integrated in the heat pump machine.*
* *Energy meters (electricity, thermal energy) and temperature sensors: they are used to measure the energy efficiency of the whole HP system, and its operating conditions. To be used when the energy efficiency of the whole HP system has 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.*

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

## Boundary Conditions

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

*[Refers to the climatic zones classification, specified in Annex A1].*

*Location Temperature*

|  |  |
| --- | --- |
| **Location\*** |  |
| **Latitude** |  |
| **Longitude** |  |
| **Climatic Zone** |  |
| **Heat source temperature (°C) (in case of ground or water source)** |  |
| **Temperature of the water main (°C)** |  |

\**Please add an image with the exact location of the site on the map.*

## Design Conditions

*[The following table shows the reference outdoor design conditions, according to the specific climatic zone].*

|  |  |  |  |
| --- | --- | --- | --- |
| Climatic Zone | Reference city | Winter (°C) | Summer (°C) |
| Design Dry-Bulb | Design Dry-Bulb |
| 1a - Coastal below 200 m altitudes | Beirut | 7 | 34 |
| 1b - Coastal above 200 m altitudes | Bayssour | - 3 | 34 |
| 2 - Western Mid Mountain | Qartaba | - 4 | 34 |
| 3 - Inland Plateau | Haouch El Oumaraa | - 4 | 34 |
| 4 - High Mountain | Bcharre | - 5 | 34 |

*[To not oversize the heat pump thermal capacity, a backup heating system could be integrated to work at the lowest outdoor temperature. In this case, according to EN 14825:2016, a bivalent temperature should be defined.*

*The bivalent temperature is the lowest outdoor temperature point at which the heat pump has a capacity able to meet 100 % of the heating load without back up heater, below this point, the heat pump can still deliver capacity, but the additional back up heating system is necessary to fulfil the full heating load].*

 *[Please find in Annex A5 the reference climatic data for each climatic zone. If other data are considered, please specify the source of the climatic data adopted for the evaluation of the energy needs and for the HP sizing]*

*[Please specify the indoor and outdoor design temperatures].*

*Design temperatures*

|  |  |
| --- | --- |
| **Outdoor design temperature (°C)** |  |
| **Room Set-Point Temperature (°C) during heating season** |  |
| **Room Set-Point Temperature (°C) during cooling season** |  |
| **Heating Set-Point Temperature (°C)\*** |  |
| **Cooling Set-Point Temperature (°C)** |  |
| **DHW Set-Point Temperature (°C)** |  |

*\*In case of automatic regulation of the HP supply temperature according to the external temperature, describe it.*

## Energy Needs

### Heating and/or Cooling energy needs

 *[Information about heating / cooling energy needs only if it is linked to a hydronic system (e.g. radiator, fan-coil, floor heating and cooling). Please specify the monthly values for a reference year (01=January, 02=February, …, 12=December)].*

*Heating and cooling energy needs*

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

### Domestic hot water demand

*[Estimate the hot water demand].*

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

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

*Monthly DHW Demand (liters)*

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

### Domestic hot water energy needs

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

 *[Assuming the temperature difference and the volume of water requested, the thermal power requirements can be calculated using the following formula:*

$$E\_{DHW}=\frac{ρ∙V∙c∙∆T}{3600·η}$$

*Where:*

* + *EDHW: energy needs for domestic hot water (kWh/month)*
	+ *ρ: density of water = 1 (kg/liter)*
	+ *V: volume of water required (liter/month)*
	+ *c: pure water specific heat (kJ/kg/°C) = 4.18 kJ/kg/°C*
	+ *η: efficiency of the storage tank (%)*
	+ Δ*T: temperature difference between the set point temperature and the temperature of the water main (°C)]*

*[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 108.4 kWh/month to cover the energy needs].*

*[The monthly thermal power for DHW energy needs should be calculated].*

*Monthly DHW energy needs (kWh)*

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

## Heat Pump Selection

*[Once heat, cool and domestic hot water energy needs are stated, appropriate heat pump should be selected].*

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

*[To determine the proper size of the heat pump of the system, the maximum value of energy needs, including thermal losses through distribution system (e.g. piping, heat exchangers), throughout the year, has to be identified].*

*[Depending on the specific system configuration, the heat pump could be designed to cover the entire energy demand of the building or, if there are other generation systems, only a part of it (for example the heat pump could be used only for DHW, etc.). In this case, please detail the system configuration and all the generation systems for the different uses, including also backup systems, if present (e.g. electrical resistance, or the pre-existing system which is going to be replaced by heat pumps)].*

*[To increase the lifetime of the heat pump and to not damage its efficiency, the number of starts of compressor’s heat pump should be limited. Thus, the heat pump thermal capacity should not be oversized. If energy needs vary widely during the year, consider to use a multiple compressor or inverter heat pump, or add a buffer tank, in order to avoid reaching too low HP capacity ratio, which could damage its performance].*

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

*[To improve the performance of the heat pump, the control logics of the operating conditions have a key role (e.g. automatic regulation of the HP supply temperature according to the external temperature)].*

*[Declare the seasonal performance of HP for heating (SCOP) and cooling (SEER), according to EN 14825:2016 standard].*

*[All features concerning the specific site and HP 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 details*

|  |  |
| --- | --- |
| **Number of heat pumps** |  |
| **Type of heat pumps (e.g. air-water, water-water)** |  |
| **Type of refrigerant per heat pump** |  |
| **Global Warming Potential[[3]](#footnote-4) of refrigerant per heat pump** |  |
| **Heat pumps configuration (master-slaves)[[4]](#footnote-5)** |  |
| **Number of compressors per heat pump** |  |
| **Inverter compressor per heat pump (Yes/No) (if inverter compressor, specify the capacity range in %)** |  |
| **Rated power output per heat pump for heating (kW) (declare the operating conditions)** |  |
| **Rated power output per heat pump for cooling (kW) (declare the operating conditions)** |  |
| **Capacity of internal storage per heat pump (if present) (l)** |  |
| **COPEN 14511 per heat pump (heating operating conditions)\*** |  |
| **EEREN 14511 per heat pump (cooling operating conditions)\*** |  |
| **SCOPEN 14825 per heat pump\*** |  |
| **SEEREN 14825 per heat pump\*** |  |
| **Rated voltage per heat pump (V)** |  |

*\*Please attach the source (e.g. test certificate, product brochure).*

## Domestic hot water storage tank sizing (if foreseen)

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

*[As a general rule, for residential units, the dimensioning of a domestic hot water storage tank can be based on a reference value of 20 liters per person (e.g. for a dwelling with 4 occupants, a tank of 80 liters can be used), but this value can change depending on the use of the building (e.g. office, hospital, schools), the habits of the users and other specific aspects (e.g. the water consumption changes if there is a bathtub instead of a shower stall)].*

## Buffer tanks / heating and cooling (if foreseen)

*[The buffer tanks could be useful to reduce the number of on/off cycles of compressor’s heat pump and enlarge his lifetime].*

*[As a general rule, to be verified for the specific application, the dimensioning of buffer tanks for on/off heat pumps can be done based on 15 to 25 liters capacity per kW of heat pump power output at nominal working conditions].*

## Water loop pumps sizing

*[The pump is needed to push enough heat transfer fluid 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 and 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, or check if the heat pump internal pump, if present, is enough.*
4. *Consider to use a variable speed pump, according heat pump manufacturer’s instructions.*
5. *Select a pump(s) of the maximum energy efficiency class].*

*[if pumps are not integrated into the heat pump case, be careful to provide a control system to regulate the running time of pumps according to the working cycle of the heat pump].*

## Location of implementation

*[Please attach a map of the site where the HP system will be installed, highlighting the urban context (e.g. show if there are other buildings near it, specify if there are particular facilities)].*

## Summary of Heat Pump System Components

*[Use manufacturer’s specifications to fill in the HP 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

*[For each Heat Pump, specifications and information will be summarized in the following table].*

*Heat pump Information*

|  |  |
| --- | --- |
| **Manufacturer**  |  |
| **Type/Model** |  |
| **Rated power output for heating (kW)** |  |
| **Rated power output for cooling (kW)** |  |
| **COPEN 14511 (heating mode)** |  |
| **EEREN 14511 (cooling mode)** |  |
| **Type of refrigerant**  |  |
| **Dimensions** |  |
| **Weight** |  |
| **Warranty (years)** |  |
| **Cost (USD)** |  |

*[Heat Pumps COP and EER should be stated according EN 14511 standard].*

### Storage Tank

*[Please summarize the storage tank specifications in the following table].*

*Storage Tank Information*

|  |  |
| --- | --- |
| **Manufacturer**  |  |
| **Number of tanks used** |  |
| **Capacity per tank (L)** |  |
| **Insulation (material, thermal conductivity and thickness)** |  |
| **Heat Exchanger (**Yes/No**)** |  |
| **Cost (USD)** |  |

### Buffer Tanks

*[Please summarize the buffer tanks specifications in the following table].*

*Buffer Tanks Information*

|  |  |
| --- | --- |
| **Manufacturer**  |  |
| **Number of tanks used** |  |
| **Capacity per tank (L)** |  |
| **Insulation (material, thermal conductivity and thickness)** |  |
| **Maximum working temperature** |  |
| **Minimum working temperature** |  |
| **Cost (USD)** |  |

### Water loop pumps

*[Please summarize the pumps specifications in the following table].*

*Pumps Specifications*

|  |  |
| --- | --- |
| **Manufacturer**  |  |
| **Type**  |  |
| **Number of pumps used** |  |
| **Power (W)** |  |
| **Input Voltage (V)** |  |
| **Variable speed pump (Yes/No)** |  |
| **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].*

## Description of the calculation methods

*[Please give an accurate description of calculation methods and simulation tools, if used, for the evaluation of energy needs and dimensioning of each component of the HP system, summarized above].*

*[If a simulation tool has been used, please detail the inputs of the simulation and attach the full simulation report].*

## Electrical, Hydraulic & Mechanical Drawings and Connections

*[Electrical, Hydraulic & Mechanical Drawings and Connections, for each operating mode of the system (e.g. heating, cooling, DHW), 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]**.*

# Post-Installation Measurements

*[To quantify the energy consumptions, the real operating conditions of the heat pump and its real performance, a monitoring data analysis is required].*

*[The minimum set of monitoring data to be collected are: the energy consumption of the heat pump unit, thermal energy output of the heat pump and its operating temperatures (HP supply and return temperatures), temperature and relative humidity for indoor and outdoor conditions].*

*[For simple system configurations made of a single heat pump unit without buffer tank, the HP on-board sensors could already provide the above information. Thus, it is suggested to ask to the HP provider how to get it].*

*[For more complex heat pump system configurations (e.g. heat pump with external buffer tank) or for heat pump with rated power output > 20 kW, the installation of additional monitoring devices is required. So, the additional required measures are: the energy consumption of the auxiliaries (at least those installed between heat pump and buffer tank, or on the circuits directly connected to the heat pump), thermal energy after the buffer tank and the temperature inside it].*

*[All the measurements have to be stored (e.g. data logger, server, cloud service, computer). An internet remote connection to access the monitoring data is suggested, in order to simplify the data analysis and, consequently, to improve the control of the system].*

*[Please detail in the following table the measurements recorded by the HP on-board sensors, specifying the sample time].*

*Measurements’ Sample Time Information*

|  |  |  |
| --- | --- | --- |
| **Ref. No.** | **Measurement** | **Sample****time** |
| **1** | HP electric energy input |  |
| **2** | HP thermal energy output |  |
| **3** | HP supply temperature |  |
| **4** | External temperature |  |
| etc. |  |  |

*[Please detail in the following tables the additional monitoring devices, specifying for each sensor: the type (e.g. for a temperature sensor if it is a thermoresistance or a thermocouple) and the model, the measured physical quantities, the measurement accuracy, the sample time, and the cost].*

*Additional Monitoring Devices’ Information*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Ref. No.** | **Item** | **Type/****Model** | **Measurement** | **Accuracy** | **Sample****time** | **Cost (USD)** |
| **1** | Electric energy meter |  | e.g. electric energy, electric power |  |  |  |
| **2** | Heat meter |  | e.g. thermal energy, supply temperaturereturn temperaturewater flow rate |  |  |  |
| **4** | Temperature sensor |  |  |  |  |  |
| **5** | Temperature sensor |  |  |  |  |  |
| **7** | Data logger |  |  |  |  |  |
| etc. |  |  |  |  |  |  |
| **Total Amount of the HP system (USD)** |  |

*[Please attach a system schematic with the position of the sensors, using the reference number indicated in the previous table].*

# Reference case

*[It is required to define a reference case to evaluate energy savings, cost savings and greenhouse gas emissions reductions].*

*[In case of new constructions the reference case should be defined].*

*[In case of building retrofit, refers to annual consumptions of the existing system that will be replaced by the heat pump system].*

# Financial Analysis

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

*Financial Proposal for HP System Products*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ref. No.** | **Item** | **Item Description** | **Quantity** | **Amount Needed (USD)** |
| **1** | Heat Pump |  |  |  |
| **2** | Pump |  |  |  |
| **3** | Controller |  |  |  |
| **4** | Sanitary and buffer tanks |  |  |  |
| **5** | Electric energy meters |  |  |  |
| **6** | Heat meters |  |  |  |
| **7** | Temperature sensors |  |  |  |
| **8** | Data logger |  |  |  |
| **9** | Accessories |  |  |  |
| **10** | Installation |  |  |  |
| **11** | VAT |  |  |  |
| **Total Amount of the HP 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 HP system options, determine the most cost-effective system designs, and give the client a global view of the advantages and benefits of his investment in such projects, the life cycle cost analysis of the HP 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. An example is explained in annex A3].*

*Yearly Cost Savings*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Energy demand covered by the HP system (kWh)*** | ***Energy consumptions of the reference case (e.g. kWhel)*** | ***Energy cost of the reference case (USD)*** | ***Energy consumptions of the HP system (kWhel)*** | ***Energy cost of the HP system (USD)*** | ***Cost Savings (USD)*** |
|  |  |  |  |  |  |

*[Energy and Cost Savings must be detailed].*

*Simple payback time*

|  |  |  |
| --- | --- | --- |
| ***Implementation Cost (USD)*** | ***Cost Savings (USD /year)*** | ***Simple payback time (year)*** |
|  |  |  |

$$Simple payback time=\frac{Implementation Cost}{Cost Savings}$$

*[The implementation cost represents the initial investment including the cost of all the new components of the HP system and the installation cost].*

*[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 greenhouse gas emissions must be provided and detailed, separately for each energy source (e.g. grid electricity, diesel generator, fuel)].*

*[Refers to the greenhouse emissions factors specified in annex].*

# Conclusion

*[The conclusion of the HP 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 HP system*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***HP System Description*** | ***Energy Savings (kWh/year)*** | ***Cost Savings (USD /year)*** | ***Implementation Cost (USD)*** | ***Simple Payback Period (year)*** | ***tCO2 reduced*** |
|  |  |  |  |  |  |

* *ESCO’s or consultants 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*
* *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]*

# **ANNEX**

## A1. Lebanese climatic zones

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

The Climatic Zone 1, which corresponds to the coastal region, is split into two subzones:

* zone 1a: which includes those cities whose altitude is below 200 m;
* zone 1b: which includes those cities whose altitude is above 200 m.

The table below contains cities belonging to Zone 1. To identify the specific subzone (1a or 1b), refer to the altitude of the considered city, as explained previously.

|  |  |  |
| --- | --- | --- |
| **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***

|  |  |  |
| --- | --- | --- |
| **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.***

## A2. COP and EER test conditions according EN 14511

The COP and EER values have to be referred to the test conditions specified in the European standard EN14511 for air-to-water (brine) units:

* COP (heating mode):
	+ Low temperature condition: *Air inlet: 7°C D.B. - 6°C W.B. – Water outlet/inlet: 35/30°C*
	+ Intermediate temperature condition: *Air inlet: 7°C D.B. - 6°C W.B. – Water outlet/inlet: 45/40°C*
	+ Medium temperature condition: *Air inlet: 7°C D.B. - 6°C W.B. – Water outlet/inlet: 55/47°C*
	+ High temperature condition: *Air inlet: 7°C D.B. - 6°C W.B. – Water outlet/inlet: 65/55°C*
* EER (cooling mode): *Air inlet: 35°C D.B. – Water outlet/inlet: 7/12°C*

## A.3 Example of evaluation of yearly cost savings

The following table represents an example of calculation of yearly cost savings on energy consumption, between the HP system and the reference case, described in chapter 1.5.

In this example, the reference case is based on a “Business as Usual” case, where the DHW demand is covered by an electrical resistance, with an efficiency of 1, while the actual solution consists of an air water heat pump, with a Seasonal COP of 3.

Considering 0.06 USD/kWhel as price for electrical energy, for this example there would be a yearly cost saving on energy consumption of 40 USD.

*Yearly Cost Savings*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ***Energy demand covered by the HP system (kWh)*** | ***Energy consumption of the reference case (e.g. kWhel)*** | ***Energy cost of the reference case (USD)*** | ***Energy consumption of the HP system (kWhel)*** | ***Energy cost of the HP system (USD)*** | ***Cost Savings (USD)*** |
| 1000 | 1000 | 60 | 333 | 20 | 40 |

## A4. Energy conversion factors for Greenhouse Gas emissions

 *Energy Conversion Factors*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Fuel Type** | **Net Calorific Value (TJ/Gg)** | **Effective CO2 emission factor (Kg/TJ)** | **Units** | **kgCO2 per unit**  |
| **Grid electricity** | - | - | kWh | 0.65 |
| **Gas/Diesel Oil** | 43.3 | 74 800 | Tonnes | 3238.84 |
| **Liquefied Petroleum Gases (LPG)**  | 52.2 | 65 600 | Tonnes | 3424.32 |
| **Natural Gas**  | 50.4 | 58 300 | Tonnes | 2938.32 |
| **Residual Fuel Oil**  | 41.7 | 78 800 | Tonnes | 3285.96 |
| **Petroleum Coke** | 41.9 | 115 000 | Tonnes | 4818.5 |
| **Wood Pellets**  | 31 | 132 000 | Tonnes | 4092 |

***\*Source: IPCC Guidelines for National Greenhouse Gas Inventories.***

## A5. Climatic data for each climatic zone

The reference climatic data for each climatic zone can be downloaded at the following links.

For each climatic zone two different files are provided:

* “Yearly external temperatures”: hourly temperatures of the typical meteorological year

<http://lcec.org.lb/Content/uploads/LCECOther/Hourly_Climatic_Data_Lebanon.xlsx>

* “External temperatures bins”: sum of all hours occurring at a given external temperature\*

<http://lcec.org.lb/Content/uploads/LCECOther/Bin-Climatic-Data-Lebanon.xlsx>

*\*(bin width = 1 K, number of hours for bin Tj corresponds to the number of hours whose external temperature* 𝜗 *is inside the range: Tj – 1 <* θ *<= Tj ).*

1. *This form refers to different use of the system that can vary according to the specific situation (e.g. only DHW, space heating and DHW, space heating and cooling). Please complete only the fields related to the uses of the specific system solution in the proposal.* [↑](#footnote-ref-2)
2. *EER is equivalent to the COP in cooling mode.* [↑](#footnote-ref-3)
3. *Global Warming Potential (GWP) represents the climatic warming potential of a greenhouse gas relative to that of carbon dioxide (CO2), calculated in terms of the 100year warming potential of one tonne of a greenhouse gas relative to one tonne of CO2.* [↑](#footnote-ref-4)
4. *In case of projects with heat pumps working in cascade configuration (more than one heat pump installed in the same HP system).* [↑](#footnote-ref-5)