Heat Pump Project – Phase 1

Introduction
Lebanon external energy dependency ratio is very high (above 95%) since electricity is either imported or produced by imported fuel with a small fraction produced by renewable energy sources (hydro is the only relevant renewable energy source for the electricity sector).

Power peak demand is higher than the installed supply capacity. Due to this deficit, the Greater Beirut area suffers from power cuts for 3 hours per day on average, the South for 8.2 hours per day and the whole country for about 6 hours per day\(^1\). When electricity is not available from the grid, it is mostly produced locally through privately-owned diesel engines, leading to an increase of generation costs, worsening the carbon emission factors, and increasing production of air pollutants. To this end, climate change mitigation strategies represent a priority for Lebanon.

Lebanon aims to embark on a long-term low-emission and climate resilient development trajectory to ensure a sustainable future for its population, despite its current challenging national circumstances. In September 2015, Lebanon presented the “Intended Nationally Determined Contribution” (INDC) under the United Nations Framework Convention on Climate Change (UNFCCC) that foresees the following targets (Conditional): 1) GHG emission reduction of 30% compared to the business-as-usual scenario in 2030; 2) 20% of the power and heat demand in 2030 is generated by renewable energy sources; 3) 10% reduction in power demand through energy efficiency measures in 2030 compared to the demand under the business-as-usual scenario.

Renewable energy technologies (RES) and energy efficiency measures can significantly help Lebanon in implementing its ambitious climate change mitigation targets, also reducing energy dependency on foreign countries. According to MED-DESIRE study\(^2\) electricity is the main energy vector both for residential sector (58%) and industry (54%). Moreover 81% of Lebanese residences use electric heaters for domestic hot water\(^3\) (DHW).

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\(^1\) UNDP/CEDRO 2013


\(^3\) Lebanon’s First National Survey Study of The Solar Water Heaters Market, UNDP/GEF, 2014
General Objective
Support the Lebanese government in addressing the climate change mitigation challenges presented in the INDC under the UNFCCC by introducing “heat pump” technologies in the heating, domestic hot water production and cooling sectors (for residential and tertiary applications mainly) through know-how and technology transfer, in line with the European legislation and Montreal Protocol for the phasing out of the high global warming potential refrigerant gases (fluorinated greenhouse gases - including hydrofluorocarbons -HFCs).

This objective will be achieved through following specific actions:

- Ensure the quality of products on the market, in line with the European legislation and Montreal Protocol (see annex 1) on the use of high global warming potential gases (fluorinated greenhouse gases, including hydrofluorocarbons - HFCs)
- Establish a capacity and infrastructure which can make Lebanon a landmark for Energy Efficiency in Middle Eastern countries: for Lebanese assemblers of Italian components, for potential future local manufacturers of heat pumps and air conditioners, for research institutes working on heating and cooling technologies;
- Ensure the quality in design and installation of vapour compression technologies (e.g. air conditioners and heat pumps) for domestic hot water, heating and cooling plants;
- Demonstrate the economic and environmental advantage of such systems through pilot applications in Lebanese buildings (for residential and tertiary sectors mainly).

Project Activities
The two following lines of project activities are devoted to reach two complementary aims:

1. quality insurance of the heat pumps/air conditioners for the DHW and space heating that will penetrate the Lebanese market in the next years. This will be carried out by setting up the infrastructures and the regulatory measures needed for establishing a product certification system for these appliances, in line with the European legislations.
2. accelerate the decarbonisation rate of the DHW, air conditioning and space heating sectors (based on vapour compression technology) through the penetration of highly efficient technologies in the Lebanese market.

Component 1 Establishment a national test laboratory for quality insurance and certification of domestic hot water production, air conditioners and heat pump products
Component 1.a): Design and construction of a national test laboratory for vapour compression system used for: domestic hot water production, air conditioners and heat pump

The heat pump market is just starting in Lebanon. No official test lab for this category of appliances is operating and no certification schemes are in force. Therefore the implementation of actions aiming at the assessment of the level of efficiency of such systems, will have a key role in driving the use of these technologies towards the decarbonisation process planned in the “INDCs”. Furthermore the national laboratory will ensure the quality of products on the market, in line with the European legislations and Montreal Protocol in view of the phasing out of the high global warming potential refrigerant gases (fluorinated greenhouse gases, including hydrofluorocarbons - HFCs).

In the framework of the current project, the first national test laboratory for vapour compression appliances used in the residential and tertiary Lebanese sectors (DHW production, air conditioning and space heating) will be designed and constructed. The lab will consist of a climatic chamber which will be provided by an Italian manufacturer. The latter selected by LCEC on the basis of an open, public and transparent tender procedure.

Following activities are planned:

1. Identification of requirements for the test lab:
   
   In this phase of the project relevant rules and regulations in which the design choices have to be taken will be defined, keeping in mind specific Lebanese environmental boundary conditions and the type of vapour compression products for use in buildings which are likely to enter the Lebanese market.

2. Selection of site:

   A suitable site for hosting the laboratory will be selected based on technical requirements and the needs of the staff which will run the laboratory. Among the required technical characteristics, the following can be mentioned: availability of utilities (electricity, water, heat…) with sufficient capacity and stability, availability of space (for the laboratory itself, the auxiliary systems, offices and for a store room, for both appliances to be tested and tools).

3. Design of test lab facility:

   A detailed layout of the laboratory will be designed, aiming at achieving flexible and reliable use and taking into account both, the current needs and possible further developments of regulations.
Technical specifications of the test installation will be produced to define all components of the lab and to ensure performances, measurement accuracy, quality of materials, functionality, security and management procedures that could have an impact on the final product.

Taking into account the regulation requirements identified in activity a1), the standard prescriptions collected in action b) and the site characteristics, the laboratory will be designed both in terms of technical features and minimum performance. In particular:

- Test rooms size and construction characteristics;
- Flow rates and temperature ranges of hydronic circuits;
- Temperature and humidity range of the air in the test rooms;
- Cooling and heating power of the auxiliary system;
- Accuracy of flow rate, temperature and humidity regulation;
- Accuracy of measurement sensors.

4. Procurement of test lab facility:

   Based on the design phase, a tender document will be written to define, in accordance with other Lebanese entities involved in this phase, specific procedures, all procurement components and potential manufacturers who can fully satisfy them. The tender for the climatic chamber will be addressed to Italian manufacturers.

5. Installation of test lab facility:

   The installation of the test facility will be carried out by the manufacturer selected in activity a4). Moreover, installation work will be supervised by LCEC in order to ensure compliance with the requirements and to share with the manufacturer specific decisions on issues arising during the installation phase.

6. Commissioning of test lab facility:

   At the end of the construction and installation phase the technical features and performances of the laboratory will be verified and the facility will be fully commissioned in accordance with the tender requirements.

1.b): Creation of national standards for products testing employed for domestic hot water production, air conditioning and space heating based on vapour compression technologies

   1. Review and analysis of existing European Framework Standards for testing products used in DHW production, air conditioning and space heating.

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4 Main European standards currently in force:
EN 14511 - Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling
EN 14825 - Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling - Testing and rating at part load conditions and calculation of seasonal
The European Standards provide indication about the test procedure and the required accuracy for measuring the performances of heat pumps in heating mode, cooling mode and for DHW production. As currently European Standards represent the state of the art for these products testing, they can be used as reference for the preparation of the Lebanese national standards.

2. Adaptation of standards to Lebanese conditions:
Within this activity the European standards will be analyzed to verify their applicability to Lebanon and, if needed, adapted. Most likely it will be necessary to update the test conditions to be used for the calculation of the seasonal performance indexes. European Standards provide test conditions related to three reference European climate conditions, namely cold, average and warm climate. The adaptation of the European Standards, will probably require the definition of new test conditions, representative of the climate condition(s) found in Lebanon.

3. Issuing of a Lebanese national standard:
A new Lebanese national standard will be issued based on the test procedure specifically defined for the Lebanese conditions.

1.c): Transfer know how on DHW, air conditioning and heat pump lab testing according to the procedures defined in the previous task and dissemination to the main stakeholders

1. Realization of training sessions:
To achieve the full functionality of the laboratory, the personnel will be trained on both, the use of the laboratory and the new standards. A single training session will cover both the topics with a theoretical part on standards and the main laboratory features, followed by the application of the procedure in the laboratory.
Target of the training session will be the laboratory staff, but also university professors or researchers that may benefit of the laboratory to carry out their research on domestic hot water production, heating and cooling appliances.
In particular, the training session about the use of the laboratory will include:
- training about the laboratory conduction and maintenance
- training about sensors calibration
- training about installation of the product to test in the lab facility and training about the laboratory operation: regulation of flow rate, water, temperatures, improvement of stability etc.

2. Realization of first pilot tests:

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performance
EN 16147 - Testing of Heat Pumps for Domestic Hot Water Production
Pilot tests on the different standards covered by the laboratory will be carried to verify the full functionality of the laboratory and its capability to meet the requirements. Moreover, the pilot test may represent an opportunity to test the training of the staff operating in the laboratory and to set up, if needed, an additional training session to cover possible gaps. For this first set of pilot tests to enter in the Lebanese market priority will be given to Italian products.

3. Initiate the accreditation of the testing lab according to ISO/IEC 17025:
   A deep analysis of the required procedures for the accreditation of the test lab according to ISO/IEC 17025 will be done and consequently all preparatory steps will be implemented. The accreditation timeframe depends on external factors and falls beyond the aims the current project.

4. Preparation of dissemination material:
   In order to disseminate the most important component results, one brochure will be developed, layouted and printed (at least 1,000 copies).
   The brochure will cover the test laboratory and testing activities. The brochure will be tailored for both non-technical audience and a technical section for designers, installers and researchers.

5. Final workshop for public administration representatives, installers, designers, researchers
   Technical results gathered during this project component need to be widespread towards designers, installers and researchers. A result-oriented workshop will be organized at the end of the project component, showing the results of all activities.

Component 2: Establishment of a financial mechanism and a monitoring scheme for highly efficient DHW, air conditioners and space heating appliances based on vapour compression technology

2. a): Provision of financial incentives for the realization of DHW, air conditioning/heat pump installations in buildings
This component foresees, in the framework of the already existing National Lebanese Financing mechanism (NEEREA), the establishment of financial incentives for the installation of demonstrative plants (to reach 60 depending on type of technologies and size) with vapour compression technologies in both residential and tertiary sectors.

The Lebanese financial contribution will be utilized in order to provide soft loan through NEEREA for the systems installed in the residential sector (small and medium capacity) and tertiary sector.
The IMELS financial contribution will be reserved to Italian manufacturers in order to cover, through NEEREA, the 30% of investment costs (grant) of the systems foreseen in the tertiary sector and only for those technologies which use lower Global Warming Potential (GWP) refrigerants than HFCs.

Following activities are planned:

1. Feasibility study and preliminary design of demonstrative plants, preparation of NEEREA guidelines:
   Typical Lebanese building typologies will be identified based on previous applications to NEREEA program. Focus will be put on heating, cooling and domestic hot water production and distribution. Based on the know-how gathered, approaches for the integration of these technologies in typical Lebanese buildings will be developed as basis for successive feasibility studies. Such feasibility studies will analyse each of the selected sites for demonstrative plants and develop suggestions for integrating the mentioned technologies in buildings. Each feasibility study will address:
   - Hydraulic integration of DHW, air conditioning and space heating systems based on vapour compression technologies according to experience in other markets and to peculiarities of Lebanese framework conditions;
   - Minimum requirements in terms of hydraulic components;
   - Minimum requirements in terms of electric plant;
   - Special requirements in terms of encumbrance, positioning of the appliances, Lebanese standards;
   - For installations falling under the performance-monitoring program: description of monitoring equipment, its characteristics and special requirements in terms of encumbrance, electricity supply, hydraulic integration and placements, maintenance;
   - For installations falling under the performance-monitoring program: requirements in terms of data connection, communication protocol and data format;

A specific guideline for DHW, air conditioning and space heating systems based on vapour compression technologies, to be used by applicants for requesting NEREEA contribution (http://lcec.org.lb), will be developed.

2. Training for optimal installation of demonstrative systems and monitoring devices:
   One training course will be organised for training designers and installers at national level in order to ensure quality of successive demonstrative installations. Contents will include:
• General description of the used vapour compression technologies (DHW, air conditioning and heat pumps) technology, state of the art in most developed markets worldwide, available products in Lebanon;
• Description of the NEREEA mechanism and application process, with focus on the demonstration projects financed in the framework of IMELS contribution;
• Detailed analysis of the guidelines developed in the previous activity;
• Detailed description of selected measurement technology and its specific requirements, including lessons learnt from previous experiences.

3. Co-financing of the demonstration installations (including the monitoring devices) through the financial mechanism. The IMELS grant will be reserved to Italian manufacturers and only for those technologies which use lower GWP refrigerants than HFCs:
Dedicated rules for application to NEREEA mechanism will be developed for the demonstration projects financed in the framework of IMELS contribution. Such rules should make sure that:
• designers and/or installers have been trained or have previous experience with the vapour compression technologies used for DHW. Air conditioning and space heating in buildings and with measurement equipment (the latter for projects to be monitored);
• the installed appliances are purchased from Italian manufacturers
• access to plants is ensured for the whole duration of the project, in order to guarantee performance monitoring.

4. Co-financing of the appliances installations through a soft loan according to NEEREA mechanism
See previous point.

5. Support in NEEREA financing submission and approval:
Technical support to the NEEREA unit at the LCEC in order to evaluate NEEREA applications related to vapour compression technologies in buildings. Such support will be first given by external experts through a preliminary training and afterwards through remote cooperation on each single application.

6. Expert supervision of installations for best practice installation:
Once approved, each project will be followed by an expert technician through on-site visits, aimed at checking the demonstrative installations and (if applicable) monitoring devices.

2.b): Design and realize an energy performance monitoring program for DHW appliances, air conditioners and heat pumps under real operation conditions
1. Setting-up an energy performance monitoring program for half of the sites selected in the previous activity:
   - definition of procedures and authorization request for entering the buildings hosting the appliances;
   - definition of performance indicators;
   - definition and implementation of algorithms for performance indicator calculation;
   - development of an online portal with access control, to enable different subjects to access different views of the collected data and performance results (e.g., users may access a single plant or multiple plants, may see simplified or detailed data charts and views);
   - preparation of information technology (IT) infrastructure (main servers, backup systems) to host the data collection and the online portal, and to enable the calculation of the indicators;
   - implementation of alarm functions ensuring correct operation of monitoring equipment.

2. Collection of monitoring data remotely:
   - addition of all plants selected for the monitoring activity to the IT infrastructure;
   - assessment of remote connection capabilities (e.g., connection difficulties, problems in retrieving data);
   - collection of monitoring data;
   - assessment of data and identification of possible sensors installation problems (e.g., wiring problems in temperature sensors or electricity meters).

3. Elaboration of monitoring results:
   - calculation of performance indicators and accompanying charts for all plants;
   - correlation analysis between performance results and environmental conditions, HVAC system settings, building conditions;
   - upload of all results on the online portal.

4. Identification of possible improvements for efficiency optimization:
   Evaluation of efficiency will be made for all plants and suggestions for efficiency improvements will be developed.

2.c): Dissemination activities in Lebanon, Italy and EU: at start of Component 2 activities in order to identify beneficiaries of pilot plants; during the Component 2 to disseminate results.

1. Work out technical guidelines for design and installation of the appliances in Lebanese buildings:
Based on know-how gathered in Italy and other European partners and on initial results of activity 2.a.1), a technical guideline for designers, installers and end users will be developed by external experts. It will describe the mentioned technologies, suggest best practice integration schemes, positioning of monitoring equipment and sensors, suitable control strategies, hydraulic integration into the heat distribution system, etc. Based on final results of activities 2.a.1) and 2.b.3), the technical guideline will later on be updated. This document will be made available by LCEC to as many operators and persons as possible (e.g. on NEREEA website), in order to widespread best practices and lessons learned about the use of the appliances in buildings.

2. Preparation of dissemination material:
   In order to disseminate the most important project results, one brochures will be developed, layout and printed (at least 1,000 copies).
   The brochure will cover demonstration plants and monitoring program. The brochure will be tailored for non-technical audience, with a technical section for designers and installers who have not been involved in one or more project activities.

3. Workshop with stakeholders for identification of beneficiaries
   Since vapour compression appliances, used to cover all the needs of a a building, are new technologies in Lebanon (particularly for DHW and space heating), and in order to reach enough NEREEA applications (to reach 60 demonstration projects), potential beneficiaries will be contacted directly or indirectly by LCEC. One workshop with stakeholders selected by LCEC will therefore be organized during the first year, in order to collect suggestions to later on identify potential beneficiaries of NEREEA/IMELS contribution under component d).

4. Final workshop for installers, designers, large building owners and facility managers
   Technical results gathered during the project need to be widespread towards designers and installers, building owners and facility managers. A result-oriented workshop will be organized at the end of the project, showing results of all activities.

➢ Phase 1
While the abovementioned project activities elaborate on the overall aspects of the project, it is important to highlight the below specificities of this Phase 1:

Component 1.a) (Phase 1) includes the following activities:
1. Identification of requirements for the test lab
2. Selection of site
3. Design of test lab facility
4. Procurement of test lab facility
5. Initiation of the installation of test lab facility
   The finalization of the installation will need to be performed throughout another phase of this project, same for the final testing and commissioning of test lab facility:

Component 1.b) (Phase 1) includes the following activities:
1. Review and analysis of existing European Framework Standards for testing products used in DHW production, air conditioning and space heating
2. Adaptation of standards to Lebanese conditions
3. Initiation of the administrative process towards issuing of a Lebanese national standard
   The technical and legal follow-up on this process needs to continue throughout another phase of this project.

Component 1.c) including the training sessions on the testing facility, pilot tests and initiation of the accreditation process as per ISO/IEC 17025 will need to be performed after finalization of the installation of the testing facility and will be part of the next phase of the project.

Component 2.a) (Phase 1) includes the following activities:
These component activities need to continue throughout the next phases in order to increase the market penetration of the technology and therefore to have a higher impact and leverage for the project.

1. Feasibility study and preliminary design of demonstrative plants, preparation of NEEREA guidelines
2. Training for optimal installation of demonstrative systems and monitoring devices
3. Co-financing of the demonstration installations (including the monitoring devices) through the financial mechanism. The IMELS grant will be reserved to Italian manufacturers and only for those technologies which use lower GWP refrigerants than HFCs and which are in line with the Kigali Amendment to the Montreal Protocol
4. Co-financing of the appliances installations through a soft loan according to NEEREA mechanism
5. Support in NEEREA financing submission and approval
6. Expert supervision of installations for best practice installation
Component 2.b) (Phase 1) includes the following activities:

These component activities need to continue throughout the next phases in order to increase the market penetration of the technology and therefore to have a higher impact and leverage for the project.

1. Setting-up an energy performance monitoring program for half of the sites selected in the previous activity
2. Collection of monitoring data remotely
3. Elaboration of monitoring results

Identification of possible improvements for efficiency optimization will have to be performed during the next phase of this project based on the monitoring results.

Component 2.c) (Phase 1) includes the following activities:

1. Work out technical guidelines for design and installation of the appliances in Lebanese buildings
2. Preparation of dissemination material
3. Workshop with stakeholders for identification of beneficiaries

The technical guidelines developed during this phase will need to be updated in the next phase of the project based on the results of the monitoring process for the pilot projects. A Final workshop for installers, designers, large building owners and facility managers needs to be held at the end of all phases of the project to disseminate and capitalize on all project results.

- Stakeholders

A. Role of Italian companies in each project phase

1. Design and construction of a national test laboratory for vapour compression system used for: domestic hot water production, air conditioners and heat pump:
   - Italian climatic chamber and lab instruments manufacturer will delivery of the test laboratory.
2. Transfer know-how on lab testing according to the procedures defined in previous task:
   - Italian appliances manufacturers will be beneficiaries of first set of pilot tests to enter the Lebanese market.
3. Selection of heat pump projects among those submitted for NEEREA financial support:
   - Projects based on Italian technology will have priority.
4. Design and realize an energy performance monitoring program for the aforementioned systems under real operation conditions
• The Italian system/technology manufacturers will have access to monitoring data collected.

5. Dissemination activities in Lebanon and Italy
   • The Italian system/technology manufacturers will benefit from know how collected during the project.

B. Public and Private actors involved in the development of the project
   Lebanese Center for Energy Conservation (LCEC), Italian Ministry for the Environment, Land and Sea (IMELS), Lebanese Ministry of Energy and Water, Central Bank of Lebanon, Lebanese Standards Institution (LIBNOR), research institutes and test labs.

- Project Duration – Phase 1
  18 months
### Activity

**Component 1 Establish a national test laboratory for quality insurance and certification of domestic hot water production, air-conditioners and heat pump products**

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#### Design and construction of a national test laboratory for heat pumps

1. **1.a**
   - Identification of requirements for the test lab
   - Selection of site
   - Design of test lab facility
   - Procurement of test lab facility
   - Installation of test lab facility (to be continued in Phase 2)
   - Commissioning of test lab facility (Phase 2)

#### Creation of national standards for heat pumps testing

1. **1.b**
   - Review and analysis of existing European Framework Standards for heat pump testing
   - Adaptation of standards to Lebanese conditions
   - Issuing of a Lebanese national standard

#### Transfer know-how on heat pump lab testing according to the procedures defined in the previous task (Phase 2)

1. **1.c**
   - Realization of training sessions (Phase 2)
   - Realization of first pilot tests (Phase 2)
   - Initiate the accreditation of the testing lab as per ISO/IEC 17025 (Phase 2)
## Activity

**Component 2: Financial mechanism and monitoring of operation of highly efficient DHW, air-conditioners and heating appliances based on vapour compression technology**

### 2.a Realization of heat pump installations (at least 60) through financial incentives (mix loan and grant), including the monitoring devices

1. Feasibility study and preliminary design of demonstrative plants, preparation of NEEREA guidelines for heat pump projects
2. Training for optimal installation of Heat pump systems and monitoring devices
3. Co-financing of the heat pumps installations (including the monitoring devices) through a IMELS grant.
4. Co-financing of the installations through a soft loan according to NEEREA mechanism
5. Support in NEEREA financing submission and approval; supervision of installation work
6. Expert supervision of installations for best practice installation

### 2.b Design and realize an energy performance monitoring program for heat pump under real operation conditions

1. Setting-up an energy performance monitoring program for 30 sites (out of the 60 installations) selected in the previous activity
2. Collection of monitoring data remotely
3. Elaboration of monitoring results
4. Identification of possible improvements for efficiency optimization (Phase 2)

### 2.c Dissemination activities in Lebanon and EU: at project beginning in order to identify beneficiaries of pilot plants; during the project to disseminate results

1. Work out guidelines for design and installation of heat pumps in Lebanese buildings
2. Preparation of dissemination material
3. Workshop with stakeholders for identification of beneficiaries (installation of heatpumps)
4. Final workshop for installers and designers (Phase 2)
5. Final workshop for large building owners and facility management (Phase 2)
## Project Budget – Phase 1

Total Budget: 2,550,831 €

IMELS contribution: 1,976,766 € (Component 1 – 1,379,525 €, Component 2 – 597,242 €)

LCEC Contribution: 574,065 € (361,565 € for soft loan and 212,500 € of human resources)

<table>
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<tr>
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- Total: 479,454 | 1,256,569 | 812,809 | 276,959 | 950,301 | 747,506 | 200,495 | 308,267 | 65,303
Annex 1

Vapour compression products for Domestic Hot Water production, Air Conditioning and Space Heating in Italy and Lebanon
What are Vapour compression products for Domestic Hot Water production, Air Conditioning and Space Heating?

Heat Pumps on the market mainly use two kinds of technologies: vapour-compression and sorption. The former are driven by electricity, the latter by heat (either hot water/vapour or exhaust gas from burning processes). Vapour-compression Heat Pumps are by far the most common technology, although several projects are currently ongoing in Europe, with the purpose of improving the availability and the market share of sorption heat pumps.

Heat pumps are appliances capable of delivering heating energy, “pumping” the heat from a colder to a warmer environment. Heat pump technology is well-known since the middle of the 19th century, but has raised lots of interest in recent years, following the trend towards renewable energy and energy efficiency: part of the delivered heat is indeed subtracted from the ambient (air, water or ground), thus reducing fossil energy consumption.

It is therefore important to distinguish between heat pumps conceived for heating (and DHW production) and heat pumps conceived for cooling. Both can basically be reversed and provide both, heating and cooling, but the former are optimised for delivering heat and are the scope of the present project. The latter, contrariwise, are optimised for delivering cooling and this process does not imply any benefit in terms of renewable energy: they are therefore not especially targeted by the project.

The present project aims at diffusion of heat pumps for heating and cooling purposes in Lebanon. Heat pumps will be integrated in buildings so as to deliver heat for domestic hot water and/or space heating, thus ensuring a high renewable energy contribution.
The international framework for Heat Pump technology

Heat Pump technology represents a valuable option for increasing energy efficiency and cover part of the energy demand with RES in domestic hot water production and space heating and cooling (where space heating and cooling is needed).

More than 7.5 million heat pump units are currently installed in Europe, using renewable energy from air, water and ground to provide building’s heating, cooling and hot water demand. Size ranges from small units for single family houses to large industrial installations and district heating applications. Benefits of these appliances include energy saving, use of renewable energy sources and reduction of CO₂ emissions. Major manufacturers are mostly established in Europe and Italy especially (a non-exhaustive list of Italian companies is available in the next paragraph).

In February 2016, the European Commission proposed an EU heating and cooling strategy⁵, namely its first ever plan to tackle the massive amount of energy used to heat and cool Europe’s buildings. In the official document⁶, as well in working documents⁷, heat pumps represent one of the key technologies to increase energy efficiency in the DHW, space heating and cooling sectors.

European Governments are engaged in improving framework conditions for renewable energy sources through European legislation: the Directives on renewable energy (2009), energy performance of buildings (2010), energy efficiency (2012), and the regulation on Ecodesign and the Energy Label (2013). All such legislative provisions consider these systems as one of the key technologies for covering the building energy needs. Some countries, such as Germany, are already introducing incentives for power-to-heat technologies, heat pumps being one of the most promising.⁸

In terms of financial incentives, heat pumps are supported in many European countries, such as Germany, Austria, France, Belgium, and Sweden⁹. Italy strongly supports these

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⁹ Heat Pump Implementation Scenarios until 2030, Ecofys, 2013
appliances, as well as other renewable and energy efficiency measures, through a tax
deduction of 65%\textsuperscript{10} and the so called “Conto Energia Termico”\textsuperscript{11}.

\textit{Are there risks for the Environment?}

To control emissions from fluorinated greenhouse gases (F-gases), including
hydrofluorocarbons (HFCs), the European Union has adopted two legislative acts: the
Regulation’ which covers all other key applications in which F-gases are used. The latter
(http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R0842), adopted in
2006, is being replaced by a new Regulation adopted in 2014 which applies from 1 January
2015. This strengthens the existing measures and introduces a number of far-reaching
changes by:

- Limiting the total amount of the most important F-gases that can be sold in the EU
  from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in
  2030. This will be the main driver of the move towards more climate-friendly
  technologies;
- Banning the use of F-gases in many new types of equipment where less harmful
  alternatives are widely available, such as fridges in homes or supermarkets, air
  conditioning and foams and aerosols;
- Preventing emissions of F-gases from existing equipment by requiring checks,
  proper servicing and recovery of the gases at the end of the equipment’s life.

The EU has also proposed global action on HFCs under the Montreal Protocol beginning
with a 2019 freeze on production and use in developing countries, and a reduction target
of 85% for developed states. The EU is consulting stakeholders on a draft regulation on
labelling on F-gas appliances and on a regulation on requirements for certification
companies and installers on F-gases.

For what specifically concerns these appliances, technology manufacturers and suppliers
will have to apply the required changes, in particular to reduce or completely avoid the
use of high Global Warming Potential gases. This will definitely not affect the role of heat
pump technology in the European and world markets, but rather lead to technical
adjustments (some manufacturers already started switching to new gases), which will
need to be tested and/or certified by third party laboratories.

\textsuperscript{10} http://www.acs.enea.it/
\textsuperscript{11} http://www.gse.it/it/Conto\%20Termico/Conto\%20Termico\%202.0/Pagine/default.aspx
As a conclusion, the phase out of refrigerants with high GHG potential will solve the only environmental risk connected to the use of vapour compression technologies in buildings. They will most probably be replaced with “natural” refrigerants, leaving unchanged the potential for energy saving connected to these technologies.

**Heat pumps market in Italy**

Heat pumps are a booming technology: in 2014 approximately 800,000 units have been sold in Europe, thus reaching 7.5 million of systems in operation. Italy was the second largest market, with 100,700 units and a cumulative value of 200,000 systems in operation. This is still far below the market potential, which has been estimated in roughly 700,000 units per year in Italy.\(^{12}\)

Several manufacturers and distributors are operating in Italy, among them many Italian companies. Some brands are listed below:

Aermec, Alfa Laval, Ariston, Blue Box Group, Carrier Distribution Italy, Climaveneta, Clivet, Daikin Air Conditioning Italy, Ebm-Papst, Emerson Climate Technologies, Ferroli, Galletti, Haier A/C (Italy) Trading, Hidros, Hitachi Air Conditioning Europe – Branch Italy, Mitsubishi Electric Europe, Rhoss, Riello, Robur, Sabiana, Sanyo Argo Clima, Sic, Siemens Building Technologies, Tecnoclima, Termal Hot Wave, Tonon Forty, Viessmann, Vortice Elettrosociali.

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Heat pump market in Lebanon and its potential

Heat Pump market is just starting in Lebanon. No official test lab for Heat Pumps is operating and no certification is required for heat pumps in order to enter the Lebanese market.

The potential impact of this technology in Lebanon has been estimated for DHW uses in residential buildings under the following hypothesis:

- 81% of Lebanese households are currently using electric boilers;
- 5% of electric boilers installed in existing buildings\(^\text{13}\) (year 2016) could be easily substituted yearly with electric Heat Pumps;
- All new buildings\(^\text{14}\) (starting 2017) are equipped with Heat Pumps;
- The average Coefficient of Performance (COP) for domestic hot water production of Heat Pumps in Lebanon is 2.4\(^\text{15}\);
- The average energy demand for domestic hot water production per person in Lebanon equals 170 kWh/y\(^\text{16}\);
- CO\(_2\) emission factor for electricity in Lebanon is 0.768\(^\text{17}\) g/kWh.

Under abovementioned conditions, the use of this technology in the time frame 2017-2030 would lead to cumulated energy savings of over 580 GWh and CO\(_2\) emission savings of 450 million tons. Furthermore, at current electricity subsidies, the Lebanese government would save approximately 41 million US$.

Considering that Heat Pumps will be introduced as well in tertiary buildings and in space heating systems, above mentioned savings are likely to be much higher.

Furthermore NEEREA green financing mechanism, set up by the Central Bank of Lebanon (BDL) in collaboration with the LCEC and local commercial banks, can provide interest-free long-term loans to residential, commercial, non-profit and industrial users for the installation of Heat Pumps in new and existing facilities, overcoming the financial barriers which may hinder market uptake.

\(^{13}\) Living conditions survey 2007, Central Administration of Statistics
\(^{14}\) Analysis of Lebanon’s Real Estate Sector, BankMED, February 2015
\(^{15}\) According to Commission Delegated Regulation (EU) No 812/2013 with regard to the energy labelling of water heaters, a class A heat pump for a common load profile “L” has a COP in the range of 1.9-2.9.
\(^{17}\) Technical Paper Electricity-specific emission factors for grid electricity, Brander, Sood, Wylie, Haughton, Lovell, 2011
Heat pump technology is thus capable of playing a key role in reducing fossil fuel and electricity dependency, improving quality of life in the Lebanese community and reducing CO$_2$ emissions.

Looking at other countries’ experiences, it is obvious that introducing such new technologies requires several support measures in order to ensure the use of good quality products and efficient installations. However the country is not able to provide the resources necessary to implement this strategy completely on its own. International support is required to fully implement and track the existing mitigation strategies and to further mainstream mitigation throughout the economy. This support will include capacity building and technology transfer activities.