ABSTRACT

Moderate winters and mild to hot summers characterise the climates of the countries of Southern Europe, in particular of those on the Mediterranean rim. In these regions the maintenance of year round comfort conditions requires heating in Winter and cooling in Summer, especially in buildings used for commercial activities, but also in apartment buildings. This contrasts with the situation in both Central and Northern Europe, where demand for cooling is very low or non-existent. Therefore, South European countries may be viewed as presenting a demand for equipment nearer to that of the US and Japan rather than to that of Central and Northern Europe. In this context, according to data of 1996 around 70% of all heat pumps installed in Europe are sold in Italy, Spain or Greece.

Equipment in use today in this region - heat pumps and air conditioners - typically run with R22 and will eventually be running in the near future with either one of the proposed replacements for R22 in Japan and the US, R407C or R410A. These equipment are mostly small size single-room or single-flat units which are characteristically installed across the external envelope of the building with all the attending consequences in terms of noise, aesthetics and condensate dripping on the side walks and the passers-by.

While the technological developments in Europe are basically directed towards the replacement of conventional refrigerants by naturally occurring ones, such as hydrocarbons and ammonia, they have been mostly concentrated on heating-only-equipment, typical application in Central and Northern Europe. On the other hand, the technological developments in the US and in Japan - the main providers of reversible heat pumps - tend to replace refrigerants used up to now, such as the environment damaging CFCs and HCFCs, by variations of the same substances combined in various kinds of mixtures. The substances involved, R32, R134a, R143a, R125, etc., are not environmentally neutral (null ODP, but significant GDP), which contrasts with propane and ammonia. Most of them are zeotropic, requiring larger heat exchangers and the corresponding larger refrigerant charges, and making servicing more difficult, particularly after a leakage of refrigerant. They are also problematic for the selection of adequate lubricating oils, due to the differential solubility of the various mixture components and its effects upon the transport processes in the heat exchangers. In contrast, propane offers as an additional advantage its compatibility with the materials already used at present in the refrigerant loop, such as lubricating oil, and the metal composition of the various components.

Equipment already on the market from European manufacturers, address only in part the problems faced by the application of hydrocarbons, in particular propane, under climates typical of the Mediterranean rim. Currently, new European manufactured equipment operating with propane as refrigerant use welded-plate compact heat exchangers in order to keep the refrigerant charge to a minimum. The ranges of heating (and cooling) capacities and of operation (temperatures) are typical of the colder climates of central and northern Europe. Equipment for operation under the climatic conditions typical of Southern Europe should be especially adapted to the region's demands, in order to compete successfully in cost, reliability and energetic efficiency. Furthermore, moving from a CFC or HCFC type of refrigerant to a hydrocarbon requires the manufacturers and service personnel to adapt to the

characteristics of the new operating fluid, in particular to different operating pressures and, in the particular case of propane, to its flammability.

The idea behind the HEAHP consortium was to build a new air-to-water reversible heat pump specifically for propane to be used in the commercial sector, as recent trends in standards and regulations in the field of HVAC equipment, at least in Europe, will give increased support to the use of propane as a refrigerant in indirect systems under certain conditions.

The new prototype heat pump, which we will refer to as HEAHP (High Efficiency Air to water Heat Pump) is the main output of HEAHP/J3 and will be designed to meet its main objectives: to be environmentally friendly, more efficient, adapted to the Mediterranean climate and economically feasible.

PARTNERSHIP

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1. OBJECTIVES

The two main objectives of this project were to develop a Heat Pump working with propane as refrigerant and with a higher energetic efficiency. This device will contribute to reduce the CO_2 emissions and to reduce the ozone destruction. The following list, which was included in the project proposal, describes the project objectives in detail:

1. Adapt the reversible heat pump technology to the climates of southern Europe through the study and use of propane in a reversible unit, satisfying heating and refrigeration needs, under typical conditions of this region;
2. Identify through computer simulation and experiment the improvements and modifications needed in the components in current use for them to operate with high efficiency in the heat pump to be designed. A global efficiency gain of 10%, in terms of COP, is considered achievable in this project;
3. Develop simulation tools beyond today's stage, to support the optimisation of the new designs and prototypes and of their components[1];
4. Support the manufacturers involved in the redesign of their components and equipment, for operation with environment friendly operating fluids such as propane;
5. Design, build and test experimentally a prototype reversible heat pump running on propane;
6. Improve the individual components through critical analysis of the results of experiments, concentrating on what is still economically feasible both at the component level and of the heat pump as a whole. The reduction of the size of the components shall result from the use of efficient extended surfaces and the optimisation study, which shall lead to a reduction of 40% in the charge of the operating fluid. As mentioned in 2., a 10% improvement in overall efficiency is also the target to be attained here;
7. Identify safe procedures for manufacturing, assembling and servicing heat pump equipment running on flammable operating fluids;
8. Disseminate the results obtained.

[1] Existing software tools may basically be classified in two groups:

1. Sophisticated models, that were designed to investigate the details of the elemntary processes, but which are not able to efficiently assist in the design of the components and the system. These models require comparatively large amounts of data, which many times are not available to industrial users;
2. Simple models of the input/output (fit or black-box) type, which are used to analyse the parameters of the thermodynamic cycle or of the individual components, but whcih by nature do not allow the study or evaluation of modifications to the simulated components or equipment.

What is missing, are models for engineering design in the industry, that while requiring a reduced amount of data, will still enable the evaluation of modifications in the equipment or parts thereof that they simulate.

2. TECHNICAL DESCRIPTION

2.1.Development of the optimised propane Heat Pump prototype

The development of the heat pump to work with propane was distributed in a number of interconnected tasks.

2.1.1. Assessment

An extensive analysis involving various commercial applications of the HEAHP and the functional requirements typical of the Commercial Sector and of the Mediterranean Climates, and the final synthesis of the typical size and operating conditions to be considered for the project, had been performed. A very important part of this task was the revision of all standards and normative requirements relevant to the project. As a result of this research, a typical 20kW Air-to-Water Reversible Heat Pump was considered as a first estimatation, in order to size the installations required for the project, and evaluate the required costs. This commercial R22 reference heat pump was adapted for its use with propane and instrumented for the characterisation and testing phase.

2.1.2. Components Optimisation

2.1.2.1. Reference components characterisation (R22 and propane)

This area involved all the test campaigns to be performed, including the construction or adaptation of the required facilities for the testing of compressors (at the Universidad Politécnica de Valencia), heat exchangers (PHE as well as coils) and the thermostatic expansion device (both at the Ente per le Nuove Tecnologie, l'Energia e l'Ambiente - ENEA). Safety was a major concern during the conception of the different test facilities. Specific procedures and standards regarding the managing and use of flammable gases were taken into account. These specific measures included the use of intrinsically safe electric material, special propane sensors, the use of emergency switches and alarms and appropriate air renewal procedures to ensure non-critical concentrations in case of leakage.

Compressor Characterisation and Testing

The reference Heat Pump compressor was a 4 cylinder R22 hermetic reciprocating compressor, labelled MT 100HS, from MANEUROP with a nominal refrigerating capacity of 23410 W at ARI test conditions. In all propane tests almost pure (99.95%) propane was used to ensure traceability of our results. The compressor rating procedure was performed according to the relevant standards in the field such as the ISO-917 and American ANSI ASHRAE 23-1993. A loss in refrigerating capacity due to the use of propane is observed that ranges between 18% and 20% at low to intermediate pressure ratios. For the same operating conditions, refrigerating COP (defined in agreement with the standards) increases in a range between 3% and 5%. At higher-pressure ratios the loss of capacity is reduced to about 13% but also the gain in refrigerating COP is limited to less than 1%.

Heat Exchangers Characterisation and Testing

Both heat pump heat exchangers were evaluated in a test loop built specifically for this purpose. The results of these tests allowed to decrease the size of the involved heat exchangers (thus allowing to reduce the amount of propane in the HEAHP) and helped to adjust and refine the mathematical models for further optimisation of the HEAHP. From the obtained data, an analysis in terms of two-phase heat transfer coefficients was performed to interpret the behaviour of each refrigerant.

In evaporation propane showed a lower heat transfer coefficient than R22 (5% to 8% loss). This result was unexpected from previous studies. Pressure drop with propane is about one half of the value corresponding to R22 for the same capacity (as expected from the lower density of propane). In condensation values for the heat transfer coefficients were similar for both refrigerants, whereas pressure drop showed basically the same tendency as in evaporation.

Expansion device testing

An special test bench was developed to allow the characterisation of the regulation mechanism of the thermostatic expansion valve. The lift of the valves needle was measured as a function of superheat and valve setting for both refrigerants: propane and R22 for different evaporating pressures.

2.1.2.2. Single Components Modelling & Design

One of the partial objectives of the project was the development and use of simulation tools, able to support the optimisation of the new systems and components design. This area included also the work necessary to optimise the design of each component and in order to reach the best definition of the HEAHP components, based on both the direct analysis of the experimental results obtained from the characterisation and testing area and the use of the developed mathematical models.

Compressor Modelling

At the Universidad Politécnica de Valencia a compressor simulation code beyond today's stage was created in order to support the optimisation of new designs and prototypes. The starting point of the compressor modelling was a model for a compressor with a very specific configuration and having only one cylinder. A distinctive feature of this model was the incorporation of the gas dynamics calculation for the pipes and the dynamics of the reed valves.
Compressor characterisation data have allowed to adjust the model of the compressor and to obtain the volumetric efficiency and discharge temperatures of the compressor with errors less than 10%. The mean error in the prediction of both quantities was approximately of 3% in volumetric efficiency and 2.3% in discharge temperatures.

Plate and Air Heat exchangers Modelling and Optimisation

The modelling of the heat exchangers that was developed at the Universidad Politécnica de Valencia was intended to be an accurate and useful tool for heat exchanger optimisation and design. The models developed, work with any kind of flow arrangement (parallel flow, counterflow, cross-flow or multiple-pass) can be used with any refrigerant included in the NIST Refprop database. In contrast with the compressor, the fluid flow modelling in the heat exchangers is based on the assumption that the flow is steady.

An easy to handle windows-type interface was developed, which has allowed us to perform the parametric studies in the optimisation phase.
Some final results show the agreement of the calculated data with the experimental ones taken show errors in the capacity below 6% for R22 and below 1% for propane, and for the pressure drop, below 5% for R22 and below 2% for propane.
For the design phase the changes that were considered for the BHE were the number of plates, plate width, plate separation and fin type. After varying one parameter by keeping the rest unchanged, the BHE predicted by the model was chosen looking mainly at the COP. Though there is a continuous increase of COP with the number of plates, the behaviour of the curve becomes asymptotic, in such a way that, from a given number, a further increase is not worthy in terms of cost.
In the development of the fin and tube air heat coils, the same modelling strategy was adapted to the particular requirements of this type of exchangers. Experimental data from UPV tests and ENEA with both refrigerants, R22 and propane, were available to allow for precise adjustment of the codes. The changes which were considered for the design of the new prototypes were the tube diameter, the number of tubes, number of circuits, fin material, separation between fins, fin type, humidity of the air.

Expansion Device Model

The modelling of the expansion valve aimed to be an accurate model of the circulating flow through the valve. An innovative model of the expansion device was produced, which took into account the non-equilibrium problems involved in the flashing phenomenon. The model was able to determine with high accuracy the mass flow rate as a function of the upstream conditions and the downstream pressure.

2.1.2.3. Optimised components testing

Between the reference components and the final prototype, advanced or first optimised components were built to have a further reference point for the modelling tools as well as for the experimental work, as certainly there are aspects which cannot easily be included in a model (like f.i. hunting, ice formation or charge optimisation) In this phase, improved air and plate heat exchangers for propane were build and tested, as well as a proposed substitute for the original piston compressor.

Compressor tests

The aim of the compressor tests was to study the performance of the proposed substitute compressor, and to compare it with the reference alternative compressor, using propane as refrigerant. Though the first intention in the HEAHP development was to build a specific compressor, this was finally abandoned for reasons of time and cost. Interest was then directed towards the finding of a best commercial substitute. Finally a Scroll compressor with slightly higher nominal capacity in comparison to the first compressor was proposed.

Tests showed that the Scroll compressor working with propane would allow to recover part of the lost capacity when switching from R22 to propane, without losses in terms of COP when compared to the hermetic alternative compressor working with propane as well as R22. It was also clear that the heat exchangers would have to be readapted to the new compressor.

Advanced Heat Exchangers prototype tests

The construction of the advanced heat pump unit started after the construction of the advanced heat exchangers at ALFA LAVAL. The advanced compact brazed heat exchanger increased the heat transfer area without large increasing of the volume. The coil was also redesigned to adopt an inner diameter of 9 mm (the original diameter was 12 mm), thus allowing for a reduction in refrigerant charge (a major goal in the project). The test campaign made in ENEA confirms the previous optimisation studies, the advanced HEXs performance is similar to the original ones with an important reduction of the internal volume.

2.1.3 Heat Pump Optimisation

2.1.3.1. Reference Heat Pump Unit Characterisation (R22 and propane)

A group of tests was performed at the Universidad Politécnica de Valencia to demonstrate and quantify the use of propane in a medium size reversible, air-to-water heat pump designed to be used with R22. The reference commercial HP design, by the industrial partner CIATESA, comprised the 4 cylinder hermetic piston compressor, a brazed plate heat exchanger to heat or cool water in a closed circuit, a coil (and ventilator) to exchange heat with ambient air and a thermostatic expansion valve to control superheat. A liquid receiver after the condenser ensures adequate feeding of the expansion valve with liquid refrigerant. To cover sufficiently the expected loads the most representative temperature and humidity profiles of the target area were found to establish an adequate test matrix for the measurements. The test methodology to rate the HP in terms of capacity and COP followed the requirements set in standard prEN 255.

Different thermodynamic variables such as temperature, pressure, and refrigerant mass flow rate were continuously recorded during the tests to allow a deeper insight into the thermodynamic evolution of the refrigerant and its interaction with the HP components. When comparing this particular reference heat pump with propane and R22, it was shown that:

- There was a loss in capacity with propane, ranging from 11% to 13% in cooling mode and between 14% to 18% in heating mode.
- A gain in COP is obtained with propane that was larger in cooling mode (10% to 14%) than in heating mode (around 5% for all temperatures).

2.1.3.2. Heat Pump Model

A refrigeration plant is a closed and very interconnected system, and therefore a tool to analyse that interaction between the design of the different elements is crucial for the optimisation of the global design of the heat pump.

The validation of the model was made with the results of the heat pump characterisation tests. The simulation agrees quite well with the experiments giving a relative error of less than 10% in terms of COP and capacity. These good results are due mainly to the accurate component models.

2.1.3.3. Advanced heat pump unit characterisation

The idea behind the construction of an intermediate prototype, the Advanced Heat Pump Unit (AHPU), was to test some first ideas with respect to the optimisation of components and system for propane. It was also a necessary step for the development and final adjustment of the different computer codes.

The performance in cooling mode of the AHPU with propane comparing to the reference HP working with R22, at the same superheat, resulted in a decrease of capacity in the range of 3% to 7%. The differences in capacity were higher with increasing air temperature. Lower values of superheat caused higher capacity differences. In heating mode, having the same setting of the valve, the decrease in capacity was in the range of 5% to 9%. The COP performance of the AHPU with propane was better in comparison to the RHPU with R22, having in cooling mode an increase of around 12% and around 10% in heating mode. Already at this stage, refrigerant charge reduction was larger than 40% and it was regarded as feasible to lower charge even more by a proper redimensioning of HEX volumes and liquid receiver capacity.

2.1.3.4 Final prototype design, construction and testing

The final development of the HEAHP was performed co-ordinating both modelling tools and experimental results on the previous prototypes. The possible design choices that could be realistic for the final design were listed and analysed by means of the models to take the final decisions. Apart from the adaptation of the model to the geometries and specifications of the new components, other design choices were analysed such as the usage of a recuperator (which was finally discarded), the flow arrangement in the BHPE - co- or countercurrent flow-, the possible usage of smaller pipings and others. Of course, cost factors were always in the background of the discussion.
After the design and construction of the HEAHP prototype, several tests were performed in CIATESA to fine-tune and optimise the machine's performance before its certification at CEIS, an official laboratory placed in Madrid, Spain. It was decided to perform the experiments in CIATESA only for a reduced test matrix with the purpose of optimising refrigerant charge and expansion valve setting.

The tests at CIATESA and certification campaign showed that the HEAHP is able to work properly with 66% less charge than the R22 RHPU. This is a very important issue due to cost savings and due to the safety concerns discussed under 'Normative requirements'.

The HEAHP cooling production lies between ±5% of the R22 RHPU figures, but with compressor energy consumption that is 9% to 13% lower. The increase in COP in cooling mode ranges from at least almost 10% to 19%.

In heating mode COP results are even better, being 15% to 20% higher in the HEAHP with respect to the R22 RHPU. The way of achieving this has been different than in cooling mode: a significant heating capacity increase (between 11% and 23%) has been obtained with the same (or even slightly lower) energy consumption.

2.2. Final Conclusions

The HEAHP consortium has produced a pre-commercial air-to-water reversible heat pump prototype working with propane for use in the mild climate conditions typical of Southern Europe. With respect to our previous commercial R22 reference machine, this prototype works safely, with a much lower charge (66%), a similar or even higher capacity and much better efficiency (increase of 10% to 20%). All the aimed improvements included in the milestones (40% lower charge, similar capacity, 10% better efficiency) were clearly surpassed.

The obtained results have been possible not only because of the excellent properties of the refrigerant, but also because of the intense combined experimental and computational effort of the consortium to adapt heat pump technology and designs to propane.

3. RESULTS AND CONCLUSIONS

The following tables contain the main Project results, its owner or main owner and a brief description.

Name of the result	Owner / main owner	Description
Exploitation of the Final Heat Pump designed among all partners and manufactured at CIATESA.	CIATESA	The results obtained will be mainly used to manufacture and sale the Heat Pump, as a way to open the use of environmentally safe refrigerants in the market. A marketing process will be also required to do so.
Methodology for characterisation of reversible air-to-water heat pumps	UPV	Development of a new energy-saving methodology for measuring heating and cooling capacities of Heat Pumps.
Global model of an air-to-water reversible heat pump unit working with propane. Software and documentation	UPV	Development of a very precise Heat Pump model incorporating very accurate sub-models for each Heat Pump component. It is also provided with a Graphic User Interface
Heat exchangers calculation program	UPV	Development of program for Heat Exchangers simulation allowing, through a Graphic User Interface, the study of different geometries and flow configurations
Program for calculation of the performance of volumetric compressor	UPV	This program simulates any type of piston compressor. It has the possibility to choose the circulating refrigerant in a database. The simulation gives pressure and temperatures of the refrigerant in all points, the movement of the walls and the circulating mass flow rate.

Name of the result (continuation)	Owner / main owne r	Description
Heat Exchanger Improved Prototypes	AL Artec	An advanced design of the copper brazed heat exchanger (APHE) and of the air heat exchanger (AAHE) for R290 have been built and supplied by AL Artec. They were design according to the previous Characterisation test results, the outputs of the calculation module developed by UPV and AL Artec know-how and experience.
Report entitled "Climate Related Applications"	ENEA	This report (35 pages) was elaborated at the beginning of the project in order to evaluate the climatic profile of the southern Europe countries to identify the range of temperature and relative humidity typical of these regions.
Report entitled "Identification of Operating Requirements"	ENEA	This report (9 pages) was elaborated at the beginning of the project in order to define the operating requirements that shall be met by the developed Heat Pump. This requirements are mainly related to the commercial applications and to the climate conditions of the Southern Europe.
Report entitled "Plate Heat Exchangers Characterisation"	ENEA, AL Artec	This report (14 pages) presents the experimental results of the laboratory activities performed on the original copper brazed Plate Heat Exchanger (PHE). The PHE has been tested both with R22 and R290 (propane).
Report entitled "Air Heat Exchangers Characterisation"	ENEA, AL Artec	This report (8 pages) presents the experimental results of the laboratory activities performed on the original Air Heat Exchanger (AHE. The AHE has been tested both with R22 and R290(propane).
Report entitled "Expansion Valve Characterisation"	ENEA	This report (7 pages) presents the experimental results of the laboratory activities performed on the Thermostatic Expansion Valve (TEV). The TEV has been tested both with R22 and propane.

Name of the result (continuation)	Owner / main owner	Description
Report entitled "Plate Heat Exchanger Tests"	ENEA	This report presents the experimental results of the laboratory activities performed on the Plate Heat Exchanger (PHE) for propane. The PHE has been tested assuming a different configuration for the PHE with respect to the standard one used in the heat pump.
Report entitled "Air Heat Exchanger Tests"	ENEA	This report presents the experimental results of the laboratory activities performed on the Advanced Air Heat Exchanger (AAHE) for propane. The AAHE has been tested in the same conditions of the standard Air Heat Exchanger.
Report entitled "Identification of Commercial Applications"	AEDIE	This report (27 pages) was elaborated at the beginning of the project in order to define the basic characteristics of the Heat Pump. When starting the project, it was necessary to fix the characteristics of the Heat Pump to be developed.
Report entitled "Identification of Normative Requirements"	AEDIE	This report (15 pages) was elaborated at the beginning of the project in order to define the Normative requirements that shall be met by the developed Heat Pump. This requirements are mainly related to the use of an inflammable refrigerant (propane).
Report entitled "Government Perspective, Regulation and Standards"	AEDIE	This report (39 pages) presents an overview of all those measures and instruments that have been adopted at a governmental level and which influence the Heat Pump market. The European Community, Greece, Italy, Portugal and Spain have been considered.

Name of the result (continuation)	Owner / main owner	Description
Promotion Campaign	AEDIE	As part of the tasks developed in the project, five reports were elaborated in order to support a Heat Pumps promotion campaign, specially focused on issues related to propane and natural refrigerants.
Procedural Handbook	AEDIE	As part of the tasks developed in the project, a Procedural Book was elaborated containing technical information on the developed Heat Pump prototype.
Micro-economic impact study	AEDIE	At the end of the project, a micro-economic study was elaborated in order to determine the economic and environmental consequences of the commercialisation of the developed Heat Pump.

4. EXPLOITATION PLANS AND ANTICIPATED BENEFITS

The following tables contain the main Project results and a the corresponding exploitation plans and anticipated benefits.

Name of the result	Exploitation plan
Exploitation of the Final Heat Pump designed among all partners and manufactured at CIATESA.	The manufacturing of the unit would be in charge of CIATESA. The manufacturing would take place after request by the Commercial Department.
Methodology for characterisation of reversible air-to-water heat pumps	A dissemination campaign will be carried over in the next months in connection with the promotion campaign of the project. This campaign will include the publication of most relevant set-up characteristics and its performance in specialized journals and meetings.

Name of the result	Exploitation plan (continuation)
Global model of an air-to-water reversible heat pump unit working with propane. Software and documentation	A dissemination campaign will be carried over in the next months in connection with the promotion campaign of the project. This campaign will include the publication of the global heat pump model characteristics in specialized journals and meetings. Contacts with manufacturers in the automotive sector are being held, to show the features and philosophy of this heat pump design tool.
Heat exchangers calculation program	A dissemination campaign will be carried over in the next months in connection with the promotion campaign of the project. The features and possibilities of the code will be published in specialized international scientific journals. Contacts with potential industrial partners are planned.
Program for calculation of the performance of volumetric compressor	A dissemination campaign will be carried over in the next months in connection with the promotion campaign of the project. The features and possibilities of the code will be published in specialized international scientific journals. Contacts with potential industrial partners have been made and are planned in the future.
Heat Exchanger Improved Prototypes	The advanced version of the PHE and AHE will be presented to the Heat Pump manufacturer market. That will be done by direct contact with the potential customers, and by all the available advertising tools (Articles on technical magazines, Internet, exibitions).
Report entitled "Climate Related Applications"	ENEA will incorporate this report to its background information in order to increase its knowledge. ENEA participates at the I.E.A.'s activities in representation of the Italian Ministry of Industry. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities
Report entitled "Identification of Operating Requirements"	ENEA will incorporate this report to its background information in order to increase its knowledge. ENEA participates at the I.E.A.'s activities in representation of the Italian Ministry of Industry. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities

Name of the result	Exploitation plan (continuation)
Report entitled "Plate Heat Exchangers Characterisation"	ENEA will incorporate this report to its background information in order to increase its knowledge. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities. AL Artec will use the results of the PHE characterization campaign together with its own know-how and experience in the PHE (plate heat exchanger) design and in the relative calculation software, in order to improve the reliability of the software itself for the use of R290 (propane).
Report entitled "Air Heat Exchangers Characterisation"	ENEA will incorporate this report to its background information in order to increase its knowledge. ENEA participates at the I.E.A.'s activities in representation of the Italian Ministry of Industry. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities. AL Artec will implement the properties of propane in the program data base, then compare the experimental result with the outputs of the calculation programs in the same conditions, and, if necessary, correct the calculation module to reduce the deviations to an acceptable level. That will be made by an internal technical software developer.
Report entitled "Expansion Valve Characterisation"	ENEA will incorporate this report to its background information in order to increase its knowledge. ENEA participates at the I.E.A.'s activities in representation of the Italian Ministry of Industry. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities.
Report entitled "Plate Heat Exchanger Tests"	ENEA will incorporate this report to its background information in order to increase its knowledge. ENEA participates at the I.E.A.'s activities in representation of the Italian Ministry of Industry. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities.

Name of the result	Exploitation plan
Report entitled "Air Heat Exchanger Tests"	ENEA will incorporate this report to its background information in order to increase its knowledge. ENEA participates at the I.E.A.'s activities in representation of the Italian Ministry of Industry. As a research, technical assistance, documentation and information agency, ENEA will use this report for its Heat Pump study and promotion activities.
Report entitled "Identification of Commercial Applications"	AEDIE will incorporate this report to its background information in order to increase its knowledge. AEDIE holds the Secretariat of the Spanish National Group on Heat Pumps, associated to the the International Energy Agency (IEA). This association, supported by the Spanish Industry and Energy Ministry (MINER), has as main function the promotion of Heat Pumps in Spain. As a research, technical assistance, documentation and information association, AEDIE will use this report for its habitual Heat Pump promotion activities.
Report entitled "Identification of Normative Requirements"	AEDIE will incorporate this report to its background information in order to increase its knowledge. AEDIE holds the Secretariat of the Spanish National Group on Heat Pumps, associated to the the International Energy Agency (IEA). This association, supported by the Spanish Industry and Energy Ministry (MINER), has as main function the promotion of Heat Pumps in Spain. As a research, technical assistance, documentation and information association, AEDIE will use this report for its habitual Heat Pump promotion activities
Report entitled "Government Perspective, Regulation and Standards"	AEDIE will incorporate this report to its background information in order to increase its knowledge. AEDIE holds the Secretariat of the Spanish National Group on Heat Pumps, associated to the the International Energy Agency (IEA). This association, supported by the Spanish Industry and Energy Ministry (MINER), has as main function the promotion of Heat Pumps in Spain. As a research, technical assistance, documentation and information association, AEDIE will use this report for its habitual Heat Pump promotion activities.

Name of the result	Exploitation plan
Promotion Campaign	AEDIE will incorporate this report to its background information in order to increase its knowledge. AEDIE holds the Secretariat of the Spanish National Group on Heat Pumps, associated to the the International Energy Agency (IEA). This association, supported by the Spanish Industry and Energy Ministry (MINER), has as main function the promotion of Heat Pumps in Spain. As a research, technical assistance, documentation and information association, AEDIE will use this report for its habitual Heat Pump promotion activities
Procedural Handbook	AEDIE will incorporate this report to its background information in order to increase its knowledge. AEDIE holds the Secretariat of the Spanish National Group on Heat Pumps, associated to the the International Energy Agency (IEA). This association, supported by the Spanish Industry and Energy Ministry (MINER), has as main function the promotion of Heat Pumps in Spain. As a research, technical assistance, documentation and information association, AEDIE will use this report for its habitual Heat Pump promotion activities
Micro-economic impact study	AEDIE will incorporate this report to its background information in order to increase its knowledge. AEDIE holds the Secretariat of the Spanish National Group on Heat Pumps, associated to the the International Energy Agency (IEA). This association, supported by the Spanish Industry and Energy Ministry (MINER), has as main function the promotion of Heat Pumps in Spain. As a research, technical assistance, documentation and information association, AEDIE will use this report for its habitual Heat Pump promotion activities