The GROUNDHIT project

Introduction

- **GROUNDHIT stands for GROUND source heat pumps of HIgh Technology**
- **Project coordinator: Dr. C. Karytsas (Centre for Renewable Energy Sources)**
- **Project technical manager : Mr. D. Mendrinos (Centre for Renewable Energy Sources)**

The GROUNDHIT project includes:

- Technology development of borehole heat exchangers
- Technology development of water source heat pumps
- Demonstration of developed technology
- Dissemination and support actions

Project budget: 3,586,070 €

EC contribution: 1,677,182 €

or 46.77%

Project duration: 4 years

June 2004 - May 2008

Project partners

- Centre for Renewable Energy Sources (CRES) – Greece: *project coordinator*
- Compagnie Industrielle d'Applications Thermiques (CIAT) - France
- EWS Erdwärme-Systemtechnik GmbH & Co. KG (EWS) - Germany
- Geothermische Vereinigung e.V. (GtV) - Germany
- GEOTEAM GmbH. Consultants for Hydrogeology, Geothermics and Environment (GEOTEAM) – Austria
- Escola Superior de Tecnologia de Setubal (ESTS) – Portugal
- MENTOR Investment Consultants SA (MENTOR) – Greece
- Chemical Process Engineering Research Institute (CPERI) – Greece
- University of Oradea (UOR) – Romania
- University of Silesia (USI) – Poland
- BRGM (BRGM) - France

Borehole heat exchangers (BHE) technology development

- Develop a complete BHE system **(reengineer configuration, geometry, pipes, U-footpart, grouting, tools, surface manifolds, etc.)**
- Key objectives: **low cost, safety, durability, thermal efficiency**
- Key project partners: **EWS (Oliver Kolsch) and GtV (Dr. Burkhard Sanner)**

Water Source Heat Pumps technology development

- Develop a ground source heat pump prototype **of improved energy efficiency (COP=5.5)**
- Develop a ground source heat pump prototype **that can deliver 80ºC** (for use in high temperature heating systems)
- Develop a warm groundwater source heat pump prototype **(evaporator water envelop 20-40ºC) of improved energy efficiency (COP=7.0)**

Water Source Heat Pumps technology development

- Reengineer key items: refrigerants, compressor(s), evaporator, condenser / gas cooler, internal heat exchanger / accumulator, microcomputer control, expansion valves, overall system configuration.
- Reengineer other components such as capacitors, refrigerant charge compensator, refrigerant piping & insulation, reversing valve, check valves, strainers, driers, discharge mufflers.
- Key objectives: energy efficiency, reliability, safety.
- Key project partner: CIAT (M.Abry, E.Auzenet, E.Plisson, C.Blanc).

Intermediate evaluation points

- Each one of the heat pumps pre-prototypes:
  - Groundsource of COP=5.5 *(March 2006)*
  - Groundsource delivering 80ºC water *(October 2006)*
  - 20-40ºC warm groundwater *(July 2006)*

  will be evaluated in terms of achieving technology breakthrough
- If successful, manufacturing of two prototypes per heat pump type and demonstration will continue as planned

Heat Pump prototypes release test

- Key objective: to provide independent opinion on the energy performance and operation temperature range of the heat pump prototypes
- Measured parameters: COP, water source temperature envelop, temperature range of supply water
- Key project partner: CRES

CENTRE FOR RENEWABLE ENERGY SOURCES

ΚΑΠΕ CRES

Demonstration site in Portugal

- Demo of a system comprising a **borehole heat exchanger and the first water source heat pump prototypes (of COP=5.5)**
- Location: **Setubal, Lisbon**
- Key project partner: **ESTS (Prof L.Coehlo, Prof J.Garcia)**

Demonstration site in Austria

- Demo of a system comprising a **borehole heat exchanger and the second water source heat pump prototype (delivering 80ºC),** coupled with a high temperature heating system
- Location: **Gleisdorf, Graz**
- Key project partner: **GEOTEAM (Prof. J.Goldbrunner)**

Demonstration site in Greece

- Demo of a system comprising a **warm ground-water well and the third water source heat pump prototype (input water envelop 20-40ºC)**
- Location: **Neo Ryssio, Thessaloniki**
- Key project partner: **MENTOR (Ou. Diakogianni, G. Radoglou)**

Monitoring & technology validation

- Monitoring duration: **8-11 months**
- Location: **in all three demo sites**
- Key objectives: evaluate the **technical**, **economic** and **operational performance** of all three geothermal heat pump systems under real conditions for both heating & cooling
- Key project partners: **CRES, CIAT, EWS, ESTS, GEOTEAM, MENTOR**

Monitoring & technology validation

- Technical performance: **Power output (kW), Absorbed electricity (kWe), COP, SPF, maximum input temperature, maximum temperature delivered**
- Economic performance: **Running costs, Payback, Return on investment (ROI)**
- Operational performance: **System availability factor, Frequency & duration of operation out of normal parameters (refrigerant slugging, high discharge pressure, low COP)**

Dissemination actions

- Project brochure & project poster (CRES)
- Project Internet pages (GtV)
- Knowledge & results dissemination plan (CRES)
- 1st project workshop (GtV)
- Publications, press releases, brochures mail out, etc. (all partners)
- Exhibition in Poland (USI)
- Final project workshop (GtV)

Support actions

- Study for the creation of spin-offs (MENTOR)
- Socio-economics impact study (MENTOR)
- Market study (MENTOR)
- Intellectual property protection (CIAT,EWS,CRES)
- Technology assessment & market penetration strategy for borehole heat exchanger (EWS) and heat pumps (CIAT)
- Report on raising public participation & awareness (CRES)
- Support document for policy making (MENTOR)

Project management

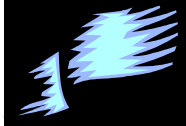
- Project coordinator - Dr. C. Karytsas: liaison between the project partners and the European Commission
- Decision making: according to the consortium agreement signed between the partners
- Coordination of project activities: by the project management committee
- Each work package: cooperation of project management committee with the WP leader

Project management committee

- CRES : Dr. C. Karytsas & Mr. D. Mendrinos
- CIAT : Mr. M. Abry
- GtV : Dr. B. Sanner
- ESTS : Prof. L. Coehlo
- MENTOR : Mr. G. Radoglou
- UOR : Prof. M. Rosca

Project impact

- A successful GROUNDHIT project will result in improving competitiveness and widen market opportunities of geothermal heat pumps.
- Furthermore, the knowledge gained, will also effectively aid technology development of other heat pumps in the same direction.
- The worldwide potential impact of the project is great: huge savings in fossil fuels use can be made, leaving more oil and natural gas for both developed and developing countries.



Real Life

- Project success is not an easy task.
- GROUNDHIT is an ambitious project that requires hard work from all of us involved.
- But we will have our reward: effective contribution to the welfare of humanity.

What This Means

by working hard towards

the objectives of the GROUNDHIT project

we place our stamp

in the route of mankind

GROUNDHIT Project

Work-Packages

GROUNDHIT project - research

- WP#1: Borehole Heat Exchanger (BHE) Development
- WP#2: Ground Source Heat Pump (GSHP) of COP>5,5 Development
- WP#3: Ground Source Heat Pump (GSHP) 80°C Development
- WP#4: 40°C Ground Water Heat Pump (GWHP) Development

GROUNDHIT project - demo

- WP#5: Manufacturing of Prototypes
- WP#6: Demo of BHE + GSHP (COP>5,5) in Portugal
- WP#7: Demo of BHE + GSHP (80^{o}C) in Austria
- WP#8: Demo of Well + 40 ^{o}C GWHP in Greece
- WP#9: Monitoring & Validation of Ground Coupled Heat Pump Systems
- WP#10: Innovation Related Activities

Work Package #1

Borehole Heat Exchanger (BHE) Development

WP #1 - Objectives

- Design advanced prefabricated borehole heat exchanger parts that can be mass-produced and can easily be assembled on site to a borehole heat exchanger.

WP #1 - Description of work

- **Theoretical Design** (partners 1-CRES, 3-EWS, 4-GtV, 9-UOR): Technology assessment, materials evaluation, computer simulation, geometry formulation, drafting prototype engineering design.
- Main parameters under consideration are the required length for a given power output, soil characteristics including temperature, moisture content, particle size and shape, and heat transfer coefficients.
- Special attention will be placed on correct sizing of the BHE and on minimizing interference between neighbouring BHE. Key points are building load, borehole spacing, borehole fill material and site characterization. Additional parameters are flow rate, pressure drop and control parameters, possible leaks associated with corrosion of fittings, quality of workmanship, as well as with the selection of pipe material and of the circulated heat transfer fluid.

WP #1 - Description of work (cont.)

- **Field testing** (partner 3-EWS): evaluation of the prototype design obtained from theoretical analysis, tuning geometry, verifying durability and costs, verifying capability for mass production and on site assembly.
- Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES, 4-GtV).

WP #1 - Deliverables

- Prefabricated Borehole Heat Exchanger Parts Prototype Design Drafts

WP #1 - Milestones & expected results

- Completion of theoretical design
- Prefabricated borehole heat exchanger parts prototype design drafts development

Work Package #2

Ground Source Heat Pump (GSHP) of COP>5,5 Development

WP #2 - Objectives

- Design a ground coupled electrical heat pump of improved efficiency (COP>5,5) suitable for operation together with a borehole heat exchanger.

WP #2 - Description of work

Theoretical design (partners 1-CRES, 2-CIAT, 6-ESTSetubal, 8-CPERI, and 9-UOR): assessment of possible technologies, identification of possible design layouts for the prototype, computer modelling, drafting specifications for individual mechanical components.

Laboratory experimentation (partner 2-CIAT): Perform laboratory experiments in order to verify the results of the theoretical design.

Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES, 2-CIAT).

WP #2 – Description of work (cont.)

The theoretical design will include:

- Carry out a technology assessment study relevant to existing commercially as well as demonstrated heat exchanger technologies, compatible with safe and environmentally friendly cooling fluids evaporation, and with objective to allow higher evaporation temperatures (i.e. falling film evaporators, laminar flow under vacuum, etc).
- Carry out a technology assessment study relevant to existing commercially as well as demonstrated compression technologies, compatible with safe and environmentally friendly cooling fluids mechanical compression, and with the scope to reduce electric consumption and to limit overheating - non isentropic effects (i.e. injection compressors, heat recovery units, etc).

WP #2 – Description of work (cont.)

- Component matching and sizing of parts of the heat pump, based on in company (CRES) software for heat pumps simulation or other existing software.
- Seek methods of recovery of heat from the cycle, so that the overall COP of the cycle could be increased
  (i.e. application of desuperheaters in the hot gas line during summer operation, etc).

WP #2 – Description of work (cont.)

Key laboratory actions for improving the energy efficiency (COP) of a heat pump are: selecting type and sizing heat exchangers, compressors, relief valves and other fittings; testing refrigerants; tuning evaporation and condensing temperatures for best values for use with a ground heat exchanger (e.g. ~ -5ºC and ~ +50ºC), developing, producing, perfecting and testing a prototype for heating and cooling.

Energy efficiency can be further improved by an automated relief valve and by electric current frequency modulation at the compressor.

Instrumentation and optimisation of overall performance of the heat pumps prototypes; refrigerant temperatures, mass flow, pressures; effect of hot and cold sources temperature, refrigerant charge, superheat regulation; optimisation of COP by optimising evaporators and condensers; running in steady state conditions and transient flow regimes.

WP #2 – Description of work (cont.)

The only anticipated risk is that the desired COP of 5,5 may be associated with high production costs. In that case, a more cost-effective prototype may be considered with lower COP, but still higher than state-of-the-art.

WP #2 - Deliverables

- Ground Source Heat Pump of COP>5,5 Prototype Design Drafts

WP #2 - Milestones & expected results

- Completion of theoretical design
- Industrial Ground Source Heat Pump of COP>5,5
  Prototype design drafts development

Work Package #3

Ground Source Heat Pump (GSHP) 80°C Development

WP #3 - Objectives

- Design a water source electrical heat pump able to deliver 80ºC, suitable for operation together with a borehole heat exchanger.

WP #3 – Description of work

Theoretical design (partners 1-CRES, 2-CIAT, 6-ESTSetubal, 8-CPERI, 9-UOR): assessment of possible technologies and refrigerant types, identification of possible design layouts for the prototype, computer modelling, drafting specifications for individual mechanical components.

Laboratory experimentation (partner 2-CIAT): Perform laboratory experiments in order to verify the results of the theoretical design.

Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES, 2-CIAT).

WP #3 – Description of work (cont.)

The theoretical design will investigate the feasibility of the following technologies:

- Alternative working fluids such as CO_2 or other refrigerants,
- Cascade cycles,
- Two stage compression

Key laboratory actions: specification and supply of components, prototype production for heating and cooling, perfection and testing. Instrumentation and optimisation of overall performance of the heat pumps prototypes; refrigerant temperatures (e.g. ~ -5ºC evaporation and +90º condensing), mass flow, pressures; effect of hot and cold sources temperature, refrigerant charge, superheat regulation; optimisation of COP by optimising evaporators and condensers; running in steady state conditions and transient flow regimes.

WP #3 – Description of work (cont.)

The high output temperature may require different types of refrigerants: special emphasis will be placed on the selection of refrigerant. Safety and environmental impact will be parameters of major importance.

Risks include the need for large compressor and associated very high costs. If the corresponding production costs prohibit the successful introduction of the product to the market, an alternative unit will be designed with evaporation temperature relaxed to higher (cost optimised) values (e.g. ~ 35ºC evaporation and +90º condensing); this unit will be intended for use in series with a ground coupled heat pump.

WP #3 - Deliverables

- 80ºC Ground Source Heat Pump Prototype Design Drafts

WP #3 - Milestones & expected results

- Completion of theoretical design
- Industrial 80ºC Ground Source Heat Pump Prototype design drafts development

Work Package #4

40°C Ground Water Heat Pump (GWHP) Development

WP #4 - Objectives

- Design a water source electrical heat pump of exceptionally high efficiency (COP=7), able to utilise geothermal water up to 40ºC.

WP #4 – Description of work

Theoretical design (partners 1-CRES, 2-CIAT, 6-ESTSetubal, 8-CPERI, and 9-UOR): assessment of possible technologies, identification of possible design layouts for the prototype, computer modelling, drafting specifications for individual mechanical components.

Laboratory experimentation (partner 2-CIAT): Perform laboratory experiments in order to verify the results of the theoretical design.

Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES, 2-CIAT).

WP #4 – Description of work (cont.)

Key laboratory tasks include: sizing heat exchangers, compressors, relief valves and other fittings; testing refrigerants; tuning evaporation and condensing temperatures for best values for use with warm ground water 20 to 40ºC (e.g. ~ +15ºC and ~ +50ºC), developing, producing, perfecting and testing a prototype for heating & cooling.

Instrumentation and optimisation of overall performance of the heat pumps prototypes; refrigerant temperatures, mass flow, pressures; effect of hot and cold sources temperature, refrigerant charge, superheat regulation; optimisation of COP by optimising evaporators and condensers; running in steady state conditions and transient flow regimes. Energy efficiency can be further improved by an automated relief valve and by electric current frequency modulation at the compressor.

WP #4 – Description of work (cont.)

The only anticipated risk is that the desired value of COP=7 may not be achieved for the desired input temperature range. In this case the input temperature range and the corresponding evaporation temperature will be tuned to values closer to 40ºC. That way the temperature difference within the cooling cycle will be minimised and the COP will be maximized.

WP #4 - Deliverables

- 40ºC Ground Water Heat Pump Prototype of very high efficiency Design Drafts

WP #4 - Milestones & expected results

- Completion of theoretical design
- Industrial 40ºC Ground Water Heat Pump Prototype of very high efficiency design drafts development

Work Package #5

Manufacturing of Prototypes

WP #5 - Objectives

- Manufacturing of the demo Borehole Heat Exchanger prefabricated parts.
- Manufacturing of the Ground Source electrical Heat Pumps of improved efficiency (COP>5,5) demo prototype (heat pump #1).
- Manufacturing of the Ground Source Heat Pump demo prototype delivering 80ºC (heat pump #2).
- Manufacturing of the 40ºC Ground Water Heat Pump demo prototype of very high efficiency (heat pump #3).

WP # 5 – Description of work

Pre-Prototype development for prefabricated borehole heat exchangers parts based on the results of the theoretical analysis (partner 3-EWS): at small scale from successful field-testing. Release test and validation. In situ thermal response test. Manufacturing (paid by partners 5-GEOTEAM and 6-ESTSetubal) of prefabricated parts of 30 kW total nominal capacity, needed for the demonstration sites in Portugal and Austria (15 kW per demonstration site).

Industrial pre-prototypes development for the three ground coupled heat pump models (partner 2-CIAT): fine tuning of successful experiments, laboratory testing and validation. In addition, partner 2-CIAT will manufacture two heat pump units for each successful pre-prototype (the first one for the demonstration site, and the second one for the release test and the exhibition in Poland). Each heat pump unit will be rated as 15 kW and will be equipped with all necessary auxiliary equipment.

WP #5 – Description of work (cont.)

The measuring equipment should be able to measure and monitor continuously:

- The cooling cycle parameters,
- The parameters of both water circuits (at the evaporator and the condenser):
  - Input and output temperatures,
  - Flow rates,
  - Energy delivered or extracted,
- Electricity consumed
- COP

The data output should be in digital form directly to a PC connected to the INTERNET, in order to allow remote monitoring of system parameters. The measuring equipment and the accompanying PCs will be integrated within the demo heat pump units, and will also be provided by partner 2-CIAT.

WP #5 – Description of work (cont.)

After the completion of the laboratory tests for the heat pumps pre-prototypes development, evaluation of the corresponding pre-prototype will take place by partner 2-CIAT. If the research targets have been achieved by at least the technology break-through point (the pre-prototypes have COP>5,0 for heat pump #1, 75ºC output for heat pump #2, and COP>6,5 for heat pump #3) the Commission with the coordinator will decide, in view of the results, whether the achieved improvements are sufficient to warrant the continuation of the project. Otherwise, no demonstration or any other activities related to the corresponding prototype will take place.

Partners 1-CRES, 2-CIAT, 3-EWS, 4-GtV and 9-UOR, will prepare the technical manuals of the demo prototypes.

Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES).

WP #5 - Deliverables

- Borehole Heat Exchanger Pre-Prototype parts
- Demo 30 kW Borehole Heat Exchanger parts
- Ground Source Heat Pump Pre-Prototypes of COP>5,5
- Two Demo Ground Source Heat Pump Prototypes of COP>5,5
- Ground Source Heat Pump Pre-Prototype delivering 80ºC
- Two Demo Ground Source Heat Pump Prototypes delivering 80ºC
- 40ºC Ground Water Heat Pump Pre-Prototype
- Two Demo 40ºC Ground Water Heat Pump Prototypes

WP #5 - Milestones

Intermediate Project Evaluation Points:

- **Month 22 (March 2006):** Evaluation of Ground Source Heat Pump Pre-Prototype of COP>5,5
- **Month 29 (October 2006):** Evaluation of Ground Source Heat Pump Pre-Prototype delivering 80ºC
- **Month 26 (July 2006):** Evaluation of 40ºC Ground Water Heat Pump Pre-Prototype

WP #5 – Results

Pre-Prototypes development for:

- Borehole Heat Exchanger parts.
- Ground Source Heat Pump Prototype of COP>5,5.
- Ground Source Heat Pump Prototype delivering 80ºC.
- 40ºC Ground Water Heat Pump Prototype.

Production of:

- Demo Borehole Heat Exchanger parts (30 kW).
- Two Demo Ground Source Heat Pump Prototypes of COP>5,5.
- Two Demo Ground Source Heat Pump Prototypes delivering 80ºC
- Two Demo 40ºC Ground Water Heat Pump Prototypes.

Work Package #6

Demo of BHE + GSHP (COP>5,5) in Portugal

WP #6 - Objectives

Release test and construction of a ground coupled heat pump system in Portugal comprising:

- Ground source heat pump of COP>5,5 coupled with
- Prefabricated advanced borehole heat exchanger, and
- Heating and cooling system

WP #6 – Description of work

1. Construction of the heating and cooling system (partner 6- ESTSetubal).
2. Drilling the boreholes (partner 6- ESTSetubal).
3. On site installation and assembly of the demo borehole heat exchanger from the prefabricated parts (partners 6-ESTSetubal and 1-CRES).
4. Modification of the test stand assembly, into fully equipped test stand able to simulate conditions for the electrically driven water source heat pump prototype. Release test of the ground source heat pump prototype of COP>5,5. The release test will take place in the CRES laboratory in Athens and the second prototype will be used. Unit pre-evaluation. (partner 1-CRES).

WP #6 – Description of work (cont.)

5. Installation of demo ground source heat pump of COP>5,5 (partners 6- ESTSetubal & 1-CRES).
6. Integration of ground source heat pump system, including *additional measuring equipment* for ambient, ground and indoor temperature (partners 6- ESTSetubal & 1-CRES).
7. Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES).

Other partners (3-EWS, 4-GtV, 9-UOR) will provide expert advice upon request.

WP #6 - Deliverables

- Release test report for the ground coupled heat pump prototype of COP>5,5
- Integrated system of BHE plus ground coupled heat pump of COP>5,5

WP #6 - Milestones & expected results

- Completion of the Portuguese demo site

Work Package #7

Demo of BHE + GSHP (80°C) in Austria

WP #7 - Objectives

Release test and construction of a ground coupled heat pump system in Austria comprising:

- Heat pump able to deliver 80ºC coupled with
- Prefabricated advanced Borehole Heat Exchanger
- Heating and cooling system

WP #7 – Description of work

1. Construction of the heating and cooling system (partner 5-GEOTEAM).
2. Drilling the boreholes (partner 5-GEOTEAM).
3. On site installation and assembly of the demo borehole heat exchanger from the prefabricated parts (partners 5-GEOTEAM and 1-CRES).
4. Modification of the test stand assembly, into fully equipped test stand able to simulate conditions for the electrically driven water source heat pump prototype. Release test of the ground source heat pump prototype delivering 80ºC. The release test will take place in the CRES laboratory in Athens and the second prototype will be used. Unit pre-evaluation. (partner 1-CRES).

WP #7 – Description of work (cont.)

5. Installation of the demo ground source heat pump delivering 80ºC (partners 5-GEOTEAM and 1-CRES).
6. Integration of the ground source heat pump system, including *additional measuring equipment* for ambient, ground and indoor temperature (partners 5-GEOTEAM and 1-CRES).
7. Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES).

Other partners (3-EWS, 4-GtV, 9-UOR) will provide expert advice upon request.

WP #7 - Deliverables

- Release test report for the ground source heat pump prototype delivering 80ºC
- Integrated system of 80ºC ground coupled heat pump

WP #7 - Milestones & expected results

- Completion of the Austrian demo site

Work Package #8

Demo of Well + 40°C GWHP in Greece

WP #8 - Objectives

Release test and construction of a heat pump system in Greece comprising:

- 40ºC-groundwater heat pump of COP>7 coupled with
- Geothermal well yielding warm water close to 40ºC
- Heating and cooling system

WP #8 – Description of work

1. Drilling and completion of the geothermal well (partners 7-MENTOR, 1-CRES and 8-CPERI). This activity will start during the 9th month of the project in order to comply with the local geothermal concessions regulations. The well should be able to provide groundwater of around 40ºC temperature, with sufficient flow rate for the supply of the 15 kW demo heat pump prototype. MENTOR will hire a local drilling contractor as subcontractor for the well drilling.
2. Construction of the heating and cooling system (partners 7-MENTOR and 8-CPERI). MENTOR will hire a local contractor as subcontractor for the corresponding works.
3. Engineering design and completion of the geothermal water transmission line from the well to the energy user (partners 7-MENTOR and 1-CRES). MENTOR will hire a local contractor as subcontractor for the corresponding works.

WP #8 – Description of work (cont.)

4. Modification of the test stand assembly, into fully equipped test stand able to simulate conditions for the electrically driven water source heat pump prototype. Release test of the groundwater heat pump prototype able to use inflowing water of 40ºC in the evaporator in heating mode. The release test will take place in the CRES laboratory in Athens and the second prototype will be used. Unit pre-evaluation (partner 1-CRES).
5. Installation of the demo 40ºC-groundwater heat pump (partners 7-MENTOR and 1-CRES). MENTOR will hire a local contractor as subcontractor for the corresponding works.

WP #8 – Description of work (cont.)

6. Integration of ground source heat pump system, including *additional measuring equipment* for ambient, groundwater and indoor temperature (partners 7-MENTOR and 1-CRES). MENTOR will hire a local contractor as subcontractor for the corresponding works.
7. Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES).

Partners 4-GtV and 9-UOR will provide expert advice upon request.

WP #8 - Deliverables

- Release test report for the 40ºC-groundwater heat pump prototype
- Integrated system of hot water source heat pump and geothermal well

WP #8 - Milestones & expected results

- Completion of the Greek demo site

Work Package #9

Monitoring & Validation of Ground Coupled Heat Pump Systems

WP #9 - Objectives

Demonstration, on site monitoring and validation of:

- Site in Portugal: A ground coupled heat pump system comprising:
  - Ground source heat pump of COP>5,5 coupled with
  - Prefabricated advanced borehole heat exchanger, and
  - Heating and cooling system.
- Site in Austria: A ground coupled heat pump system comprising:
  - Heat pump able to deliver 80ºC coupled with
  - Prefabricated advanced borehole heat exchanger, and
  - Heating and cooling system.
- Site in Greece: A ground coupled heat pump system comprising:
  - 40ºC-groundwater heat pump of COP>7 coupled with
  - Geothermal well yielding warm water close to 40ºC, and
  - Heating and cooling system.

WP # 9 – Description of work

Operation and monitoring running parameters and energy performance of each heat pump system at demo sites. Preparation of the technology validation and evaluation report.

WP #9 – Description of work (cont.)

Parameters for quantitative evaluation in terms of objectives achievement include:

- Technical performance:
  - Power output (kW)
  - Absorbed electricity (kWe)
  - COP
  - Maximum input temperature
  - Maximum temperature delivered
- Economic performance:
  - Running costs
  - Payback
  - Return on investment
- Operational performance:
  - System availability factor
  - Safety parameters (cut-outs, durations, overcharge)

WP #9 – Description of work (cont.)

Qualitative evaluation of the developed technology in terms of viability and user acceptability will also be performed.

Partners 6-ESTSetubal, 5-GEOTEAM and 7-MENTOR will be responsible for the operation and measurements of the units at the sites of Portugal, Austria and Greece respectively, all being closely assisted by the leader of this work package partner 1-CRES.

Partners 3-EWS and 8-CPERI will undertake the validation/evaluation of the advanced borehole heat exchangers and partners 1-CRES and 2-CIAT the validation/evaluation of the heat pumps.

WP #9 – Description of work (cont.)

Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES).

Other partners (4-GtV, 8-CPERI and 9-UOR) will provide expert advice and on site assistance.

WP #9 - Deliverables

- Technology monitoring and validation report

WP #9 - Milestones

- Completion of on sites preparations

WP #9 - Results

Monitoring data for the following ground coupled heat pump systems at three sites:

- Ground Source Heat Pump of COP>5,5 plus BHE.
- Ground Source Heat Pump Prototype delivering 80ºC plus BHE.
- 40ºC Ground Water Heat Pump Prototype plus geothermal well.

Work Package #10

Innovation-related activities

WP #10 - Objectives

- Making the necessary intellectual property protection arrangements for the knowledge and new technology produced
- Disseminating the developed technology to a global target group
- Facilitating the market penetration of the developed technology

WP #10 – description of work

- Preparation of project presentation material. It will include the project brochure and the project poster (partner 1-CRES).
- Elaboration of market study for the heat pump prototypes and the prefabricated parts of borehole heat exchanger (partner 7 – MENTOR replacing 10-NUOVA CESEN).
- Elaboration of study for the creation of spin-offs (partner 7 - MENTOR).
- Elaboration of study on the socio-economic impacts of the technology under development and demonstration (partner 7 - MENTOR).
- Intellectual property protection (partners 1-CRES, 2-CIAT and 3-EWS).
- Preparation of the final Plan for Dissemination of Knowledge & project results (partner 1-CRES).

WP #10 – description of work (cont.)

- Preparation of the project Internet pages and maintaining and updating the project Internet site (partner 4-GtV). The Internet pages will include an interactive session, where the visitors can participate in discussions, provide input, make suggestions and exchange ideas with the project partners.
- Organisation of the First workshop in France, where the project research results will be announced. The workshop will address the European geothermal community, energy users and decision makers, at European level and will be open to the public (partner 4-GtV). The workshop will take place during the 24-25th (instead of last -48th) month of the project and will have an audience of 100 participants.

WP #10 – description of work (cont.)

- Elaboration of the take-up study on prefabricated advanced borehole heat exchangers: technology assessment, best practices for market penetration (partner 3-EWS).
- Elaboration of the heat pumps take-up study: technology assessment, best practices for market penetration (partner 2-CIAT).
- Partner 11-USI with the assistance of partner 1-CRES will organise the exhibition in Poland, where all successful heat pump prototypes will be exhibited. The exhibition is scheduled for the 4th year of the project and every effort will be made for the exhibition to coincide with a major promotional event on geothermal energy.

WP #10 – description of work (cont.)

- Working out the report on raising public participation and awareness (partner 1-CRES).
- Preparation of the support document for policy making. It will provide input for the future development of energy policy and legislation, including the improvement of existing regulatory measures in EU aiming at assisting market penetration of the developed technology (partner 7-MENTOR in place of 10-NUOVA CESEN).
- Organisation of the Final workshop in Germany, where the project demonstration results will be announced. The workshop will address the European geothermal community, energy users and decision makers at European level, and will be open to the public (partner 4-GtV). The workshop will take place during the 48th month of the project and will have an audience of 100 participants.

WP #10 – description of work (cont.)

- **Various dissemination activities**: Publications to Technical & Scientific Magazines, Press Releases, mail-out of the project brochure, other dissemination activities (partners 1-CRES, 4-GtV). Partner 12-BRGM will identify target group in France, and disseminate to them the project results by mailing out printed material. They will also participate in the two project workshops to be held in France and Germany.
- Continuous review and assessment of work progress and recommendations for corrective actions by the project management committee (partners 1-CRES, 2-CIAT, 4-GtV, 7-MENTOR, 9-UOR).

In addition, each partner will provide input and assistance on all above matters concerning its respective country or region.

WP #10 - Deliverables

- Project presentation
- Internet site
- Market study
- Study for the creation of spin-offs
- Socio-economic impacts study
- Final Plan for using and disseminating knowledge
- First workshop

WP #10 - Deliverables

- Borehole heat exchangers take-up study
- Heat pumps take-up study
- Exhibition in Poland
- Report on raising public participation and awareness
- Support document for policy making
- Final workshop

WP #10 - Milestones & expected results

- Preparation of above studies, intellectual property rights, internet site and organisation of workshops