

## ***Promotion of tri-generation technologies in the tertiary sector in Mediterranean countries (Greece, Italy, Spain, Portugal)***

### **ADENE - Agência para a Energia, Portugal**

#### **Summary**

The project "Promotion of tri-generation technologies in the tertiary sector in Mediterranean countries (Greece, Italy, Spain, Portugal)", or **TriGeMed**, that is supported by the SAVE Programme of the European Commission, aims to promote the uptake of trigeneration (CHCP) by the tertiary sector in the EU member states allocated around the Mediterranean Basin, i.e. Greece, Italy, Spain and Portugal. In addition, the propulsion of this promising technology is assisted via the dissemination of information on it in the wider geographical area of Mediterranean, e.g. Cyprus, Malta, Morocco, Tunisia, etc.

The project achieved its objectives through the carrying out of a survey on the development status and prospects for CHCP applications in the tertiary sector of the 4 Mediterranean countries aim of the study, followed by the implementation of a wide dissemination strategy for the promotion of the generated results and that included the production of several information tools documenting the consolidated survey data, the launching of a web-site and the circulation of e-bulletins, press promotion, organisation of a series of national workshops to announce the project results, etc. A significant potential for the development of CHCP plants in the tertiary sector of the 4 countries was identified; only for the sub-sectors that were analysed the maximum market potential is about 1100 MWe. However, for the effective exploitation of this potential is essential that a number of key obstacles are removed through the adoption of effective and well targeted penetration strategies.

<b>End-user area</b>	<b>Target Audience</b>	<b>Technical</b>
<input type="checkbox"/> New buildings	<input type="checkbox"/> Citizens	<input checked="" type="checkbox"/> Energy efficiency
<input type="checkbox"/> Refurbishment of buildings	<input type="checkbox"/> Households	<input checked="" type="checkbox"/> Heating
<input type="checkbox"/> Transport and mobility	<input checked="" type="checkbox"/> Property owners	<input checked="" type="checkbox"/> Cooling
<input type="checkbox"/> Financial instruments	<input type="checkbox"/> Schools and universities	<input type="checkbox"/> Appliances
<input type="checkbox"/> Industry	<input checked="" type="checkbox"/> Decision makers	<input type="checkbox"/> Lighting
<input checked="" type="checkbox"/> Legal initiatives (municipal regulations, directives, etc)	<input checked="" type="checkbox"/> Local and regional authorities	<input checked="" type="checkbox"/> CHP
<input checked="" type="checkbox"/> Planning issues	<input type="checkbox"/> Transport companies	<input type="checkbox"/> District Heating
<input type="checkbox"/> Sustainable communities	<input checked="" type="checkbox"/> Utilities	<input type="checkbox"/> Solar energy
<input type="checkbox"/> User behaviour	<input checked="" type="checkbox"/> ESCOs	<input type="checkbox"/> Biomass
<input type="checkbox"/> Education	<input type="checkbox"/> Architects and engineers	<input type="checkbox"/> Wind
<input type="checkbox"/> Other	<input type="checkbox"/> Financial institutions	<input type="checkbox"/> Geothermal
	<input type="checkbox"/> Other	<input type="checkbox"/> Hydro power
		<input type="checkbox"/> Other

#### **Context**

Competitiveness, environmental protection and security of supply are the central targets setting the framework for implementing a Community energy policy. It has been since long time realized that

cogeneration (combined heat and power production, or CHP) can contribute significantly and cost-effectively to all these targets. To reach them CHP technologies expand towards new application fields with their use facing now the challenge of adaptation into small-scale applications in the tertiary sector. Moreover, CHP systems combined with absorption chillers have provided lately an efficient way of recovering "waste" heat to cooling energy, the energy producing scheme known as "trigeneration" or combined heat, cooling and power production (CHCP).

Several studies have revealed that a significant share of the EU's electricity could be supplied by CHP plants and was still underlined, namely by the EC, the need for the promotion of CHP systems and presented a strategy to remove any barriers that obstruct the penetration of cogeneration in the European Energy Market. Furthermore, among the suggested measures a doubling of the existing installed CHP capacity (9%→18%) is proposed, up to 2010, with the inherent significant reduction of CO<sub>2</sub> emissions, estimated in 4% or 65 million tons per year. Despite those estimations and the fact that technologies used in CHP systems have improved in recent years, significant hurdles exist that limit widespread uses of CHP/CHCP. As a consequence, these hurdles have kept the levels of CHP/CHCP penetration far below the estimated figures and promoted the use of polluting and less-efficient electricity generation equipment.

By other hand, it is well known that the tertiary sector is a major energy consumer, especially in the Mediterranean area, where substantial cooling load exists during the summer period, and consequently can receive substantial benefits from the application of cogeneration technologies, particularly CHCP. Assuming that there is a great potential in improving the efficiency in this sector, a major part of interventions can consist of the replacement of conventional heating & cooling systems into CHCP schemes. The use of absorption chilling for provision of cooling integrates and maximizes the technical and economic benefits from CHP. In addition, the rapid increase of the air conditioning equipment penetration to those markets has added considerable loads to the electricity networks, which often marginally cover the electricity needs during peak load periods. It is therefore essential to provide alternative solutions to the capacity increase and one of them is the use of absorption chillers for cooling, through CHCP systems. The need of a widespread diffusion of the CHCP technologies in the concerned countries, justified by an absence of initiatives targeting specifically to this integrated approach for the sector, will not only result in considerable energy savings, but also in an enforcement of rational use of energy and alleviation of impacts on the environment in a region characterized by a poor overall energy efficiency. Therefore, the project is aiming on the assessment and dissemination of benefits from the use of CHCP at the tertiary sector, in a region with high potential for its exploitation, the Mediterranean basin.

## **Objectives**

The project aims:

1. To demonstrate the competitive advantages of CHCP applications for the coverage of the energy demand (i.e. electricity, heat and cooling) in the tertiary sector buildings, e.g. hotels, hospitals, etc.;
2. To identify the existing technical, legal, regulatory and financial barriers for the penetration of trigeneration in this sector;
3. To indicate solutions to overcome those barriers and to create favourable conditions for CHCP investments;
4. To help adapt the findings in a broader geographical area - the South Basin of Mediterranean.

The accomplishment of these aims has been achieved by: undertaking a **survey** on market potential for trigeneration applications in the tertiary sector of the Mediterranean countries, on the example of Greece, Italy, Spain and Portugal; and, implementing a **wide dissemination strategy**, on EU level and beyond, through the production of multilingual information tools, a publication and a CD-ROM, documenting the survey results, organisation of series of regional workshops and launching a project web-site.

## **Process**

The duration of the project was 2 years, from January 2002 to December 2003. Its work programme consisted of two main phases. During phase 1 a survey was undertaken in order to evaluate the technical

and market potential for the promotion of the trigeneration technologies in the tertiary sector of the 4 involved countries. This was achieved by implementing the following tasks:

1. Production of a comprehensive and useful compilation of the existing CHCP technologies available in the EU market, as well as the relevant key players, through:
  - an inquiry of the state-of-art of the technology in Europe, together with the examination through a survey of the existing CHCP technologies available in Greece, Italy, Spain and Portugal, on the tertiary sector, and determination of the correspondent technology deficits;
  - the creation of a database of manufacturers, suppliers, engineering firms, consultants, ESCOs and other actors related to CHCP, containing as much as possible relevant information about these entities and their "products"/services.
2. Detailed assessment and identification of the potential for trigeneration application in representative buildings of the tertiary sector and quantification of the respective benefits, through a *pilot action*.
  - selection of buildings (2-3) per country, from different branches of the tertiary sector, representative of the category in terms of volume and energy consumption;
  - collection of buildings data (infra-structure, electricity, heat & cooling loads, consumption, etc.);
  - carrying out of a pre-feasibility study for each of the buildings, for determination of the viability of proceeding to investments in CHCP (concluded by calculation of indices such as payback period, NPV and IRR, besides the assessment of energy efficiency and environmental benefits).
3. Estimation of the technical and economic potential for trigeneration in each country and of benefits arising from its implementation at a national level. (This was mainly based on the same subsectors to which belong the buildings selected in the previous task, i.e. for Greece - Hotels and Hospitals, for Italy - Commercial Buildings and Hotels, for Spain - Hotels, Hospitals and Airports, for Portugal - Hotels and Hospitals, and regarding the economic potential this one was calculated through different scenarios that were defined from legal and economic considerations).
4. Identification of market potential for trigeneration and main existing barriers for the penetration of this technology in each country.
5. Determination of strategies for accelerating/increasing penetration of CHCP in Mediterranean area.

During phase 2 "Dissemination of project results", a set of information tools was produced, essential for the implementation of a full-fledged dissemination strategy, on the EU level and beyond, for the promotion of the results derived by the survey. These tools comprise a survey report, a publication, a multilingual CD-Rom application and the project web-site providing on-line access to the downloadable report data as well as to valuable contacts through the established links. Once these tools were in place, the dissemination strategy was implemented through the organisation of a series of 4 national workshops, one per each country involved (Madrid - 12 Nov. 2003, Lisbon - 18 Nov. 2003, Rome - 25 Nov. 2003, and, Athens - 4 Dec. 2003), the launch of the web-site ([www.trigemed.com](http://www.trigemed.com)), wide press media coverage through press-releases and publication of some articles and targeted e-mailing of an electronic bulletin promoting the project and the achieved results.

The project addresses several target groups and other key actors, namely policy makers involved in creating energy policy and legislation, regional/local decision makers responsible by local energy master-plans, representatives from the tertiary sector as enterprises or potential users/investors, banks and financial institutes, engineers, designers and buildings developers, CHP manufacturers/suppliers, relevant professional associations and academic institutions, research institutes, etc.. Furthermore, the key actors to the success of the project are the Energy Agencies and European Commission, since the results of the project will be an effective tool for the establishment of national and Community regulations and policies. In addition the existing pan-European and other networks world-wide, such as European Energy Agencies, MEDENER, OPET, Sustainable Cities, ICLEI, etc., were accessed to maximize the dissemination efforts impact.

The main problems related to the project were the lack of co-operation/difficulties in obtaining some data from external entities and that were faced by the most part of partners in the survey that was undertaken.

## Financial resources and partners

The project was implemented by an European Consortium of 8 partner companies, namely: **ADENE** - Agência para a Energia (Portugal), the Co-ordinator; **LDK Consultants** Engineers and Planners (Greece), the leader of phase 2; **IST**- Instituto Superior Técnico (Portugal); **IDAE** - Instituto para la Diversificación y Ahorro de la Energía (Spain); **ISNOVA** - Istituto per la Promozione dell'Innovazione Tecnologica (Italy); **CRES** - Center for Renewable Energy Sources (Greece); **ADEME** - Agence de l'Environnement et de la Maîtrise de l'Energie (France); and, **ISQ** - Instituto de Soldadura e Qualidade (Portugal).

The total eligible cost of the project was 519.13 kEuro, from which 50% is supported by the SAVE Programme of the European Commission. At a national level, part of the remaining 50% of that total cost by individual partner was also co-financed by National Authorities in some countries.

## Results

In spite of the recognized advantages and significant existing market potential for the implementation of CHCP in the tertiary sector of the 4 analysed countries, there are some barriers to the higher penetration of this technology in that sector in all those countries, being these obstacles of different nature - economic, technical and other (legal, administrative, political/institutional, organisational, etc.) and not quite the same in all countries. The importance of these different obstacles in each country reflect the development level of trigeneration in the sector that is different in the 4 countries - Spain with 23 CHCP plants (48 MW of installed electrical capacity) and Italy with 11 plants (but representing 123 MW of installed electrical capacity) are the ones that are far most advanced in this field, followed by Portugal that has 10 CHCP plants, equivalent to 28 MWe of installed capacity. Greece is giving the first steps in what concerns to CHCP implementation in the tertiary sector, since before 1994 these installations were not allowed by Greek law and natural gas is available in the big cities from 2002, which implies that for the moment there are only 3 CHCP units, representing a total installed electrical capacity of approx. 2 MW.

Because of this, the strategies for removal of those barriers must be, in a general way, different from one country to other, according to the specificities/barriers of each country. Even so, based on the conclusions for the individual strategies in each country, it is evident there are several common measures which appear to be applicable in most countries of the region. Accordingly, it is apparent that the prompt adoption of those measures will significantly facilitate the increase of CHCP share in the tertiary sector of the Mediterranean countries and constitute an efficient tool to achieve energy savings and reduction of CO<sub>2</sub> emissions. It can be stated that for those common measures are of high priority and relate mostly with tackling economic and organisational barriers (e.g. review of electricity and gas tariffs, financial support - promotion of innovative financing schemes, improvement of administrative/licensing procedures, and, needs of awareness raising and dissemination campaigns about the CHCP technology), as well as defining clear strategic goals (e.g. primary energy savings and/or CO<sub>2</sub> emissions savings).

The results of the pilot actions showed attractive financial viability for most cases, with payback times in the magnitude of 4-5 years. For the 9 pre-feasibility studies carried out (3 hospitals, 1 airport, 3 hotels, 2 commercial buildings), it was concluded that the investments correspondent to the implementation of CHCP plants in the considered buildings, estimated in a total of 12,695 kEuro, could conduct to 16,438 tons of CO<sub>2</sub> emissions savings per year. Extrapolating these results for the correspondent subsectors, the estimation of the technical, economic and market potentials has given the following results:

**Table 1: Summary of trigeneration potentials for Spain. Units in MWe \*.**

Potential	Hotels	Hospitals	Airports	TOTAL
(Effective) Technical	587	369	34	990
Economic scen.1 - minimum - maximum	18 - 250	27 - 141	14 - 25	59 - 416
Economic scen. 2	339	256	30	625
<b>Market potential</b>				
Technical	584	293	17	894
Economic scen.1 minimum - maximum	15 - 247	0 - 65	0 - 8	15 - 320
Economic scen. 2	336	180	13	529

Notes: 1) Economic potential calculated for two different frameworks or scenarios: scenario 1 (current policies) and scenario 2 (services framework), in which distributed generation is recognised; 2) \* The same trigeneration potentials in terms of trigenerated cold are: Total Technical = 222 MWc, and, Total Economic = 10 MWc (min.) - 136 MWc (max.).

**Table 2: Summary of trigeneration potentials for Portugal. Units in MWe \***

Potential	Hospitals	Hotels	TOTAL
(Effective) Technical	66.1	negligible	66.1
Economic scen.1	17.5	negligible	17.5
Economic scen. 2	67.0	negligible	67.0
<b>Market potential</b>			
Technical	62.1	negligible	62.1
Economic scen.1	13.4	negligible	13.4
Economic scen. 2	62.9	negligible	62.9

Notes: 1) Calculation of potentials done similarly as for Spain, with the difference that for scenario 2 of the economic potential were taken into consideration own specificities of the country (lower development level of the CHCP market and other specific factors); 2) \* Trigenerated cold potentials for Hospitals subsector: Technical = 26.4 MWc, and, Economic = 6.1 MWc (min.) - 23.5 MWc (max.).

**Table 3: Summary of trigeneration potentials for Greece. Units in MWe \***

Potential	Hotels	Hospitals	TOTAL
(Effective) Technical	96.1	20.3	116.4
Economic scen.1	21.8	20.3	42.1
Economic scen. 2	9.9	14.2	24.1
<b>Market potential</b>			
Technical	96.1	20.3	116.4
Economic scen.1	21.8	20.3	42.1
Economic scen. 2	9.9	14.2	24.1

Notes: 1) Calculation of potentials done similarly as for Portugal; 2) \* Trigenerated cold potentials: for Hotels subsector: Economic = 7.8 MWc (min.) - 17.1 MWc (max.), for Hospitals subsector: Economic = 11.2 MWc.

**Table 4: Summary of trigeneration potentials for Italy. Units in MWe**

Potential	Hospitals	Commercial buildings	TOTAL
Technical-Economic	155	335	490
<b>Market potential</b>			
Technical-Economic	122	326	448

Concerning the primary energy and emissions savings associated to the estimated technical potential for the whole 4 countries, arising from the implementation of trigeneration, are respectively:

- Primary energy saving: 6,800 GWh/year
- CO<sub>2</sub> emissions saving: 727,700 t/year.

These results clearly demonstrate the no negligible benefits that the CHCP technology may represent for all countries of the South Basin of Mediterranean. The achievement of the objectives of the TriGeMed project was a reality, not only by the results of the survey, but also by the dissemination that followed, with a participation of almost two hundred people in the 4 workshops carried out and the wide circulation of e-bulletins by the foreseen channels, addressed to the selected target groups and key actors, that in most cases reacted as being interested to know more about this promising technology.

## Lessons learned and repeatability

The main lesson learned from this project is that there is a significant technical potential for the implementation of trigeneration in the tertiary sector of countries of the Mediterranean area. With the pilot actions carried out the advantages of CHCP applications for the coverage of the energy demand in

the most representative tertiary buildings were clearly demonstrated, confirming that the technology is worthwhile, and having important technical, economic and environmental impacts, the last ones contributing effectively for a sustainable development of urban areas, enhancing competitiveness, prosperity, and the comfort and safety of the tertiary sector buildings and correspondent places/cities where are located. However, important barriers that hinder the penetration of this promising technology have been identified, and if not eliminated (at least some), any proposed strategy won't have the expected results. This means that only with a strong involvement of the national authorities, mainly those ones with influence on decisions related with energy policies and regulation of energy tariffs, that may lead to concrete actions (and, for instance the need of reducing some natural gas tariffs is imperative), such measures may contribute for coherent national strategies with effective impacts.

The project had the merit to sensitize potential users and investors and other entities about CHCP and its advantages, or by other words to raise the awareness about a technology that is not well known, being fundamental the dissemination strategy that has been followed. It is expected that by the dissemination having not been limited to the countries involved in the project, the results of the project may have an important replication potential in all Mediterranean Basin, due to the similar climate conditions and characteristics of the energy market of the involved countries, and by the advantages and "precautions" related to some market barriers to be taken into consideration that were highlighted by TriGeMed.

### **Contact for more information:**

Project Web Site: [www.trigemed.com](http://www.trigemed.com)  
Organisation / Agency: ADENE - Agência para a Energia  
Main contact: Fernando Oliveira  
Address: Estrada de Alfragide, Praceta 1 - n° 47, Alfragide, 2720-537 Amadora, Portugal  
Tel: +351 21 4722800  
Fax: +351 21 4722899  
E-mail: [fernando.oliveira@adene.pt](mailto:fernando.oliveira@adene.pt)  
Web Site: [www.adene.pt](http://www.adene.pt)

Printed reports or other literature available:

Title: 1) Publication "TRIGENERATION IN THE MEDITERRANEAN COUNTRIES - Technologies and Prospects for the Tertiary Sector" (besides the English version, also available in Portuguese, Spanish, Italian and Greek versions)  
2) Survey Report "Promotion of tri-generation technologies in the tertiary sector in Mediterranean countries" (that can be downloaded from the project web site)

Other contacts: 1) LDK Consultants Engineers and Planners / Mrs. Athina Ignatieva (for Greece). Address: Off 21, Thivaidos str., GR-145 64 Kifissia, Athens, Greece. Tel.: +30 210 8196752 . E-mail: [ati@ldk.gr](mailto:ati@ldk.gr) .  
2) ISNOVA - Istituto per la Promozione dell'Innovazione Tecnologica / Mrs. Wen Guo (for Italy). Address: Via Flaminia, 441, I-196 Rome, Italy. Tel.: + 39 06 30484059. E-mail: [enea\\_opet@casaccia.enea.it](mailto:enea_opet@casaccia.enea.it)  
3) IDAE - Instituto para la Diversificacion y Ahorro de la Energia / Mr. Jose Luis Garcia Angulo (for Spain). Address: C/ Madera 8, 28004 Madrid, Spain. Tel.: + 34 91 4564960. E-mail: [jlgaran@idaes.es](mailto:jlgaran@idaes.es)