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## Alternative technologies for refrigeration and air Conditioning applications

Every day, efficiency in the use of energy, as well as its environmental impact (ozone depletion, green house effect, atmospheric pollution) are becoming more and more important, posing strict demands for the development and the use of new or even older (in some cases may be forgotten) techniques, aiming to contribute towards the confrontation of the above undesired situations. The use of low energy and passive air conditioning techniques are mainly met in the context of bioclimatic building design / architecture, which, at least to the writer's opinion, would be more present in our everyday life in the years to come. Regarding the effort to reduce the environmental impact, the use of Alternative Refrigeration Techniques (ART) may also be a promising way contributing to this. Such techniques are, for example, thermo-acoustic refrigeration, thermoelectric refrigeration, reverse Brayton cycle, reverse Stirling, solid sorption, etc. In the proposed project, the involved work includes among other issues, the following methodology.

First of all, we are going to identify and classify the main alternative refrigeration techniques (ARTs) that have been appeared in the past or now are under investigation. Secondly, we will describe and review the basic principles hidden behind each of these ARTs. Moreover, we will carry out a technical assessment of these ARTs from a technical aspect and we will perform a feasibility study from both a technical and an economical point of view. We will try to assign possible best suited applications to each of the ARTs considered. Additionally, we will perform a survey on the relevant current research on the above topics, either experimental or theoretical (both in physical modeling and numerical simulation), to highlight what's hot and indicate fields for potential improvements / active research. To conclude as a consequence of the above methodology, we are going to propose directions for future research on the topic.

### The suggested plan for this project would be as follows:

- o Introduction. Objectives. Why searching for alternatives? Historical topics. Why is it important? Environment & climate change, CFCs, etc. (ozone depletion, green house effect, atmospheric pollution). Reduce needs for refrigeration (for example low energy and passive air conditioning, bioclimatic building design / architecture) or change / modify refrigeration technique. Use of renewable energy.
- o Description of standard / existing refrigeration plants & techniques, their operation and related physical principles (vapour compression cycle). Measures of performance (COP) and operation from a thermodynamic point of view. Improvements related to the use of alternative refrigerants in standard plants (like for example HCs).
- o Alternative Refrigeration Techniques (ARTs): new or even older (in some cases forgotten) techniques; identify and classify the main alternative refrigeration techniques (ARTs); Compare the below ARTs:
  - Heat Driven Processes (absorption cycle, ejector cycle, adsorption, sorption)
  - Expansion Cycles (reverse Stirling, inverse Brayton)
  - Thermoelectric Processes (Peltier process)
  - Magnetic processes
  - Thermo acoustic processes
- o Each one of the ARTs under consideration will include:
  - description of the basic principles
  - historical development
  - advantages & disadvantages (pros & cons)
  - assessment from a technical point of view (reliability, technical maturity, problems remaining to be solved),
  - economics, environment
  - feasibility (technical-economical-environment),
  - possible section of applications
  - current experimental or theoretical (physical modeling or numerical simulation) research, to highlight fields for potential improvements / active research.
- o Best possible applications to each of the ARTs under consideration: Fields of application, generally and especially for Greece; different systems that could potentially and theoretically be best suited.
- o Conclusions: Recommendation of the best solution; suggestions and directions for future research on the topic.

### Background and Literature review

Nowadays, the demand of refrigeration and air conditioning applications for domestic, commercial and mobile uses is becoming more and more necessary. Every day, efficiency in the use of energy in terms of the consumption, as well as of the environmental impact such as the climate change and the global warming effect, are becoming more and more important.

The basic problem related to environmental impact of refrigeration, is the production and the use of Chloro-Fluro Carbons (CFCs) and Hydro-Chloro-Fluro-Carbons (HCFCs) as refrigerants. According to the "Refrigeration & Air Conditioning CFC and HCFC Phase Out", [1] by DETR/DTI, a number of changes, in the use of CFCs and HCFCs, have been applied in the refrigeration and air-conditioning field. In the new EC Regulation on ozone depleting substances, EC 2037/2000 applies from 1st October 2000; this date has also been given by the previous regulation, EC 3093/94.

Moreover, the use of the halocarbons like Chloro-Fluro Carbons (CFCs) and Hydro-Chloro-Fluro-Carbons (HCFCs) is regarded since 1930, according to the "pollution prevention opportunity data sheet" for "non-chlorofluorocarbon alternatives for air conditioning and refrigeration" [2]. Additionally, CFCs and HCFCs are responsible for the increase of the ozone layer and for global warming potentials. Therefore, there are other (non-halocarbon) alternatives, both processes and refrigerants, to CFCs, HCFCs, and HFCs that can be used for a wide variety of applications. Some of them are: - Vapor compression using hydrocarbons, ammonia (R-717), carbon dioxide, or water, - Water evaporative cooling (direct and indirect), - Gas expansion and others.

On the other end of the scale there is another technological development which is already in the market and is the substitution of hydro fluorocarbons (HFCs) with hydro carbons as a refrigerant. The HFCs have a global warming potential (GWP) greater than carbon dioxide. Furthermore HCs have a minimal effect to global warming. With this study [3], we come to the conclusion that the standard vapor compression cycle of HFCs is a replacement by HCs. So according to [3] with this technology, a more environmental friendly refrigeration system is being held and the existing refrigeration plants come with better efficiency levels. According to hydrocarbon refrigerants reports showed in the study, an improvement of 15% up to the standard efficiency may carry out relative to existing standard plant performance.

However, a more drastic measure for the future, towards the direction of reducing refrigeration environmental impact, would be the development and use of Alternative Refrigeration Techniques (ARTs). These techniques are either new or old ones, but generally, they are not currently applied in everyday applications. Therefore, a literature review will be performed on previous works on the research to identify and classify the main alternative refrigeration techniques (ARTs), that have been appeared in the past or present, or are currently under investigation.

The ARTs have many classifications for many and different categories. In this project, we follow the Hans's Jonsson classification for ARTs depending on the refrigeration cycles. According to Jonsson [4] there are a number of categories:

- o Vapor Compression Cycle.
- o Heat Driven Processes: (Absorption Cycle, Ejector Cycle, Absorption, Sorption)
- o Expansion Cycles: (Reverse Stirling, Inverse Brayton)
- o Thermoelectric Processes: (Peltier Process)
- o Magnetic processes
- o Thermo-Acoustic processes

A particular analysis / literature review will follow, for each of the above methods.

### Aims and Objectives

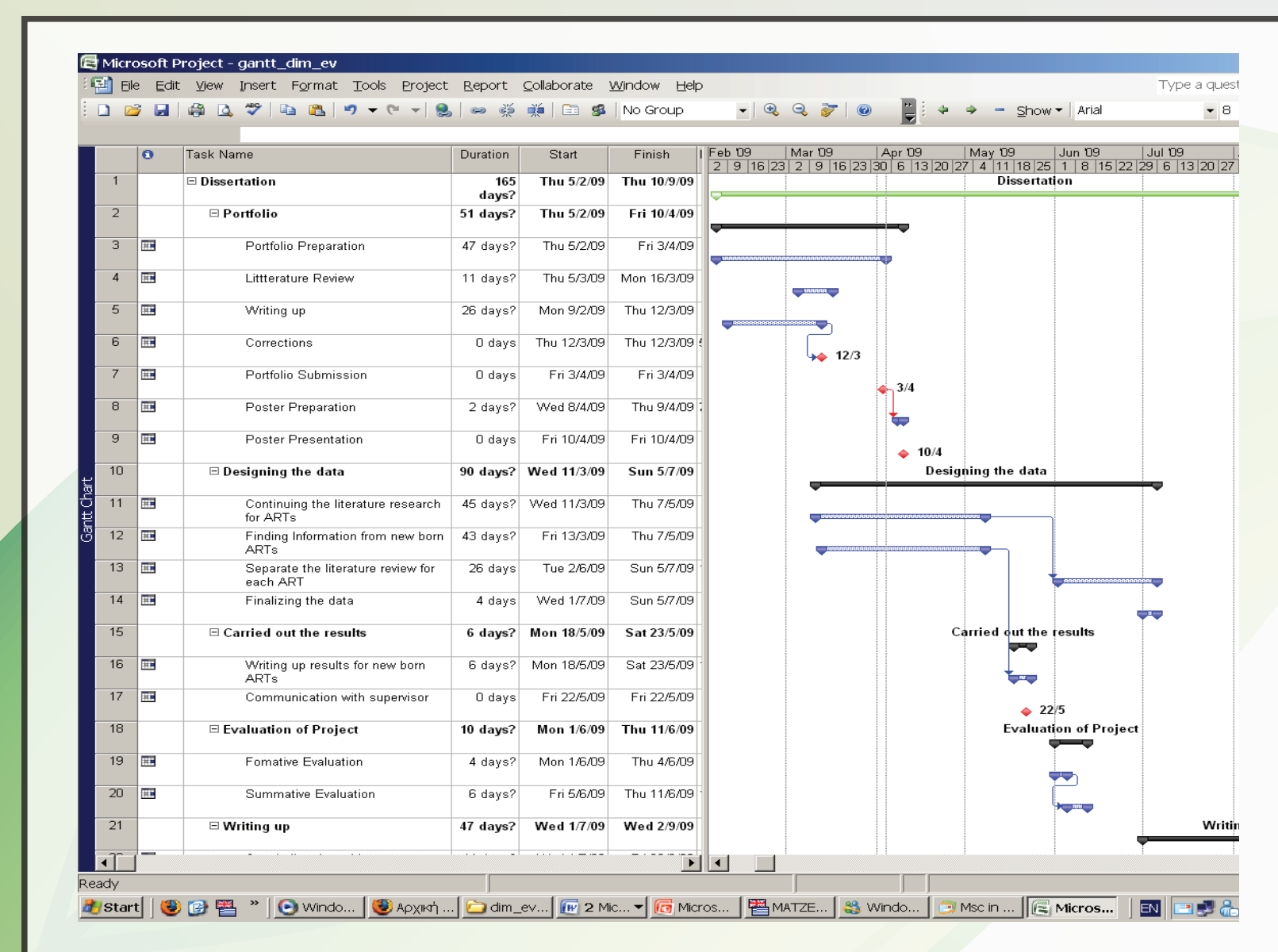
The aim of this report is to identify and classify the main alternative refrigeration techniques (ARTs) that have been appeared in the past or are now under investigation. This report will also present, argue and provide solutions for the best possible applications for each one of them, mainly for urban usage in Greece.

Regarding the objectives is to classify and evaluate the basic alternative refrigeration techniques (ARTs) that have been appeared in the past or now are under investigation, in order to describe them and record them. According to that, a research will be made in order to write down the pros and cons for every ARTs and the usage of them in the future.

### Motivation

The observation the climate changes in combination with all kind of energy scenarios, for the boost of the energy efficiency as well as its environmental impact such as the ozone depletion, green house effect, global warming, are becoming more and more important for the development and the use of air conditioning techniques. Furthermore, the current economic recession reinforces the idea of "do things with less": try to use less energy and consume the lowest energy cost possible. In fact, according to the demand in the field of air conditioning systems, people try to improve their indoor condition depending on the climate they live in; and they try to do it with the lower cost possible. For this reason, the new technologies for alternative refrigeration systems (ARTs) should be taken under consideration and stand forward. Additionally, there are several environmental parameters that cannot be ignored. Specifically, the old air conditioning techniques using Chloro-Fluro Carbons (CFCs) and Hydro-Chloro-Fluro-Carbons (HCFCs) as refrigerants should be minimized due to their damaging impact on the ozone layer and the climate changing. Taking all the above under consideration, this study focuses on new, alternative ways of refrigeration systems (ARTs) in order to bring out the most important ones that could be used in our daily life and for our own good.

As aforesaid, this entire project consists, in a great degree, information from a very special literature survey on research and applications related to what defined previously as ARTs, where existing information / results have to be methodically gathered and presented compactly in a specific text. Additionally, an attempt will be made to further discuss these results and check their potential for real applications, according to current research. As a consequence, this section of literature review is, for this particular project, not only an initial stage for the sake of completeness but also a section to explain why a method will be chosen for the rest of the project. As such, it is only a preliminary literature review on works similar to the topic of the proposed project that will be continued throughout the project.



### Conclusions

As a conclusion, suggestions and directions will be given for future research in the field of alternative refrigeration systems, in order to find new and friendlier to the environment applications, with less energy consumption, a more powerful efficiency system and with a large width of applications (urban – commercial etc.).

### References

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