Project no. **032559**

Project acronym **MEDISCO**

Project title **MEDiterranean food and agro Industry applications of Solar COoling technologies**

Instrument **Specific Targeted Project**

Thematic Priority **INCO**

D1.1 Report on food and agro industries characterization in Tunisia, Morocco and Egypt

Due date of deliverable: **month 10**

Actual submission date: **September 2008**

Start date of project: **1/10/2006**

Duration: **36 months**

Organization name of lead contractor for this deliverable:

Egyptian Environmental Affairs Agency (EEAA)

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	**X**
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Introduction

The European project MEDISCO, part of the 6th Framework Programme, seeks to develop, test and optimise solar-cooling concepts for the agro-food industry in the Mediterranean Basin, concepts which, considering local conditions, might prove economically and socially sustainable.

After having analysed the Agro-Food Industry (AFI) and determined the penetration potential of solar cooling in this sector, this project seeks to define which technologies might best suit current and future requirements in the food and preservation sectors on the Mediterranean Basin's south bank. The selected technologies will be implemented at two pilot sites, which will be monitored to study their performance and verify their functionality. In other words, the scope of the project is to determine which methodology is technically and economically best suited to install high-performance solar-cooling systems meant as the best compromise between innovative technologies, primary-energy savings and cost-effectiveness.

This deliverable, designated "D1.1", also intends to develop the methodological tools that will make it possible to discern the main features, particularly those involving energy and economic issues, of the agro-food sector. First, the methodology and related questionnaires used in the national studies will be presented. Then, the three studies (conducted in Tunisia, Morocco and Egypt) will be presented in detail. Lastly, the purpose of this deliverable is to define a methodological guide which would be used in any future penetration evaluation of renewable energies (and particularly of solar cooling) in the agro-food industry of the Southern and Eastern Mediterranean Countries (SEMC).

This document is structured in three parts:

- The definition of the national studies' methodology. This first step aims at developing the methodological tool that will be implemented to realise the national studies in the 3 SEMC involved in the project;
- The summary of the results of the three studies of the AFI in Tunisia, Morocco and Egypt;
- Definition of a more general methodological tool to evaluate the penetration potential of renewable energies (in particular solar cooling) in the AFI of the SEMCs. This tool considers the findings, observations and improvements capitalized during the implementation of the 3 national studies, in order to create a more "universal" tool which could easily be applied to any other SEMC.

PART 1: Presentation of the initial methodology

This first part of the document aims at defining the initial methodology applied in the three countries involved in the MEDISCO Project. Using the existing methodological tools as a basis, this first step defines the framework of the national studies meant to determine the national energy and economic stake(s) of the cold sector within the AFI.

The methodology followed three main research steps: the country's energy context, the structure of the AFI sector and the study of cold production within the AFI sector.

1. The country's energy context

Introduction: general description of the country

Prior to any energy study, the studies inventory the country's territory, presenting the main national data:

- ***Geographical data***

Provided information relates to the location, surface area and various geographical zones of the country.

- ***Demographic, economic and political data***
- ***Climatic data***

This information relates to the countries' climatology. These are the characteristics which influence energy needs and system operation: seasons, temperatures, winds, precipitations, rate of average sunshine, etc.

These data provide a first idea of the potential use of new and/or renewable energies.

1.1. The national energy balance

The aim is to present the energy characteristics of the country. The assessment of resources and consumption allows defining the country's main energy stakes in the framework of the national energy policy.

First, the methodology consists in presenting the various ***energy resources*** used by the country and any imports and/or exports made to meet the needs.
Particular attention is paid to electricity. Indeed, the production of this common energy source requires significant important uses of primary energy resources.

Next, the study will present the country's ***energy consumption*** (generally presented in Tonne Oil Equivalent, or TOE). The information provided on national energy consumption also indicate the shares of each resource used (electricity, natural gas, oil, coal…) and the shares of the country's various economic sectors (building, industry…)

These data make possible the establishment of the country energy balance, *i.e.* its ***situation of energy dependence or self-sufficiency.***

1.2. The country's energy policy

Conscious of the economic, social and environmental stakes of the energy sector, states often implement ***energy regulation mechanisms***. This legislation is generally complemented by incentive (or sanctions) to comply with the energy policy and to foster the development of the various economic sectors.

The presentation of these **systems of energy-policy implementation** also suggests the stakes of the energy sector and its role in economic growth.

Generally, energy data may be obtained from the various ministries or governmental departments dedicated to the energy sector (ministry of energy, national energy agency…)

2. The agro-food sector

During this second stage, the study will delve deeper into its target sector, *i.e.* the Agro-Food Industry (AFI). The methodology consists in revealing the strategic nature of the AFI in the application of new and renewable energy technologies.

With this in mind, the study will ensure it provides the necessary information on the sector's structure and the economic market it represents for the country. Finally, the study will define the sector's impact on the country's energy consumption according to the resources used and the sector's various activities.

2.1. The structure of the country's agro-food industry

First, the study will define the organisation of the AFI, which is centred on a **number of companies** with differing features. On the basis of the total number of industries, their size or category (international group, domestic company, small or medium enterprises or SME…) and their field of activity (fruits and vegetables, milk, meat, seafood, cereals…) must be defined.
Next, the study will define ***employment*** within the AFI, and the share of each sector activity.
This description of the sector makes it possible to define the AFI's significance to the economic structure of the country and the industry.

2.2. The agro-food industry market

To study the AFI market thoroughly, the methodology consists in describing the sector's role in the national economy on the basis of ***financial data*** (turnover, share in gross domestic product, added value…) ***and quantitative data*** (production volumes, import and export volumes…)

Furthermore, the study will present the ***investments*** made in this sector over the past few years. This indicator allows establishing the strategic stake of the AFI in the country's economy, and the sector's push toward development and competitiveness.
The agro-food industry is also characterised by a market focused on ***international trade***. The varied food requirements of countries and the economy's globalisation have fostered the export of local products or the import of raw materials. Such international trade generates not only customer-supplier relationships, but also partnerships between industries and foreign investors and companies.
Thus, the relationships between economic players can be an important cause of process or product modification to satisfy client expectations. The study will then define the international trade relationships and partnerships of the AFI.

2.3. The agro-food industry's energy situation

After having described the AFI's structure and market, the study will present the energy situation of the sector on the two following scales:

- ***sector-wide***, to measure the sector's share of consumed energy compared to the total energy first of the country, then of the industrial sector,
- ***by sector activity***, to measure the share of each activity (meat, fish, milk, cereals…) compared to the sector.

This analysis of the AFI's energy situation makes it possible to evaluate the importance of the sector in national energy consumption, but also to identify those sector activities which are high consumers and may be the subject of a more thorough study.

3. Cold in the agro-food industry

Introduction: The applications of cold in the agro-food industry

In the AFI, refrigeration and commercial and industrial cooling are necessary for the following reasons:

- they ensure the preservation and value realisation of "perishables"
- they satisfy the local market in time and space
- they export products to the local and foreign markets
- they avoid foodstuff losses
- they play a significant role in price levels by adjusting supply to demand

Food products go through various freezing stages between production and consumption. This "cold chain" must not be broken between the following stages:

- Fast processing of healthy products
- Refrigeration for preservation at 0°C
- Deep-freezing for preservation below -18°C
- Storage of processed products in refrigerated warehouses
- Transportation of products by refrigerated containers to the various distribution points
- Presentation of refrigerated products at distributors' establishments

- Preservation of products in home refrigerators and freezers

On the basis of cold applications and product-preservation objectives, the methodology consists in studying certain stages of the cold chain in various sector activities. The stages will be studied in light of their priority role within the AFI or the activities.

After a description of the sector's refrigeration capacities and the volume of products involved in industrial cold, the study will rely on a questionnaire meant for companies. The questionnaire allows evaluating cooling technologies, the equipment used, and the process-related consumption and costs.

On the basis of the characteristics and stakes enhanced, the study will identify the measures and means to be implemented for the development of cold in the sector's various activities.

3.1. Overall survey of cold in the agro-food industry

If the objective is to evaluate the penetration potential of solar cold in the AFI, a survey of the "cold" field in the AFI must first be conducted. To do so, the socioeconomic, functional and legislative characteristics of cold in the AFI must be defined as clearly as possible.

3.1.1. Socioeconomic characteristics of the cold in the agro-food industry

The methodology consists in thoroughly studying the issue of cold within the AFI. Thus, the study will define the following characteristics:

- The players

The study will focus on the AFI ***companies or industries*** involved in cooling their production and will define the proportion of the AFI which uses cooling systems.
The study will also define their weight in terms of ***employment***, compared to the AFI as a whole. If the sources allow it, a distinction will be made between permanent and seasonal jobs. Indeed, the AFI is a sector with significant seasonal job requirements because of production and harvesting needs.

- Economic characteristics

The study will describe the economic weight of the field of "cooling" within the AFI. The main characteristics of the companies using cooling are ***total turnover*** and ***total exports***.
The study will also try to evaluate the companies' ***investment*** in their development and that of processes and products, and the evolution in cooling equipment.

- Sector activities

The aforementioned socioeconomic data must be developed according to AFI activities. Thus, the study will identify the main activity(ies) by weight, in terms of number of industries or jobs, in economic terms, and in terms of cooling use.

3.1.2. Refrigeration and/or cooling capacity of the agro-food industry

The study will evaluate the cooling capacity of companies to determine their needs, considering their production and their potential use of solar cold instead of or to complement existing facilities.
Should there be no data, the study will define, at the very least, AFI production volumes requiring cooling facilities, or cold storage volumes.

To determine the penetration potential of solar cold and study its economic interest, the study will evaluate the impact of cooling on industrial energy consumption and on the IFA's economy (sector's energy cost).

3.1.3. Industrial-cold legislation and compliance of the agro-food industry

First, where there are already available data, the ***legislative framework*** applicable to cooling activities and/or the agro-food industry must be presented. The study will reveal the means and compliance measures implemented to enforce this specific agro-food cold legislation.
Next, the study will focus on compliance with the ***industrial processes***, particularly continuity in the "cold chain". Should there be breaks in the cold chain, the study will point out the stages affected and possible actions carried out or required.

3.2. Evaluation of the various agro-food activities' cold needs

After having defined the main determining factors of cold within the AFI overall background, the methodology will consist in studying thoroughly the issue of cold within the AFI's main activities.
To do so, the study will define the social and economic components of the main activities, and will then describe their cooling needs and each activity's ability to meet such needs.

3.2.1. Characteristics of the various agro-food Industries

As was done previously (breaking down according to domestic and agro-food levels), the study will evaluate the role of the dominant activities within the AFI. This step also allows understanding each activity's weight in the national economy.

The determination of each activity's ***number of companies and/or production units, employment, turnovers, exports…*** makes possible to carry out a preliminary inventory of the activities, to evaluate the importance of the cold issue in these activities.

3.2.2. The "cold" issue in the main agro-food activities

After having defined the context of the main AFI activities, the study will canvass cold and cooling needs for each activity involved.

However, the specific needs of each activity are not data which can be accessed directly. The purpose of the study will be to define those parameters deemed essential to evaluate the needs required for production operations and their consequence for the industries.

The main parameters applicable when defining cooling needs in AFI activities are:

- production volume and the proportion requiring cooling systems
- refrigeration and/or frozen-storage capacity implemented within the activity
- type of equipment required by each activity for the good operation of the production line
- energy consumption of each activity using cooling processes and equipment

3.3. Survey on the specific cooling needs of companies

The methodology presented in the two preceding points aims at defining cold needs within the AFI and its activities. This third point consists in focusing more specifically on the needs of a few selected specific agro-food companies thought direct interviews.
It seems obvious that it would be impossible to carry out an exhaustive study of the needs of all national agro-food companies. This part of the methodology relies on a questionnaire as a tool with which agro-food companies may be surveyed concerning their cold needs.

Introduction: Presentation of the standard questionnaire

The questionnaire (Appendix 1) was drawn up by the Egyptian Environmental Affairs Authority (EEAA). It has been sent to the main agro-food companies. The study group will determine the survey's sample by selecting companies for their potential interest in solar-cooling technology and choosing companies from all main AFI activities.
National studies carried out in Tunisia and Morocco required the translation of the questionnaire to French (attached as Appendix 2).
Completing the questionnaire is not mandatory. Sample definition, therefore, will be limited by the choice of companies. The study group will ensure it is available to coach the companies. The analysis of the results will grant an insight into the specific energy needs of agro-food companies, according to their activities and production processes.

The purpose of the questionnaire is to define the cooling characteristics of companies and to evaluate the potential for the application of solar cooling. This is why the standard questionnaire is structured in four sections:

- Company profile
- Analysis of the production processes
- Heat and cold production equipment
- Annual consumption and costs

3.3.1. Company profiles

The first part of the questionnaire deals with the company's main information, which breaks down into three types:

- ***Presentation of the company***: name, location, activity (within the AFI), number of employees.
- ***Contact within the company***: address, name of referral agent, phone and fax numbers, e-mail address. These data allow the follow-up and coordination of the study.
- ***Description of production***: the company's product types and annual output.

The goal of this section is to determine the company's general activity.

3.3.2. Production process

The second part of the questionnaire involves production process details. The questionnaire contains three tables which must be completed to provide details on the company's various production operations using thermal and refrigerating energy.
These three tables determine:

- A ***summary of production operations***: a list of operations using thermal and refrigerating energy.
- ***Detail of each listed operation***: for each process, the questionnaire requires production parameters, including
  - its presentation (name of the process and product, amount of product)
  - its operation (energy used, duration of operation, product temperatures before and during the operation)
  - its environment (unit location, equipment material and thickness, room temperature)
- ***Production frequency***: time calculation of the activity for each manufacturing process.

The goal of this section is to define the operating parameters for the manufacture of each of the company's agro-food products. The details asked for will allow a precise evaluation of the potential use of renewable energies according to the frequency of production activities.

3.3.3. Installed heat and cold production equipment

The third section gathers technical data on all equipment using thermal or refrigerating energy:

- ***short presentation***: model, manufacturer, year of manufacture
- ***use parameters***: fuel, nominal power and temperatures, fluid used and nominal fluid flow
- ***equipment operation*** in hours per year and usage repartition during the year.

The purpose of defining the equipment's technical criteria is to evaluate its possible substitution by (or complement using) solar equipment by comparing these technical criteria.

3.3.4. Annual energy consumption and costs

The fourth section defines the influence of the processes and equipment on the energy invoice (consumption and cost).

For each type of energy used, the company will provide ***monthly*** and ***annual consumptions and costs***. The questionnaire also requires details on the various equipment using different fuels, and the electric power and installed capacity.
The final purpose of this third part is to evaluate the energy economy potential (decrease in consumption using “free” solar energy) and the related decrease in energy costs due to the introduction of solar cooling technologies in the production process of the investigated IAA companies. This evaluation, made on the basis of the results of this current study, is the purpose of the next step of the project, the Deliverable D1.2.

PART 2: Results of the three national studies

The methodology of the MEDISCO project described in Part 1 was applied to three countries of the Mediterranean Basin's south and east bank: Tunisia, Morocco and Egypt. These three studies were the subject of a report submitted to the ADEME.

The second part of this document presents the main results of the three national studies resulting from the application of the methodology to each country's specific context. This part provides three approaches:

- A comparative synoptic table featuring the main results of the three national studies in parallel form.

- For each country, a strategic overview which presents the stakes revealed in the course of applying the methodology to all three countries. These overview leas into the third approach.

- The detailed presentation of the national studies following the methodology's themes and plan. However, the studies could not always apply the methodology as a whole, and certain criteria were not studied.

Thus, the presentation of the results of the three national studies and the critical reading of the methodology's application allow for their own evaluation. The idea behind the third part is to draw conclusions regarding the application of the methodology, and, with this return on experience to define a more complete methodological guide which will be useful for any future evaluation of renewable-energy penetration in SEM AFI's.

Synoptic table of the three studies carried out in Tunisia, Morocco and Egypt

		TUNISIA	MOROCCO	EGYPT
Energy situation	**General introduction of the country**	- marked differences in relief: mountainous North and desert South - low annual population increase - significant sunshine rate	- 4 different geographical zones - rate of population growth: 1.53% - annual GDP growth: 5.9% - Mediterranean and Atlantic climate	- 3 geographical zones: the valley of the Nile, and Western and Eastern deserts - exceptionally hot and dry climate (Saharan climate except for the valley of the Nile)
	Country's energy balance	- energy dependence - importation of 10% of primary energy consumption - primary consumption increase: 6% / year	- very high energy dependence: the production is only 5.5% of the primary energy consumed	- Egypt produces more energy than it consumes, particularly due to oil resources - primary energy consumption increase: 4% / year
	Country's energy policy	_	- incentive, as part of the investment charter	- an Egyptian energy-audit agency is being set up - significant incentive in energy sector

		TUNISIA	MOROCCO	EGYPT
The agro-food industry	**AFI's structure**	- 945 companies with over 10 employees - 60,000 employees	- 2,016 companies (24% of industrial companies), - 95% of them are SME - 110,000 employees	- 920 companies, including 178 public ones - 440,000 employees
	AFI's market	- 2nd industrial sector, with strong exports - investment in the AFI is increasing	- one of the main sectors of the country's economy, but exports only 17% of production (quality and health issues)	- milk and dairy products represent main AFI production AFI (7,954,000 t/y)
	AFI's energy situation	- Primary Energy Consumption: 174 574 TOE (2 036 GWh) - Primary sources: electricity (52%) and oil (33%)	- Primary Energy for Electricity production : 29 827 TOE (348 GWh)	- Primary energy consumption: 2 440 000 TOE, including 5 250 GWh (450,000 TOE) of electricity - Primary consumption should increase by 15% to 20% over next decade

Synoptic table of the three studies carried out in Tunisia, Morocco and Egypt

			TUNISIA	MOROCCO	EGYPT
Cold in the AFI	General summary of cold in the sector	**Socioeconomic characteristics of cold**	- the "warehouse" activity includes 770 companies and 22 800 employees (38% of the total employees of the AFI) - Storage turnover represents 17% of the AFI	- the warehouse activity includes 495 companies	- 4 652 cold-storage units (containers) located in the main ports
		Refrigerating capacity	- volume: 1 310 011 m^3 - storage capacities are insufficient, except for seafood	- cold-storage capacities amount to 1 700 000 m^3 for 370 000 tonnes refrigerated (TR), equal to , 1 301 MW power installed - 66% are used in "Fruits and vegetables"	- Total cold-storage power installed is 409 MW (116 300 TR)
		Compliance with legislation and processes	- failings in compliance with legislation of AFI industrial processes, decreasing product quality, quantity and hindering exports.	- low storage capacity and lack of equipment result in break in the "cold chain" - incentives for cold-sector investment	–
	Evaluation of energy needs of AFI activities	**Industries in main AFI activities**	-	- 4 main activities for the Moroccan economy: Seafood, Fruits and vegetables, Meats, and Dairy products	- 3 main activities: "frozen vegetables", "milk and derivatives" and "meat, poultry and fish", with 728 production units and 380 866 employees
		Cold issues in main AFI activities	- "Fruits and vegetables" and "seafood" activities represent nearly 84% of installed storage capacity - AFI storage capacities are underused	-	- The "milk and derivatives" activity has the most significant production and storage capacity
	Survey on company needs	**Company profile**	- 15 companies contacted. 4 companies have answered the questionnaire - they employ in total 754 employees	- 21 companies contacted. 10 have answered the questionnaire - they employ between 4 and 1,000 people (total over 1,492)	- 30 companies contacted. 15 have answered the questionnaire - their storage installed power capacity exceeds 140 kW (40 TR)
		Production processes	- company production processes require various temperatures and operating time: from 4 to 150° C and between 20 minutes and 30 days	- equipment operating temperatures varies between -18°C and -40°C for freezing, and between -20°C and +5°C for storage	- cooling temperatures range varies from -9°C and +4°C
		Heat and cold equipment installed	–	- various equipment have distinct power requirement, from 30 kW to 5,000 kW, particularly depending on their intended use (air conditioning, storage, freezing)	- cooling needs are greatest in summer
		Annual energy consumption and costs	- each year, the 4 companies consume a total of 42 180 MWh of fossil fuels (NG and fuel) and 19,400 MWh of electricity.	- only 2 companies have provided information concerning their electricity consumption: each year, the milk and diary industry consumes 4 716 MWh, a third of which is used for cold production, and the meat industry consumes 346 MWh	- each year, the 15 companies consume 62 141 TOE (720 000 MWh) of natural gas and 42 041 MWh of electricity - their consumption accounts for 1% of the AFI's total primary energy consumption

1. Strategic study of Tunisia

The study was conducted by the ANME from 01 October 2006 on. The final version of the report was submitted in February 2008. The Egyptian Environmental Affairs Authority is the steering agency for the studies.

To conduct the study as per the proposed methodology, the ANME used the official documents and strategic studies on the AFI:

- Ministry of Industry, Energy and SME's
- agro-food technologies centre
- the industry's promotional agency

The study did not cover certain issues in the methodology. The country's general description and the classification of its energy dependence were prepared in the course of writing.
Furthermore, the study failed to proceed with the analysis of company-completed questionnaires. Therefore, the return of questionnaire results consists of a summary prepared on the basis of the answers provided by the four companies which did respond.

Introduction: strategic overview

The territory of Tunisia presents contrasting reliefs, particularly with 40% of its surface area under the Saharan desert. The Tunisian climate varies greatly, from the North's Mediterranean climate to the South's arid weather. Tunisia enjoys considerable sunshine, which favours the development of solar techniques.
Energy is an important issue for Tunisia. The sector played a significant role in its economic growth up to the 1980's. Today, Tunisia, which faces energy shortfalls because of the quick increase in demand and stagnating resources (gas and oil), must implement a true energy policy to deal with annual consumption increases and develop other energy sources.

The AFI is the country's second industrial sector. Agro-food exports are an important asset for the country's economic growth. International trade contributes heavily to national wealth. However, the AFI is a heavy energy consumer, particularly of electricity, mostly in cereals and canned goods, which account for nearly 55% of the AFI's energy consumption.

The study of cold in the AFI, carried out as part of the MEDISCO project, revealed major stakes for Tunisia's economy and energy security. Indeed, Tunisian agro-food industries, under pressure from foreign customers and because of the requirements of export markets, need to develop their production process and improve their equipment. Most equipment performance is far below customers' requirements. Furthermore, they have a negative impact on product quality and quantity.

The survey carried out on 4 companies has shown the variety of specific industrial processes and energy needs. Later on, the objective will be that of evaluating the capacities of the renewable-energy systems to face these many different company situations according to the agro-food activity.

1.1. The national context

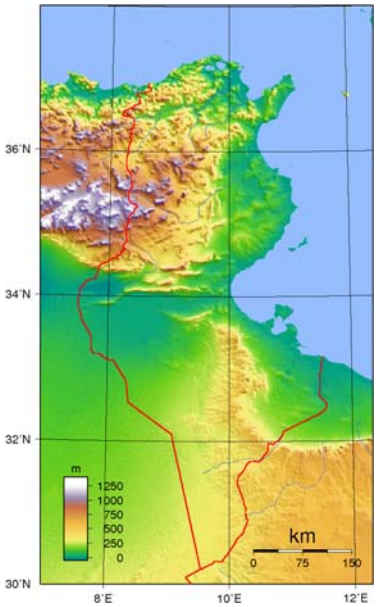
1.1.1. General description of the country

1.1.1.1. Geographical data

The Republic of Tunisia is a North African country located in the Maghreb. To the North and East lies the Mediterranean. Its Western border touches Algeria, and its South-eastern border, Libya.

Its total surface area is 163,610 km². The Saharan desert covers nearly 40% of its territory, with fertile land making up the rest of the country. Generally, the landscape is flat, except for the mountainous regions in the West and Northwest.

Tunisia is Africa's northernmost country, only 140 km from Europe through the straits of Sicily. It is the smallest state in the Maghreb. The country shares 965 km of borders with Algeria to the West, 459 km with Libya to the Southeast, and has a 1,298-km-long Mediterranean coastline North and East. Tunisia's relief varies greatly between North and West.



Topographic map of Tunisia.
Source: Wikipedia;
Author: Sadalmelik, 29 June 200y, using SRTM data

Its capital, Tunis, is also the country's largest city, with 728,450 inhabitants in 2004, *i.e.* a population density of approximately 3,426 inh/km^2.

1.1.1.2. Demographic, economic and political data

The total population of Tunisia is 10,126,300 inhabitants. Population density is 63.80 inh/km^2. Tunisia exceeded the 10-million-inhabitants mark in 2005, tripling its population since 1956 (3,448,000 inhabitants) and doubling it since the early 1970's. The fertility rate has been dropping consistently: the number of children per woman went from nearly 6 during the 1960's to 3.4 in 1994, and stands at 2 in 2006 (the lowest rate in the Arab world). Thus, annual population increase has dropped to 1.08%.

The currency is the Tunisian dinar (TND), worth 0.544291 euro. The Gross Domestic Product (GDP) is 77.16 billion USD in purchasing power parity (PPP), and 34.54 billion USD at the current exchange rate. Per capita GDP is 7,500 USD in PPP.

The Tunisian Republic is a member of the main agencies of the international community. Tunisia is part of the Arab League, the African Union and the Community of Sahel-Saharan States. The official language is Literary Arabic.

1.1.1.3. Climatic data

Tunisia's climate is divided into seven bioclimatic zones, with the Tunisian range separating the northern zone, with its Mediterranean climate, from the South's arid climate, a product of the Sahara's influence. The country's sunshine rate exceeds 3,000 hours per year.
Temperatures vary according to the latitude, altitude and nearness to or distance from the Mediterranean. Whereas winter in the Khroumire Mountains can drop to a few degrees below 0°C, summers in the desert areas can see temperatures rise as high as 50°C.

1.1.2. Tunisia's energy balance

1.1.2.1. Energy resources

Tunisia's primary energy source is oil, followed by gas; of far lesser importance are renewable energies, with hydroelectricity merely contributing a symbolic 0.2%.
However, Tunisia has suffered from an energy shortfall since 2000, and must import nearly 10% of the energy it consumes.

1.1.2.2. Energy consumption

Tunisia consumes 5.4 million TOE (63,001 GWh[1]). The sector of industry consumes 1.95 million TOE (22,750 GWh), which breaks down as follows:

Construction	Chemicals	Agro-foods	Textiles	Mechanics	Others
58%	13%	9%	5%	5%	10%

1.1.2.3. Energy balance

Tunisia produces 89.3% of the energy it consumes, making it energy-dependent. The following table presents the balance of the country's two main energy sources:

	Natural gas		Oil	
Consumption	2.94	Gm^3/y	83,000	bpd
Production	1.90	Gm^3/y	82,000	bpd
Export	0	Gm^3/y	-	bpd
Import	1.04	Gm^3/y	1,000	bpd
Reserves	77.87	Gm^3/y	308	Mbarrels
Remaining life of reserves[2]	41	Years	10.3	years

Despite its still considerable resources, Tunisia must face an annual increase in total energy consumption of approximately 6%.

[1] If *1 kWh = 3.6.x 10^6 J* and *1 TOE = 42,109 J*, then **1 TOE = 11,667 kWh.**
[2] The remaining life of reserves is determined on the basis of constant production of known resources.

1.2. The agro-food sector

1.2.1. The structure of Tunisia's agro-food industry

1.2.1.1. The number of agro-food companies

The AFI includes 945 companies with over 10 employees, 121 of which are dedicated exclusively to exports. They are distributed as follows:

Activities	Exclusively exports	Not exclusively exports	Total
Oils	8	257	**265**
Fruits and vegetables	7	52	**59**
Storage	41	67	**108**
Fish industry	39	30	**69**
Cereals	5	284	**289**
Beverages	5	46	**51**
Dairy industry	-	37	**37**
Sugar industry	2	29	**31**
Meat industry	1	23	**24**
Other foods and agro-industry	16	58	**74**

1.2.1.2. Employment in the agro-food sector

These 945 companies employ approximately 60,000 people, 12,344 of whom work exclusively in exports.

1.2.2. The agro-food industry's market

1.2.2.1. Market data

AFI production reached 7,174 million dinars (3,905 million EUR) in 2004. It rose 23% over 4 years. The AFI is the second industrial sector, after the textile Industry.
AFI imports represent 142 million dinars (78 million EUR), while exports amount to 391 million dinars (213 million EUR), *i.e.* a 2.75 ratio in favour of exports.

1.2.2.2. International trade

The main export customers are Italy (50%), Spain (18%), Libya (10%) and France (9%), with other countries accounting for the remaining 13%. Tunisia has 108 companies with international partners, which break down as follows:

France	Italy	Spain	Switzerland	Others
29	24	8	6	41

1.2.2.3. Investment in the sector

The investment in Tunisia's AFI is rising, 215 million dinars (117 million EUR) in 2004, against 210 million (114 million EUR) in 2000.

1.2.3. Energy situation of the agro-food industry

Overall, the AFI consumes 174,574 TOE, *i.e.* 2,036 GWh of primary energy. These needs are supplied by the following sources:

Electricity	Oil	Natural gas	LPG
52%	33%	13%	2%

Total energy consumption (all sources included) varies according to the AFI activity. The following table summarises the breakdown in primary-energy consumption according to AFI activities:

Cereals	Canned goods	Dairy products	Beverages	Sugar	Oil	Others
32 %	23 %	19 %	6 %	3 %	3 %	14 %
652 GWh	468 GWh	387 GWh	122 GWh	61 GWh	61 GWh	285 GWh
55,864 TOE	40,152 TOE	33,169 TOE	10,474 TOE	5,237 TOE	5,237 TOE	24,441 TOE

1.3. Cold in the agro-food industry

The study of cold in the AFI focused on its main activities in Tunisia. General data on the characteristics of cold within the AFI could not be obtained. However, the study did analyse the cold-storage activity, cross-cutting other AFI product activities.

1.3.1. Status of cold storage in the agro-food industry

1.3.1.1. Description of the "warehouse" activity

- Companies and employment

Currently, the "warehouse" activity is centred on 770 companies, 275 of which have over 10 employees. The sector accounts for 29% of AFI companies. These companies employ 22,800 people (38% of the AFI). Characteristic of the activity is the fact that a significant part (60%) of its employment is seasonal.

- Turnover and investment

In 2005, the production of cold-using companies meant a turnover of 1,200 million dinars (653 million EUR), *i.e.* 17% of the AFI (7,114,000 dinar – 3,872,100 EUR).

Tunisia is calling for an action plan to modernise the activity. 15 companies will receive 3,688 million dinars (some 2,007 million EUR) in investments for tangible assets (equipment, warehouses…), while 25 companies will share 3,735 million dinars (2,033 million EUR approximately) in intangible assets (assistance, subsidies, premiums…). All in all, toal investments amount to 7,423 million Tunisian dinars (approximately 4,040 million EUR).

1.3.1.2. Compliance with cold legislation and industrial processes

The study revealed certain failings in the compliance with legislation or industrial processes.

Thus, the Fruits and Vegetables activity, the most significant one in terms of storage and export capacity, shows that 90% of its refrigerating stations suffer from the lack of any:

- "Pre-cooling" (a quick cooling of food products prior to their introduction into coolers)
- controlled atmosphere
- moisture control
- natural refrigerant (they still use CFC or HCFC)

The first three points have a direct influence on the quality of stored products. The last point would allow energy saving and represent an improvement in terms of the ozone layer and the greenhouse effect.

Stored products are derived from living beings, and require that their physiological, biological, physicochemical, and organoleptic characteristics be taken into account. In France, 55% of the sector's companies are certified (ISO, HACCP[3]…), against only 5% in Tunisia. The technical and certification commissions encourage periodic controls of the operating and health conditions of companies in this sector, to foster the export of Tunisian foodstuffs to markets which are sensitive to the treatment of the living beings, to hygiene and to product quality.

1.3.1.3. AFI's refrigeration and cooling capacity

The storage of foodstuffs accounted for 1,310,011 m^3 of processed volumes in 2004. Except for meats (both white and red), the processed volumes and cold-storage capacities of the sector's various activities are evenly balanced.

However, it is estimated that, by 2011, cold-storage requirements will stand at 490,000 m^3 in +0°C cold and 112,000 m^3 in -0°C cold. Such capacities will not be attained, except for the "Seafood" activity, due to its significant current capacity.
To meet these needs, investments in new warehouse construction are estimated at 21,280 million dinars (11,583 million EUR): 18,700 million dinars (10 178 million EUR) in positive-temperature and 2,880 million dinars (1,568 million EUR) in negative-temperature storage.

[3] HACCP Process**: Hazard Analysis Critical Control Points**.

1.3.2. Evaluation of cold needs of various AFI activities

1.3.2.1. Characteristics of industries in the various agro-food activities

The study of AFI activities in Tunisia focused on certain types of production. The main production characteristics of agro-food markets (many companies, production and production growth) are summarised in the following table.
The data do not allow any specific characterisation of the various activities, but they do reveal the main trends and key sectors. Furthermore, the data gathered do not permit any comparative study (different units, non-exhaustive study…).

Type of product	Production unit	Annual average production	Annual growth rate
Cereal production	- Mills: 25 - Paste production: 11	16.8 million quintals/y (+ 15.3 million quintals/y in imports)	–
Olive-oil production	–	164,000 t/y	3%
Canned goods	- tomato canning accounts for 90% of the Canned Fruits and Vegetables activity - pepper (harissa) canning, intended for local market	180,000 t/y, including 21,000 t/y of harissa (12%) and between 4,000 and 11,000 t/y of canned fruit	
Dairy production	50% of dairy production is transformed	380,000,000 litres/y in 1998. Yoghurt production capacity is 4,000,000 jars; fresh butter, 9,000 t/y	8.2% between 1992 and 1998
Wine production	–	30,000,000 litres/y in 1998, including 22,000,000 litres/y meant for the local market 30% of wine production capacity is used Processing capacity is 54,000,000 bottEGP/y, with 50% used	Production from 1962 and 1998 was divided by 6.7 (surface and production-reduction policy)
Mineral water	-10 conditioning units (meant for export) -1,000 jobs, 700 of which are permanent	Exploitation of springs produces 130,000,000 litres Production capacity is 300,000,000 bottEGP/y	12%
Juice production	5 manufacturing units	Processing capacity is 40,000 t/y	Poor fruit production hinders the activity's growth

1.3.2.2. Cold requirements

In light of available data, the Tunisian study on the AFI's cold and refrigeration requirements focused on the cold-storage capacities of various activities. Cold-related energy consumptions were not provided. In 2004, the storage of foodstuffs amounted to 1,310,011 m^3, with significant variations between AFI activities:

Product	Volume (m^3)	Share of total volume (%)
Fruits and vegetables	923,661	70.5%
Seafood	175,042	13.4%
Milk and derivatives	68,025	5.2%
White meat	40,140	3.1%
Red meat	33,142	2.5%
Cream	18,592	1.4%
Others	51,409	3.9%
Total	**1,310,011**	**100%**

The "Fruits and vegetables" and "Seafood" activities represent nearly 84% of stored volumes. The AFI makes poor use of installed capacities, with 50% or 60% of storage capacities being used.

1.3.3. Survey on specific company needs

Introduction: Company profiles

The survey questionnaire was sent to 15 Tunisian AFI companies, only four of which responded, with the following results:

Company name	Location	Employees	AFI activities	Type of production	Amount of products per year
AGROMED	Sfax	200	Dairy industry	Sterilised milk	23,520,460 l.eq.[4]
				Raib and iben	2,071,043 l.eq.
				Yoghurts	8,500,023 l.eq.
				Other desserts	2,127,815 l.eq.
				Cheese	2,644,305 l.eq.
CCG "Domaine NEFERIS"		–	Winery	Red wine	500,000 b[5]
				White wine	350,000 b
				Rosé wine	150,000 b
SIAM (Société des Industries Agroalimentaires Magrébines)	Ben Arous	105	Cereal transformation	Couscous	12,456,438 kg
				Pastes	1,856,370 kg
TUNISIE LAIT "Centrale laitière"	Sousse	- 449 permanent - 150 seasonal	Dairy industry	Sterilised milk	70,000,000 l
				Yoghurt	108,000,000 jars
				Cheese	2,452,000 kg
				Butter	1,200,000 kg

It bears mentioning that no data analysis was carried out. What we are presenting here consists of a few results which appeared in the questionnaires and some observations we are in a position to make.

[4] In litre equivalents
[5] In bottles

1.3.3.1. Manufacturing process

The following table presents a few product transformation stages, with temperatures reached, amounts of processed products, and duration of the operation.

Company name	Stages	°C (initial state in final state)	Processed amounts	Duration of the operation
- AGROMED and - TUNISIE LAIT	Product reception	Ambient t °C 4-6°C	_	_
	Pasteurisation	from 4-6°C to 90°C	2,000 l/h	_
	Sterilisation	from 130-150°C to 120-140°C	_	20-23 mn
	Refrigeration	from 65°C to 4°C in 2 stages	_	_
CCG	Pre-cooling	40-20°C	_	15-30 d
	Cooling	5°C	_	1 d
	Clarification	8°C	_	2 d
	Fermentation	15-25°C	_	15-30 d
SIAM	Cooking	from 37°C to 130°C	2,200kg/h	25 mn
	Drying of the couscous	from 45°C to 130°C	2,200kg/h	90 mn
	Drying of the pastes	from 40°C to 80°C	2,500kg/h	4-10 h
	Refrigeration	from 65°C to 30°C	1,500kg/h	25 mn

These widely differing stages (in terms of temperatures, processed volume and duration of operations) represent many usage possibilities requiring technical feasibility studies on solar-powered equipment.

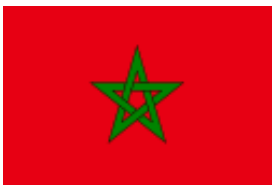
1.3.3.2. Energy consumption and cost

The following table presents each company's energy consumptions and cost.

Company name	Fuel			Electricity		
	Type of fuel	Annual consumption	Annual cost (USD/y)	Installed capacity	Annual consumption	Annual cost (USD/y)
AGROMED	LPG	850 TOE	293,930		7,317,264 kWh	388,614
CCG	_				469,070 kWh	47,648
SIAM	Fuel	1,970,740 kg	466,765	450-500 kW	4,240,070 kWh	312,846
TUNISIE LAIT "Centrale laitière"	LPG	850 TOE	232,929		7,317,264 kWh	388,614

A breakdown of monthly consumption makes it possible to identify companies' potential interest in the use of solar heat or cold production, as energy – and particularly electricity – consumption remains constant throughout the year, and even increases over May-September, the time of year when solar-powered systems offer the greatest yields.

2. Strategic study of Morocco



The study was conducted by the Renewable Energy Development Center (CDER). The report was submitted in September 2007. The Egyptian Environmental Affairs Authority is the steering agency for the studies.

To conduct the study as per the proposed methodology, the CDER called upon professional establishments:

- Professional association of the Cold sector
- National Statistics Directorate
- Ministry of Industry and Trade
- Ministry of Energy

The study covered most of the methodology's issues. The country's general description and the classification of its energy dependence were prepared in the course of writing, using a source the two other studies had in common.
The results of the questionnaire completed by the companies were the subject of a synthetic return per company and have been aggregated inside a common table

Introduction: strategic overview

The general introduction to Morocco revealed its energy stakes. First of all, population growth and, particularly, changing lifestyles have led to significant increases in energy demand. Moreover, Morocco produces no fossil fuel. Despite resorting to renewable energies (the country's main energy resources), Morocco must still import a significant amount of crude oil. Thus, Morocco is highly dependent on exporting countries. Electricity production is rising fast, but a considerable part (70%) is produced by thermal power stations (coal and fuel). Morocco recognises the importance of renewable energy sources, and fosters their use.

The AFI is one of the main sectors of the Moroccan economy. The sector is showing strong growth. However, exports are still relatively low because of difficulties in complying with the quality and sanitary criteria of customer countries. Morocco has launched a policy that provides incentives for AFI investment, both to promote exports and to rationalise energy consumption. These measures mainly involve cold, an essential element of this sector. However, the country's storage capacities are low and must be developed, despite their being energy intensive.

The study on companies' cold requirements revealed that the fish, dairy and storage industries are the AFI's main activities in terms of number of companies and power used for cold production.

2.1. The national context

2.1.1. General description of the country

2.1.1.1. Geographical data

The Kingdom of Morocco is located on the Northwest tip of the African continent, and belongs to the territory of the Maghreb. Its coastline opens on the Atlantic Ocean in the West and the Straits of Gibraltar and the Mediterranean in the North; to the East lies Algeria, while it shares its southern border with Mauritania, beyond the Western Sahara.

Source: Wikipedia, from a view of the MODIS satellite, photograph taken on 23 April 2000
Photograph from the Visible Earth project

Morocco has four distinct geographical zones:
- the Rif mountain range to the North,
- the Atlas range, spreading from Southeast to Northwest and constituting an important water reservoir for the country,
- the coastal plains, where most of the population is settled,
- the desert, in the Eastern and Southern parts of the country, bordering the Sahara.

Total surface area in 46,550 km^2.
The capital is Rabat, located at 34° 02' N 6° 51' W.
In 2007, its population stood at 1,721,760, *i.e.* a population density of 14,591 inh/km^2.

2.1.1.2. Demographic, economic and political data

Morocco's total population is 33,757,175 inhabitants, and the population density is 74.44 inh/km^2. The population growth rate is 1.528%, with an average of 2.62 children per woman. Average life expectancy is 71.22 years.

The currency is the Moroccan dirham (MAD), worth 0.0869566 euro. Morocco's economic capital, Casablanca, is also its largest city.

Moroccan GDP is 79.7 billion USD (approximately 50,100 million EUR), with 5.9%[6] annual growth in 2008 and a per capita GDP of 2,569 USD (approximately 1,616 EUR). According to the African Development Bank, Morocco's GDP accounted for 7.5% of the continent's GDP in 2001. The country is Africa's fifth economic power.

Morocco is member of a number of organisations, such as the Arab Maghreb Union, La Francophonie, the Arab League and the Organisation of the Islamic Conference. Morocco is the only African country not currently a member of the African Union.
The official language is Literary Arabic. French is also used as an administrative language.

[6] Source: BMCE Bank

2.1.1.3. Climatic data

Morocco's climate is both Mediterranean and Atlantic, with a hot, dry season followed by a cold, wet one; the end of the hot season is marked by the October rains.
The presence of the sea mitigates the variations in temperature, moderating the seasons and increasing atmospheric humidity, with the coastline receiving between 400 and 1,000 mm of rainfall. Inland weather varies according to altitude. Summers are hot and dry, especially under the burning sirocco or the chergui, a summer wind which blows in from the Sahara. During this season, temperatures average between 22°C and 24°C. Winters are cold and rainy, and bring frost and snow.
Average temperatures range from -2°C to +14°C, and can drop as low as -32°C. In the Sub-Saharan and Saharan regions, Morocco has a dry, desert climate.

2.1.2. Morocco's energy situation

2.1.2.1. Energy resources

Oil products account for two thirds of Morocco's energy consumption. Most of the country's energy needs are met through imports.

2.1.2.2. Energy consumption

Morocco's annual consumption is 143,504 GWh (approximately 12.3 million TOE), of which 19,509 GWh is electric.

2.1.2.3. Situation of dependency

Morocco is highly dependent on other countries to meet its energy needs, except for natural gas. Morocco only produces 5.5% of the energy it consumes.
The following table presents the balance of Morocco's three energy sources:

	Coal		Natural gas		Oil	
Consumption	3.958	Mt/y	0.05	Gm^3/y	158,480	bpd
Production	0.29	Mt/y	0.05	Gm^3/y	1,300	bpd
Export	0	Mt/y	0	Gm^3/y	21,200	bpd
Import	3.903	Mt/y	0	Gm^3/y	173,170	bpd
Reserves	6	Mt/y	1.218	Gm^3/y	1.6	Mbarrels
Remaining life of reserves	20.7	years	24.4	years	3.4	years

The size of exports in light of production is due to the export of refined petroleum processed from imported crude.

2.1.2.4. Energy policy incentives

Morocco has established a few measures under the terms of the investment charter:

- decrease of the tax burden for the acquisition of high energy performances equipments,
- decrease of tax rates on revenues and benefits,
- guaranteed tax incentives

- increased guarantees to investors on local and national taxes.
- better distribution of the tax burden and proper application of market-economy rules, particularly by reviewing the scope of application of tax exemptions granted.

The measures established by Morocco also seek to:
- boost exports
- foster job creation
- reduce investment costs
- reduce production costs
- rationalise energy and water consumption
- protect the environment

2.2. The agro-food sector

2.2.1. The structure of Morocco's agro-food industry

2.2.1.1. The number of agro-food companies

The AFI includes 2,016 companies, *i.e.* 24% of all Moroccan companies.
SME's (fewer than 200 employees) account for 95% of all AFI companies.

2.2.1.2. Employment in the agro-food sector

The sector includes 2.016 companies, employing 110,000 people. Breakdown according to main activities is as follows:

	Fish	Cereals	Dairy	Animal feed	Fruits and vegetables	Oil	Beverages	Meat
Employees	17,234	11,074	9,602	8,811	4,923	4,894	4,333	1,896
Companies	198	1,096,	74	205	103	172	33	46

2.2.2. The agro-food industry's market

2.2.2.1. Market data

The AFI is one of the Moroccan economy's main industries. It contributes approximately one third of the industrial GDP and 8% of the national GDP. Its production exceeds 5,400 million EUR (+2.4% against 2005) and produces 1,600 million EUR in added value. This industry exports only 17% of its production because of difficulties in meeting the quality and health criteria of developed countries.

2.2.2.2. International trade

The seafood industry exports mainly to Europe (99.94%). The rest goes to the Middle East (0.03%), Africa (0.02%) and America (0.01%).

2.2.2.3. Investment in the sector

AFI investments went from 2,715 million EUR in 2004 to 2,924 million EUR in 2005.

2.2.3. Energy situation of the agro-food industry

The AFI consumes 348 GWh (*i.e.* 29,827 TOE). This figure only represents consumed electrical energy.

2.3. Cold in the agro-food industry

The study of cold in the AFI focused on Morocco's main agro-food activities. General data on the characteristics of cold within the AFI could not be obtained. However, the study did analyse the cold-storage activity, cross-cutting other AFI product activities.

2.3.1. Status of cold storage in the agro-food industry

2.3.1.1. Description of the "warehouse" sector

Morocco has 495 cold-storage units, including industrial and commercial facilities (in stores and super/hypermarkets).

2.3.1.2. Cold-storage capacity

Current storage volume is approximately 1,700,000 m^3 of cold rooms for an installed capacity of 370 000 TR (Tons Refrigerated), equivalent to 1 301 MW. Storage capacity varies with the products, with Fruits and vegetables enjoying the most important storage capacity.

Product	capacity of storage (tonnes)	Share of total capacity (%)
Fruits and vegetables	244,000 t	66%
Dairy products and derivatives	62,000 t	17%
Fish	53,000 t	14%
Meat	7,000 t	2%
Ice	4,000 t	1%
TOTAL	**370,000 t**	**100%**

The average power of a refrigerating unit is 750 TR (2 640 kW), for a 3,500 m^3 storage volume. There are an estimated 1,980 cold rooms with a capacity of 189 TR (666 kW).
The average volume of a cold room is 10 000 to 12 000 m^3 (2 000 to 4 000 TR, i.e 7 040 to 14 008 kW) in the industrial sector, and 600 to 800 m^3 (120 to 160 TR, i.e. 420 to 563 kW) for commercial applications.
The AFI's deep-freezing capacity is 2 200 TR (i.e. 7 744 kW). Ice production capacity is 2 000 TR (i.e. 7 040 kW).

2.3.1.3. Compliance with cold legislation and industrial processes

The country suffers from low storage capacity and a shortage of equipment, a result of insufficient frozen-freight vehicles and equipment required for transport to sea- and airports. These insufficiencies result in breaks in the cold chain and poorer product quality. This also affects exports negatively.

The Moroccan State has implemented incentive measures to foster investments in the cold sector.
In the area of taxation, the State offers guaranteed subsidies which vary between 10% and 15% per conservation unit, and may amount to 200,000 EUR per unit.
Further investment assistance consists of a 15 EUR/ m^3 subsidy.

2.3.2. Evaluation of cold needs of various AFI activities

The study focused on four activities and product categories. The data presented in this chapter were synoptically compared by theme.

2.3.2.1. Characteristics of industries in the four main agro-food activities

The study of the Moroccan AFI focused on four main activities. The main characteristics of these activities are summarised in the following table

	Role in the national economy	Production unit	Number of employees
Seafood	50% of exports of transformed food products, *i.e.* 12% of total exports.	- 43 canning units - 150 deep-freezing units - ≈ 50 refrigeration units - 150 storage units	- 21,000 employees - 6,000 employees - 3,000 employees - _
Fruits and vegetables	produces 15% to 20% of the national wealth	_	40% of active population
Meats	_	_	_
Dairy products	- 10% of industrial production - investments in this industry mount to 30 million EUR	≈ 50 units, including 40 transformation units	9,000 employees

In terms of self-sufficiency, Morocco meets a significant portion of its Fruits and vegetables needs; however, productivity is strongly dependent on weather conditions.

2.3.2.1. Cold requirements of four agro-food activities

In light of available data, the Moroccan study gathered cold-storage capacities for the main activities, by volume produced or processed. Cold-related energy consumptions were not provided, but the general characteristics of some of the equipment were made available.

	Processed or produced volume	Cooling capacity	Characteristics of cold equipment
Seafood	Processed volume: - 169,000 t of frozen exports - 42,000 t refrigerated for export - 56,000 t of stored fish	–	–
Fruits and vegetables	–	1 184 cold rooms distributed in the production zones	Cooling t °C: -18°C to -20°C
Meats	Produced volume: - 265,000 t (industrial) - 50,000 t (traditional)	Storage capacity divided into 155 freezing: 7,170 TR (22 238 kW), or 53,481 m^3	Usual temperature: -40°C Compressor power is 150 to 600 kW; compressors operate all year long.
Milk and derivatives	The dairy industry processes 615 million l and produces: - 470 million l of pasteurised milk - 8,099 t of butter - 10,250 t of condensed milk - 20 million l of processed milk - 1,500 t of cheese	Processing capacities are: -1,335,000 l/d for the dairy companies -825,000 l/d for cooperatives The study does not specify whether these data include the cooling or cold-storage capacities	Industries with production of cold function with ammonia or glycolic water and require a power from 20 to 300 kW The central processing units function with: *production of glycolic water with -2°C/+4°C * cold rooms for storage with +6°C (+4°C for butter) and 110 kW for power of equipment

2.3.3. Survey on specific company needs

Introduction: Company profiles

The survey questionnaire was sent to 21 Moroccan AFI companies, only ten of which responded, with the following results:

Company name	Location	Employees	AFI activities	Type of production	Amount of products per year
SAPAX (KOUTOBIA)	——	200	Meat products	_	_
ELDIN	HAD Doualem	180	Meat	Meat from varied sources (chicken, turkey…)	_
FRIGORIFIQUE BOUZERKTOUN	——	_	Seafood	_	_
GLACIER DU PORT	Casablanca (fishing port)	_	Ice for seafood industries	_	_
LEBONLAIT	Marrakesh	1,000	Milk and derivatives	Butter, milk, pasteurised milk, yoghurt	250 t/d
TICHKA FRIGO	Marrakesh	4	Cold	Conservation of food	_
CONSERVES TEAM	Mohammedia	20	Fish	Frozen fish	_
LA MAISON DU FOIE GRAS	Casablanca	60	Meats	Meat from varied sources (chicken, turkey…)	_
DELTA FISH	Casablanca	8	Fish	Seafood for export	_
ESPADON CONSERVES	Casablanca	20	Fish	Canned fish and export	_

The study breaks down the main results by company. The synoptic table presents collected data according to the methodology's themes.

2.3.3.1. Manufacturing process

The results presented in the study do not provide any information on production processes (operation and duration of operation, production and produced amount). The study only lists temperatures reached during the deep-freezing manufacturing processes, storage and air conditioning when this affects the company.
These data are presented in the next paragraph on the equipment installed to reach these operating temperatures.

2.3.3.2. Installed equipment

The following table presents the data provided by the companies on operating temperatures and the power of the main equipment, broken down according to use (deep freezing, storage, air conditioning).

Company name	Characteristics of the equipment		
	Use	°C	Power
SAPAX (KOUTOBIA) **ELDIN** **FRIGORIFIQUE** **BOUZERKTOUN**	Freezing	-40°C and -25°C	150 kW and 30 kW
	Storage	+3°C	30 kW
	Air conditioning	+12°C	40 kW
GLACIER DU PORT **LEBONLAIT**	Freezing	-40°C	611 kW
	Air conditioning	+10°C	
TICHKA FRIGO **CONSERVES TEAM** **LA MAISON DU FOIE GRAS**	Freezing	-40°C	2 X 5,000 kW
	Storage	+5°C	absorption machine
	Air conditioning	-20°C	235 kW
DELTA FISH	Freezing	-5°C	150 kW and 100 kW
ESPADON CONSERVES	Freezing	-5°C	2 X 800 kVA 1 200 kVA
SAPAX (KOUTOBIA) **ELDIN**	Freezing	-18°C	650 kW and 30 kW
	Air conditioning	+5°C	
FRIGORIFIQUE **BOUZERKTOUN** **GLACIER DU PORT**	Freezing	-40°C	2 X 650 kW and 40 kW
	Storage	-20°C	
LEBONLAIT **TICHKA FRIGO**	Freezing	-40°C	34 kW, 5CV
	Air conditioning	+12°C	204,000 BTU
CONSERVES TEAM **LA MAISON DU FOIE GRAS**	Freezing	-40°C	2 X 850 kW
	Storage	-20°C	
DELTA FISH	Freezing	-40°C	1,000 kW and 150 kW
	Air conditioning	-20°C	

Despite the lack of data on production, processing or transformation processes, the companies' operating temperatures allow the identification of those activities which might be treated with solar technology in light of the installed equipment's power (to be studied in comparison with the solar equipment's technical capabilities).

The surveys have also revealed that operations are carried out around the clock. Two companies have indicated maintenance interventions:

- maintenance at CONSERVES TEAM is carried out during one week each year
- maintenance at LA MAISON DU FOIE GRAS is carried out over 15 days per year

2.3.3.3. Energy consumption and costs

The results of the study did not make possible the definition of companies' energy consumptions and cost. Only two companies have reported their electricity consumption:

- Electricity consumption at LEBONLAIT: 262,520 kWh per month (24,420 kWh per month during peak hours, 207,600 kWh per month during full hours, 130,500 kWh per month in off-peak hour). One third is used for cold production, another third to generate steam, and the last third for other uses.
- Electricity consumption at LA MAISON DU FOIE GRAS: 28,850 kWh per month.

3. Strategic study of Egypt

The study was carried out by the Egyptian Environmental Affairs Authority (EEAA), which is also the steering agency for the studies. The final version of the study has been submitted in February 2008.

The study covered most of the methodology's issues. The synoptic and company-based comparative analysis of the questionnaires served to draft part of the "Survey on specific company needs" of the other two national studies.

Introduction: strategic overview

The purpose of the study of Egypt was to identify its energy stakes and issues. Egypt's main energy resources are non-renewable. Egypt is one of the main producers of oil of the Mediterranean Bassin. The production of natural gas is also rising sharply. Hydroelectric production is also significant, with several dams on the Nile.
However, Egypt faces a major change in consumption, one which effectively reduces energy exports. This fact is also noted in the agro-food industry, whose energy consumption has risen by 160% between 2001 and 2005.

An Egyptian energy-audit agency is being set up, with the support of the Ministry of the Environment. The study notes a slowdown in solar-energy development, *i.e.* the lack of decision-makers' confidence in the effectiveness of solar energy. The work group insists on the effectiveness of the study carried out as part of the MEDISCO project and of a clear assessment of solar cooling concepts potential.

Rising population and food needs have resulted in an increase in the AFI's energy consumption, which stands at 18% of total industrial consumption.

The survey focused on companies with large storage capacity, and assessed the sector's large plants. The study identified two characteristics of cooling within the AFI which favour the development of solar-cooling technology:

- The first one concerns system production potentials. In fact, the cooling needs for the production and storage operations is the highest in summer, which is also the most favourable period for solar equipment to be used.

- The second one concerns the increase in the number of absorption-refrigeration units, which have doubled between 2004 and 2005, at the expense of compression-refrigeration units. This observation indicated the manufacturers' rising awareness of the need to decrease energy consumptions with equipment which, however, requires considerable initial investments. This characteristic is also intrinsic to RE and in particular to solar cooling equipments.

3.1. The national context

3.1.1. General description of the country

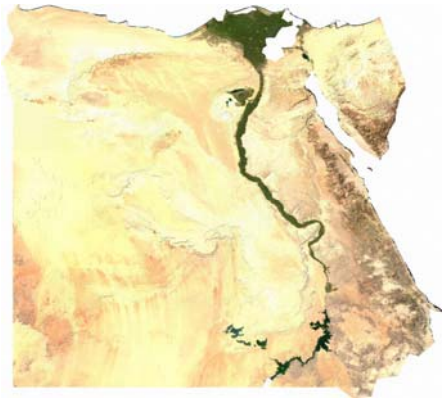
3.1.1.1. Geographical data

The Arab Republic of Egypt is a country located in Northeast Africa, although the North-eastern part of the country, the Sinai peninsula, is located in Asia. Its total surface area is 995,459 square kilometres.

There are three natural zones:

- the valley of the Nile
- the Libyan or Western desert
- the Arabian or Eastern desert

The capital of Egypt is Cairo (30° 3' 0" N, 31° 15' 0" E), with 10,834,195 inhabitants and a density of 16,756 inh/km^2.



Source: Wikipedia

3.1.1.1. Demographic, economic and political data

Egypt's total population is 78,887,007 inhabitants, *i.e.* a population density of 75.10 inh/km^2. GDP is 67,621,000 million EUR. The currency is the Egyptian pound (EGP), worth 0,115657 EUR.

The official language of the Arab Republic of Egypt is Literary Arabic, but the spoken language is Egyptian.

3.1.1.2. Climatic data

Egypt's climate is exceptional, hot and dry. The air is particularly dry and wholesome. Only the presence of the Nile reduces the presence of the Saharan climate. In winter, the temperature is temperate, and night frosts are rare. Except for January, February and March, when temperatures are sometimes rather cold in the north, average temperatures border 20° on the Mediterranean coast (maximum 31°) and 28° at Aswan (maximum 50°). In the desert, extremes are the norm: boiling hot during the day and icy cold at night. Average rainfall in Cairo is six days per year. The city of Aswan receives a bare 10 mm or so every five years. Alexandria is the Egyptian city with the most rainfall, some 19 cm per year.

3.1.2. Egypt's energy situation

3.1.2.1. Energy resources

Egypt's resources are mainly oil, natural gas and hydroelectricity. Renewable energies and coal only play a secondary role.

The country produces 3,200,000,000 million BTU of primary energy (*i.e.* 937,143 GWh or 80.32 million TOE).

3.1.2.2. Energy consumptions

The country consumes 28.52 million TOE of primary energy (*i.e.* 332,742 GWh), including 92,055 GWh of electricity.
Industry's share is 47.7% of total primary-energy consumption.
The AFI's share is 18% of industrial consumption, *i.e.* 8.55% of the country's total primary-energy consumption.

3.1.2.3. Situation of self-sufficiency

Egypt produces more energy than it consumes; it is thus self-sufficient and imports no energy.
The following table presents the balance of Egypt's three energy sources:

	Coal		Natural gas		Oil	
Consumption	1.124	Gt/y	18.3	Gm^3/y	560,800	bpd
Production	0	Gt/y	18.3	Gm^3/y	851,000	bpd
Export	0.568	Gt/y	0	Gm^3/y	305,680	bpd
Import	1.696	Gt/y	0	Gm^3/y	0	bpd
Reserves	21,792	Gt/y	1,657	Gm^3/y	3.7	Mbarrels
Remaining life of reserves	_	years	90.6	years	11.9	years

While oil exports may tend to decrease, natural-gas production will continue to produce large surpluses in coming years. Primary-energy consumption rises by approximately 4% per year.

3.1.2.4. Energy policy incentives

The Government of Egypt and the Supreme Energy Council are currently setting up an the Egyptian energy-audit agency, under the supervision of the Ministry of State for Environmental Affairs.

The government encourages the Ministry of the Environment to create and develop an energy-audit program which would be based on international and practical experience.
In 2005, the government restructured the economy, which was then highly centralised: it reduced personal and corporate taxes, implemented energy subsidies, and privatised several companies. Stock markets became bullish and GDP rose by approximately 5% per year over 2006/07.
Despite these achievements, the government has had to continue to subsidise basic necessities. Each year, subsidies contribute to a growing budget deficit of 10% of GDP. To stimulate GDP growth, the government will have to continue its reforms, particularly in the energy sector.

3.2. The agro-food sector

3.2.1. The structure of Egypt's agro-food industry

3.2.1.1. The number of agro-food companies

The country has 920 production units in the AFI. Egypt's specificity lies in the public character of certain units (178), with the remainder (742) belonging to the private sector.

3.2.1.2. Employment in the agro-food sector

The AFI employs 440,000 people.

3.2.2. The agro-food industry's market

The AFI market breaks down into several sectors. Production per main activity (in tonnes per year) is as follows:

Milk	Other dairy products	Meat and fish	Frozen vegetables
5,005,000 t/y	2,949,000 t/y	41,800 t/y	31,265 t/y

3.2.3. Energy situation of the agro-food industry

3.2.3.1. Overall (IFA' energy consumption)

The AFI's total primary-energy consumption is 2,440,000 TOE (450,000 TOE of which are in electricity). This consumption amounts to 28,467 GWh, of which 5,670 GWh are electric. It should increase by 15% to 20% over the next decade.

3.2.3.2. By sector (meat, fish, milk, fruits…)

The following table presents the 178 public companies' electricity and natural-gas consumption per sector:

	Meats	Dairy products	Fish	Frozen vegetables
Electricity	40,239 GWh	80,500 GWh	4,842 GWh	97,780 GWh
Natural gas	31,336,000 m^3	38,200,000 m^3	2,109 m^3	71,027,000 m^3

3.3. Cold in the agro-food industry

3.3.1. Status of cold storage in the agro-food industry

The study of cold in the AFI focused on Egypt's main agro-food activities. General data on the characteristics of cold within the AFI could not be obtained. However, the study did analyse the cold-storage activity, cross-cutting other AFI product activities.
The following table breaks down the distribution of the 4,652 storage units (containers) in the country's main ports, with their storage and cooling capacity:

Port	Number of units	Storage capacity (Tonnes)	Cooling capacity (TR[7]/kW)
Alexandria	640	16,000	1,280 / 4,502
Sa'id 1	360	9,000	720 / 2,532
Sa'id 2	1,730	43,250	3,460 / 12,168
Dumiata	456	11,400	912 / 3,207
Suez	386	9,650	772 / 2,715
El Menia	310	7,750	620 / 2,180
El Sukhna	490	12,250	980 / 3,446
Safaga	280	7,000	560 / 1,969
TOTAL	**4,652**	**116,300**	**9,304 / 32,720**

Cold-storage container volumes come in 25-tonne and 30-tonne capacities. Each container is equipped with cooling systems with capacities ranging between 10,000 BTU and 22,800 BTU.

3.3.2. Evaluation of cold needs of main AFI activities

The study focused on three activities and product categories. The data presented in this chapter were synoptically compared by theme.

3.3.2.1. Characteristics of industries in the four main agro-food activities

The number of production units and the overall number of employees of the three main activities are summarised in the following table.

Products	Number of production unit s	Total number of employees
Frozen vegetables	197	72,299
Milk and derivatives	296	180,915
Meat, poultry and fish	235	127,652

The study focused on the companies' production and cooling capacities. No information was provided concerning the economic characteristics of the activities (share in the national economy, in the AFI, impact on exports…).

3.3.2.2. Requirements

For the three agro-food production groups, the study has allowed determining the volume produced, the rate of growth over five years, and the cooling capacity of the industries involved.

[7] *Tonne of refrigeration*: a unit of measurement where 1 TR = 3.5168 kW

Products	Production (tonnes)	2001-2005 production growth rate (%)	Cooling capacity (TR/kW)
Frozen vegetables	31,265	123.1%	4,438 / 15,608
Milk and derivatives	2,949,000	22.55%	94,979 / 334,022
Meat, poultry and fish	41,800	Meats (slaughter-house): 1.8% Fish (fishing): 24.2% Including fisheries and Inland lakes: 44.6%	5,033 / 17,700

In the absence of data, the study could not provide any information concerning cold-related energy characteristics of AFI activities (consumption, cost…).

3.3.3. Survey on specific company needs

Introduction: Company profiles

The survey questionnaire was sent to 30 Egyptian AFI companies, only ten of which responded, with the results presented below. The factories or warehouses were selected for their storage capacity, greater than 40 tonnes, to disregard the numerous 1-to-10-tonne cold rooms found in villages and small towns.

The analysis of results focused mainly on the companies' energy features: cooling capacity, consumption and cost, operation of equipment, and equipment types. As part of the summary, the collected data are presented following the themes of the methodology as dealt with by the study.

3.3.3.1. Production and cooling capacity

The table shows each company's production and cooling capacities (in TR and °C).

Company name	AFI sectors	Amount of products (t/y)	Cooling capacity	
			TR / kW	°C
Halwani bros.	Meats and Poultry	1,300	700 / 2,462	-6
Halal Egypt		75	100 / 352	-8
Koki Poultry		3,000	61 / 215	-8
Amgad for Food Industries		3,348	68 / 239	-6
Oboor City-Industrial Zone	Dairy	3,350	61 / 215	-8
Green Land Group For Food Industries		3,000	200 / 703	-4
Bel Cheese Egypt		12,000	295 / 1,037	-5
Sharkess for milk products		190	35 / 123	-6
Farmfrites for Agriculture Development	Frozen products	650	749 / 2,634	-9
Tropicana for food industries		430	71 / 250	-6
Middle East for food industries		5,000	43 / 151	-6
Alfaysal Richbakery	Bakery	650	74 / 260	-2
El Delta Sweets		720	49 / 172	_
New Juicy	Beverages	1,080	65 / 229	2
Tiba Co. For Food production		4,800	45 / 158	4

Equipment operating temperatures are relatively low, and thus potentially compatible with solar-cooling systems.

3.3.3.2. Equipment operation

The equipment used by the surveyed companies was neither enumerated nor detailed. The following table presents the operating and maintenance times of the equipment.

Company name	AFI sectors	Operation	Maintenance downtime
Halwani bros.	Meats and Poultry	24 hrs/day, 6 days /week	30 days (November)
Halal Egypt		24 hrs/day, 5 days /week	30 days (November)
Koki Poultry		24 hrs/day, 6 days /week	None
Amgad for Food Industries		16 hrs/day, 5 days /week	None
Oboor City-Industrial Zone	Dairy	24 hrs/day, 6 days /week	30 days (November)
Green Land Group For Food Industries		24 hrs/day, 6 days /week	None
Bel Cheese Egypt		24 hrs/day, 6 days /week	None
Sharkess for milk products		24 hrs/day, 6 days /week	90 days (Nov/Dec/Jan)
Farmfrites for Agriculture Development	Frozen products	24 hrs/day, 6 days /week	21 days (November)
Tropicana for food industries		24 hrs/day, 6 days /week	None
Middle East for food industries		8 hrs/day, 6 days /week	None
Alfaysal Richbakery	Bakery	24 hrs/day, 6 days /week	3 weeks (November)
El Delta Sweets		24 hrs/day, 6 days /week	30 days (November)
New Juicy	Drinks	8 hrs/day, 6 days /week	None
Tiba Co. For Food production		24 hrs/day, 6 days /week	60 days (Nov/Dec)

These results show significant equipment use during the year, with maintenance phases during winter months (October, November, December and January).
This report also reveals that the high cooling and refrigeration needs mostly occur in summertime, when there is good solar radiation (quality and duration).
The study also revealed an increase in absorption-refrigeration units and a decrease in compression units between 2004 and 2005.

3.3.3.3. Energy consumption and costs

The following table presents each company's energy consumptions according to energy source.
Energy costs are expressed in Egyptian pounds per year (EGP/y)

Company name	Natural gas		Electricity		Annual energy cost[8] (EUR per year)
	Annual consumption (m^3 per year)	Annual cost (EGP/year)	Annual consumption (kWh per year)	Annual cost (EGP/year)	
Halwani bros.	340,568	74,925	8,250,000	1,540,000	186,777
Halal Egypt	268,475	59,065	1,333,333	240,000	34,589
Koki Poultry	468,573	103,086	1,225,228	208,289	36,013
Amgad for Food Industries	236,941	52,127	1,277,778	230,000	32,630
Oboor City-Industrial Zone	463,295	101,925	1,151,267	207,228	35,756
Green Land Group For Food Industries	284,375	62,563	3,517,160	681,420	86,047
Bel Cheese Egypt	5,531,630	1,216,959	2,285,800	411,444	188,336
Sharkess for milk products	351,478	77,325	666,667	120,000	22,822
Farmfrites for Agriculture Development	59,417,840	14,066,731	16,659,200	2,996,664	1,973,501
Tropicana for food industries	734,916	161,682	1,333,333	240,000	46,457
Middle East for food industries	2,665,472	586,404	863,492	146,794	84,800
Alfaysal Richbakery	184,270	40,359	1,401,600	252,288	33,847
El Delta Sweets	259,143	57,011	995,624	165,274	25,709
New Juicy	_	_	233,333	42,000	4,858
Tiba Co. For Food production	220,455	48,500	847,222	152,500	23,247
TOTAL	**71,427,431**	**16,708,662**	**42,041,037**	**7,633,901**	**2,815,389**

The 15 companies surveyed represent approximately 1% of the Egyptian AFI's energy consumption, *i.e.* some 20% of total electricity consumption and 53% of total fuel consumption in the public sector.

[8] 1 EGP = 0.115657 EUR

PART 3: Definition of a general methodological tool to evaluate the penetration potential of Renewable Energies into the Agro-Food Industry

The purpose of this section is to define a complete methodology to carry out future studies concerning the evaluation of the penetration potential of Renewable Energies into the Agro-Food Industry. Initially, this tool is meant to study cold in the AFI; however, it might later be applied to other industries and other energy equipment.

On the basis of the initial methodology, the organisation and development of all themes and criteria draw conclusions from their application to the three national studies. The modifications and evolutions resulting from the national studies are incorporated in this paragraph. Likewise, the methodology considers the improvements which have appeared during the drafting of the national studies and which are deemed noteworthy in terms of form or contents.

The structure presents the various themes and data which must be addressed during these studies. The information requested constitutes a number of parameters which will allow the analysis of the penetration potential of industrial solar cooling. The plan is decidedly detailed, to present the data to be used in the technical and economic evaluation of the penetration potential of new technologies as comprehensively as possible.

The characteristics of the country (**1.**) and of the agro-food industry (**2.**) allow defining the scope of the study and the potential interest of the technologies to be studied. In most cases, these paragraphs follow the initial methodology. The study of energy uses in AFI (**3.**) defines the characteristics of cold- and heat-related manufacturing processes, mostly to analyse the possible application of renewable energies to the AFI.

1. The national context

1.1. Introduction: general description of the country

The goal is to survey the country's territory. The definition of national characteristics will make possible to evaluate the influence of the country's location and organisation on the national potential. These data may be drawn from atlases, specialised works and a number of national departments.

1.1.1. Geographical data

The following information must be described:

- location of the country
- borders and neighbouring countries
- surface area
- various geographical zones
- national capital and/or metropolis (with geographical coordinates)

1.1.2. Demographic, economic and political data

The following characteristics must be described:

- demographic: population, density, average age, life expectancy, fertility index, population growth rate, urban population rate, number of inhabitants in major cities…
- economic: country's GDP and per capita GDP, currency (and foreign-exchange rate)
- political organisations: membership in international organisations, official language

1.1.3. Climatic data and renewable-energy potential

Climatic characteristics, as with geographic features, can exert significant influence on renewable-energy systems. The country's climatology must therefore be defined, particularly those factors which have a direct influence on the production of renewable energies:

- seasons
- temperatures
- dominant winds
- precipitations
- average sunshine rate
- possible presence of groundwater and/or specific subsoil characteristics
- etc…

Besides defining the national context, these data provide a preliminary outlook on the potential use of new and/or renewable energies. Using the geographical and climatic data thus gathered, it is possible to define the potential of renewable energies (solar, wind and geothermal power…).

It would seem that the preparation of a summary document would prove of interest, as it would make it possible to identify these potentials. Cartography is a tool that permits making the most out of the data required to express such potential, while also making it easier for the players involved to visualise and understand it. The goal might be the production of a schematic "map of renewable-energy potentials" of the country being studied.

1.2. The country's energy balance

The aim is to present the country's energy characteristics. A balance of resources and consumption makes it possible to define the country's overall energy stakes in light of its national energy policy.

1.2.1. The country's energy resources

First, the methodology consists in presenting the various energy resources used by the country and any imports or exports it may require to meet its needs. The evaluation of reserves is also important to understand the need for action in the energy sector.

Particular attention is paid to electricity. Indeed, production of this energy source, common in the various countries, requires a considerable use of primary energy resources. The production of electrical energy will have to be the subject of a description of resources used.

1.2.2. The country's energy consumptions

1.2.2.1. Total consumption

Next, the study will present the country's energy consumption. The information provided on national energy consumption should also indicate the share of each source or resource used. The units used are generally TOE for fuels and kWh for electricity. However, consumption will be expressed in both units through conversion. The use of common units allows a comparative analysis of consumption according to energy source, making it possible to evaluate the potential of their substitution by energy renewable.

1.2.2.2. Consumption by economic sector

The data on energy consumption will identify the share of those sectors (industry, transportation, construction…) in the national consumption, and will be also broken down by energy source or resource.
Thus, those sectors with highest energy consumption will be identified, making it possible to define new stakes for the country's energy future. Such available data may lead political decision-makers to make commitments and lead to initiatives in the development of renewable energies in these economic sectors

1.2.3. The situation of energy dependence or self-sufficiency

These data allow determining the country's energy balance, *i.e.* its situation of energy dependence or self-sufficiency.

The following table summarises the data on the energy sector. It permits a quick, comparative reading of the various factors determining the energy stakes the country faces or will face.

	Coal		Gas		Oil		Others	
Consumption		Millions of tonnes		Billions of m^3		Barrels		(unit)
Production								
Export								
Import								
Reserves								
Remaining life of reserves*		years		years		years		years

* determined on the basis of constant production

1.2.4. Prospects for change

The preceding information provides a summary of the country's energy situation. This paragraph seeks to define the long-term energy stakes.
As far as possible, the study will estimate the evolution of the various resources and the country's energy consumption, taking into consideration demographic trends, changes in the economic sectors' energy demand…

1.3. The country's energy policy

1.3.1. Energy legislation

With the passing of time, the energy sector has become a priority stake in all national policies because of the impacts energy has on a country's economy, population and environment. All States have developed cross-cutting energy policies. The goal is to present the country's commitment through its regulations on energy. A survey of current regulations makes it possible to identify the study's legislative context.

1.3.2. Implementation mechanism of the energy policy

Legislation generally comes with mechanisms to enforce the energy policy. Implementation mechanisms of the energy policy generally belong to wither of two categories:

- Incentive mechanisms, like assistance, subsidies, decreases in certain areas like investments or taxes, programs to foster energy saving.
- Dissuasive mechanisms, which act in a repressive manner, through fines or the definition of foolproof mechanisms.

The measures planned for the application of the regulation will be presented, to identify the economic players' rooms for manoeuvre.

2. The country's agro-food sector

The methodology consists in revealing the strategic nature of the agro-food industry (AFI) in the application of new energy technologies.

To do so, the study will ensure it provides the necessary information on the structure of the sector and the economic market it represents for the country. Finally, the study will break down the sector's impact on the country's energy consumptions by resources used and the sector's various activities.

2.1. The structure of the agro-food industry

First, the study will define the organisation of the AFI, which is structured around companies on the one hand and activity sectors on the other. This sector-describing paragraph makes possible the definition of the sector's weight in the country's and of the industry' economic structures.

2.1.1. Companies of the agro-food sector

The role of agro-food companies in the national economy according to category (international group, domestic company, small or medium enterprises …) must be defined on the basis of the total number of industries.

Thus, for each category of company, the study will define their number, jobs, turnover… and thus their weight in the AFI (by contrasting their characteristics with those of the sector). The following table can be used as a starting point.

Category of company	Number	Jobs	Total turnover	Share of AFI production
International groups				
National companies, export s only				
National companies (excluding exports)				
SME				
"Family" companies				
…				
TOTAL: AFI				

2.1.2. Activities of the agro-food sector

The organisation of the AFI is also structured according to activities (Fruits and vegetables, milk and derivatives, meat, seafood, cereals…). The study must ensure it evaluates the role of the dominant activities within the AFI. This step also makes it possible to understand the weight of each agro-food activity in the country's economy.

Determining the number of companies and/or production units and jobs, the turnover, the exports… of each activity makes it possible to draw up a preliminary inventory of activities, so as to evaluate the importance of energy issues in these activities. The following table can be used as a starting point:

Activities	Number	Jobs	Total turnover	Share of AFI production
Fruits and vegetables				
Cereals				
Seafood				
Meats				
Milk and derivatives				
…				
TOTAL: AFI				

2.2. The agro-food industry's market

To obtain a more in-depth look at the stake of the AFI, the methodology consists in describing the sector's role in the national economy on the basis of financial (share in gross domestic product, added value …) and quantitative (turnover, production volumes, import and export volumes …) data.

Furthermore, the study will present investments made in this sector over the last few years. This indicator makes it possible to determine the sector's strategic stake in the country's economy, and the sector's push toward evolution and competitiveness.

The agro-food industry is also characterised by a market focused on international trade. The varied food requirements of countries and the economy's globalisation have fostered the export of local products or the import of raw materials. Such international trade generates not only customer-supplier relationships, but also partnerships between industries and foreign investors and companies.

Thus, the relationships between economic players can be an important cause of process or product modification to satisfy client expectations. The study will then define the international trade relationships and partnerships of the AFI, and indicate the country's main agro-food customers and/or partners.

2.3. Overall energy situation of the agro-food industry

After having described the AFI's structure and market, the study will present the sector's energy situation on the two following scales:

- sector-wide, to measure the sector's share of consumed energy compared to total energy, first for the country, then for the industrial sector,
- by sector activity, to measure the share of each activity (meat, fish, milk, cereals…) compared to the sector.

This analysis of the AFI's energy situation allows evaluating the importance of the sector in the country's energy consumption, and also to identify those sector activities which are high consumers and may be the subject of a more thorough study. To conduct a comparative study, consumptions will be calculated using the same units of measure (TOE and kWh) for all sources used.

3. Energy used in the agro-food industry

3.1. Introduction: Presentation of the two strategic energy uses in the agro-food industry

In the AFI, product manufacturing calls on three main energy uses: cold, heat and production line.
The "production line" item will not be analysed here due to the difficulty in evaluating energy requirements throughout the AFI and its various activities. However, equipment required for production may be the subject of a company-level study when companies use such equipment.

For this study, the methodology applies to "cold" and "heat" uses, the evaluation of which may follow similar stages, and which are the subject of a single questionnaire.

3.1.1. Cooling energy

Refrigeration and commercial and industrial cooling are necessary for the following reasons:

- they ensure the preservation and value realisation of "perishables"
- they satisfy the local market in time and space
- they export products to the local and foreign markets
- they avoid foodstuff losses
- they play a significant role in price levels by adjusting supply to demand

Food products go through various freezing stages between production and consumption. This "cold chain" must not be broken between the following stages:

- fast processing of healthy products
- refrigeration for preservation at 0°c
- deep-freezing for preservation below -18°c
- storage of processed products in refrigerated warehouses
- transportation of products by refrigerated containers to the various distribution points
- presentation of refrigerated products at distributors' establishments
- preservation of products in home refrigerators and freezers

3.1.2. Thermal energy

Agro-food production also requires the use of heat-producing equipment to cook or the sterilise products. AFI companies resort to heat production for health reasons (*e.g.* to pasteurise dairy products) or to finalise the product (cooking before conditioning).

The national studies presented in Part 2 revealed the importance of heat in certain IFA activities, with temperatures required for the manufacturing processes sometimes reaching being very high levels. [9]

[9] *cf* **1.3.3.1 Manufacturing processes** in the Tunisian study, p 24

On the basis of energy uses in agro-food production, the methodology consists in studying the chosen energy category's specific energy requirements for the sector's various activities.

Using the survey of the sector's production capacities and the volume of products involved in industrial cold and heat and in the production line as a base, the study will rely on a questionnaire meant for the companies, which will make it possible to evaluate the cooling and heating technologies, the equipment used, and the consumption and costs corresponding to the process(es).

From the characteristics and stakes thus revealed, the study will identify the means and measures which must be implemented for the development of renewable energies in the sector's various activities.

3.2. Characteristics of energy uses in the agro-food industry

To evaluate the penetration potential of renewable energies in the AFI, an overview of the AFI's two priority areas, cold and heat, must first be prepared. To do so, and as far as possible, the legislative, socioeconomic and operational characteristics of the item under study within the AFI must be defined.

3.2.1. Legislation and industrial processes

First, where there are already available data, the ***legislative framework*** applicable to "cold" or "hot" activities in the agro-food industry must be presented. The study will reveal the means and compliance measures implemented to enforce this specific agro-food cold legislation.

Next, the study will focus on compliance with ***industrial processes***. In the event of any non-compliance with the processes (particularly in the continuity of the "cold chain" in the eventuality of a study of cold) the study will point out the stages affected and possible actions carried out or required.

3.2.2. Socioeconomic characteristics of energy uses in the agro-food industry

The methodology consists in conducting an in-depth study of cold and heat issues within the AFI. During the summary work for the national studies, the issue of cold was seen to affect a cross-cutting activity of the AFI, cold storage. In the case of a study on heat issues, the study should look for any cross-cutting area which may exist in the AFI (cooperatives, collective furnaces…).

Thus, the study will define the following characteristics:

- The players

The study will focus on the AFI companies or industries using heat or cold in their production, and will define the proportion of the AFI which uses such systems.
The study will also define their weight in terms of employment, compared to the AFI as a whole. If the sources allow it, a distinction will be made between permanent and seasonal

jobs. Indeed, the AFI is a sector with significant seasonal job requirements because of production and harvesting needs.

- Economic characteristics

The study will describe the economic weight of the field under study within the AFI (total turnover, total exports…).
The study will also attempt to evaluate the investments made by companies in their development and that of processes and products, and the evolution of the equipment involved.

- Sector activities

The aforementioned socioeconomic data must be developed according to AFI activities. Thus, the study will identify the main activity(ies) by weight, in terms of number of industries or jobs, in economic terms, and in terms of their use of cold or heat.

3.3. Evaluation of the various agro-food activities' energy needs

After having defined the main determining factors of heat or cold within the AFI, the methodology consists in studying thoroughly the issue of cold and heat within the AFI's main activities.
To do so, the study will describe their needs and each activity's ability to meet such needs.

However, the data on each activity's specific needs are not directly available. The aim of the study will be to define the parameters deemed essential in evaluating the requirements of their production operations and their consequences for the industries.

The main parameters used in defining the needs in AFI activities are:

- production volume and the portion requiring cooling and cooking systems
- the companies' capacities and equipments (power, hourly production…) implemented within the activities
- the type of equipment required for each activity for the proper operation of the production line
- the energy consumption of each activity related to heat and cold equipment and processes

3.4. Survey on specific company needs

The two previous points saw the methodology seeking to define the needs of the AFI and the various agro-food activities; the third point will focus more specifically on the needs of agro-food companies.

It seems obvious that it would be impossible to carry out an exhaustive study of the needs of all national agro-food companies. This part of the methodology relies on a questionnaire as a tool with which agro-food companies may be surveyed concerning their energy needs.

Introduction: Presentation of the questionnaire

The questionnaire drafted by the Egyptian Environmental Affairs Authority, or EEAA (Appendix 1), may also be used in this methodology, as it relates to both energy categories of interest.
The questionnaire will be sent to the main agro-food companies. The study group will determine the survey's sample by selecting companies for their potential interest in renewable energies and choosing companies from all main AFI activities.

Completing the questionnaire is not mandatory. Sample definition, therefore, will be limited by the choice of companies. The study group will ensure it is available to coach the companies. The analysis of the results will grant an insight into the specific energy needs of agro-food companies, according to their activities and production processes.

The purpose of the questionnaire is to define the energy characteristics of companies and evaluate the potential for the application of renewable energies. This is why the standard questionnaire is structured in five sections:

- Company profile
- Analysis of the production processes
- Inventory of heat and cold production equipment
- Collection of energy annual consumption and costs
- Analysis of results

3.4.1. Company profiles

The first part of the questionnaire deals with the company's main information, which breaks down into three types:

- Presentation of the company: name, location, activity (within the AFI), number of employees.
- Contact within the company: address, name of referral agent, phone and fax numbers, e-mail address. These data allow the follow-up and coordination of the study.
- Description of production: the company's product types and annual output.

The goal of this section is to determine the company's general activity.

3.4.2. Analysis of the production process

The second part of the questionnaire involves production process details. The questionnaire contains three tables which must be completed to provide details on the company's various production operations using thermal (heat) and refrigerating (cold) energy.
These three tables determine:

- A summary of production operations: a list of operations using thermal and refrigerating energy.
- Detail of each listed operation: for each process, the questionnaire requires production parameters, including
  - its presentation (name of the process and product, amount of product)

- its operation (energy used, duration of operation, product temperatures before and during the operation)
- its environment (unit location, equipment material and thickness, room temperature)

- Production frequency: time calculation of the activity for each manufacturing process.

The goal of this section is to define the operating parameters for the manufacture of each of the company's agro-food products. The details asked for will allow a precise evaluation of the potential use of renewable energies according to the frequency of production activities.

3.4.3. Inventory of heat and cold production equipment

The third section seeks to gather technical data on all equipment using thermal or refrigerating energy:

- short presentation: model, manufacturer, year of manufacture
- use parameters: fuel, nominal power and temperature, fluid used and nominal fluid flow
- equipment operation in hours per year and usage

The purpose of defining the equipment's technical criteria is to evaluate its possible substitution by (or complement using) equipment using renewable energies, by comparing these technical criteria.

3.4.4. Collection of energy annual consumption and costs

The fourth section defines the influence of the processes and equipment on the energy invoice (consumption and cost).
For each type of energy used, the company will provide monthly and annual consumptions and costs. The questionnaire also requires details on the various equipment using different fuels, and the electric power and installed capacity.

The purpose is to evaluate the energy potential (decrease in consumption using "free" energy) and the economic potential (decrease in energy costs and solar feasibility study).

3.4.5. Analysis of results

The study's objective is to evaluate the AFI's potential of resorting to renewable energy. To do so, the study will ensure the recovery of data.
The Moroccan study may serve as a guide for the preparation of summary cards for surveyed companies.
In addition, the study group will conduct an analytical study of these data according to the methodology's four sets of issues and the questionnaire. This analysis will draw lessons from the Egyptian study and the comparative analysis of data and surveyed companies.

Synoptic table

To conclude the completed study, the report will present a synoptic table with the country's main features. For each of the methodology's sets of issues, the table will show the key values and/or potentialities concerning the climatic, energy, economic and technical aspects.

This table will provide a summarised view of the study and a first strategic analysis of the penetration potential of renewable energies in the agro-food industry.

			COUNTRY
Energy situation	Presentation of the country		
	Country's energy balance		
	Country's energy policy		
Agro-food industry	AFI's market		
	AFI's structure		
	AFI's overall energy situation		
Energy categories within the AFI	Presentation of energy categories within the sector		
	Evaluation of activities' energy needs		
	Survey of companies' needs	Company profiles	
		Production processes	
		Installed equipment	
		Annual energy consumption and costs	

CONCLUSION

This study's objective is to design an analytical tool of the potential of integrating renewable energies in the agro-food industry of the Southern and Eastern Mediterranean countries.

To design this single instrument, the study relied on the MEDISCO project's methodology, which evaluates the penetration potential of solar-cooling systems in the AFI.

The methodology was applied to three countries of the Southern and Eastern Mediterranean Basin: Tunisia, Morocco and Egypt. The summary prepared on the basis of the three national studies allowed evaluating the effectiveness of this tool in collecting the main data as a basis of evaluation of this penetration potential.

With these three national studies to work from, the MEDISCO project will afterwards focus on developing an innovative, high-performance solar-cooling and -refrigeration concept, with the hope of providing the best compromise between the use of innovative technologies, primary-energy savings and economic considerations.
Once developed, the concepts will be installed at experimental sites, thus making it possible to measure their performance directly. The experience thus acquired will serve as a basis for the creation of guidelines for spreading these practises.

Stressing the AFI's energy and economic issues, the tool has allowed the definition of a methodological guide with a broader field of application, meant to evaluate the penetration of renewable energies in the AFI of the Southern and Eastern Mediterranean countries.
Thus, the stake is to strengthen the dynamics started by the MEDISCO project concerning the various energy categories within the agro-food industry.

APPENDIX

1. English/Arab questionnaire written by Egyptian Environmental Affairs Authority

FORM A

Company profile

بطاقة التعريف

Data البيانات	**Value** القيمة	**Notes** الملاحظات
Company name اسم المنشاة		
City / country البلد / المدينة		
Sector القطاع		
Number of employees عدد العاملين		
Address العنوان		
Contact person المسئول		
Telephone N° التليفون		
Fax N° الفاكس		
E-mail البريد الإلكتروني		

Parameter	**Unit** الوحدة	**Value** القيمة	**Notes** الملاحظات
Type of product (1) نوع المنتج) !)			
Amount of product per year (1) حجم الإنتاج السنوي			
Type of product (2) نوع المنتج			
Amount of product per year (2) حجم الإنتاج السنوي للمنتج			
Type of product (3) نوع المنتج (3)	-		
Amount of product per year (3) حجم الإنتاج السنوي (3)			
Type of product (4) نوع المنتج (4)			
Amount of product per year (4) حجم الإنتاج السنوي (4)			

FORM B
Production process analysis

تحليل العملية الإنتاجية

في هذا الجزء من الاستمارة يتم ملء الجدول رقم 1 ببيانات عن العمليات الإنتاجية التي تستهلك طاقة حرارية أو تبريدية. وكخطوه ثانية يتم ملء الجدول رقم 2 وجدول ساعات الإنتاج لكل عملية علي حده.

In this section of the questionnaire data related to the production process will be inserted
First of all, fill in the summary table 1 indicating only operations where thermal or frigorific energy is consumed. As second step fill the table 2 and the frequency table for each process aforementioned

FORM B-1

Table 1
جدول رقم 1

N. operation رقم العملية	Type of operation نوع العملة	Notes ملاحظات
1		
2		
3		
4		
5		

Table 2
جدول رقم 2

Parameter	Value	Notes
Name of the process اسم العملية الإنتاجية		
Type of energy نوع الطاقة المستخدمة		
Name of product اسم المنتج		
Initial temperature of product درجة الحرارة الأولية للمنتج		
Temperature of product during operation درجة الحرارة أثناء عملية الإنتاج		
Amount of product حجم الإنتاج		
Time required for the operation الوقت الذي تستغرقه العملية الإنتاجية		
Place where the container is located المكان الموجود به الحاوية		
Material and thickness of the container سمك الحاوية والمادة المصنعة منها		
External ambient temperature surrounding the container درجة حرارة الوسط الخارجي المحيط بالحاوية		

FORM B2

Frequency table

Month	Week	Day of work							Operation
		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Number of hours per day
January	1								
	2								
	3								
	4								
February	1								
	2								
	3								
	4								
March	1								
	2								
	3								
	4								
April	1								
	2								
	3								
	4								
May	1								
	2								
	3								
	4								
June	1								
	2								
	3								
	4								
July	1								
	2								
	3								
	4								
August	1								
	2								
	3								
	4								
September	1								
	2								
	3								
	4								
October	1								
	2								
	3								
	4								
November	1								
	2								
	3								
	4								
December	1								
	2								
	3								
	4								

FORM C

Equipment for heat (cold) generation

جهاز توليد الحرارة/التبريد

الجدول التالي يتضمن البيانات الفنية للجهاز المولد للحرارة أو التبريد إثناء العملية الإنتاجية

Please fill the table below with the technical data of the machines or appliances used to produce thermal or frigorific energy used in the productive process
Possible equipment is for example:

- *Fossil fuel hot water heater* (سخان مياه يعمل بالوقود)
- *Fossil fuel steam generator* (غلاية بخارية تعمل بالوقود)
- *Electric boiler for hot water preparation* (غلاية بخارية تعمل بالكهرباء)
- *Electric resistances for hot water preparation*
- *Electric compression chiller* (ثلاجة تجميد كهربية)
- *Thermally driven chiller* (ثلاجة تجميد تعمل بالطاقة الحرارية)
- *Cogenerator engine* (محرك يعمل بالدورة المركبة)

Please fill a different table for every type of equipment installed
رجاء استخدام جدول مستقل لكل جهاز علي حده

Equipment n° 1 **الجهاز/المعدة رقم 1**			
Parameter	**Unit**	**Value**	**Notes**
Typeالنوع			
Manufacturer اسم المصنع			
Model الموديل			
Year of manufacturing or/and installation? تاريخ التصنيع / التركيب			
Fuel used نوع الوقود			
Nominal Power (Heat or cold, output)(القدرة الاسمية (حرارة، تبريد			
Fluid produced نوعية الناقل الحراري أو التبريدي			
Nominal flow rate of the fluid produced معدل سريان الناقل الحراري			
Nominal temperature درجة الحرارة الاسمية			
Hours of functioning per year ساعات التشغيل السنوية			
Use of the equipment استخدام المعدة		.	*)*

FORM D

FORM D-1

Fuel consumption and cost ***استهلاك الوقود وتكلفته***

Parameter	**Unit** الوحدة	**Value** القيمة		**Notes** ملاحظات
Type of fuel نوع الوقود				
Used in equipment n°: يستخدم فى الجهاز رقم				
Annual consumption الاستخدام السنوي	m^3/y or Kg/y	**Jan**	/	
		Feb	/	
		Mar	/	
		Apr	/	
		May	/	
		June	/	
		July	/	
		Aug	/	
		Set	/	
		Oct	/	
		Nov	/	
		Dec	/	
Annual fuel consumption الاستهلاك السنوي للوقود	m^3/y or Kg/y			
Annual energy cost تكلفة الطاقة السنوية	USD/y			

FORM D-2

Electricity consumption and cost **استهلاك الكهرباء و تكلفتها**

Parameter	**Unit**	**Value**		**Notes**
Contracted power القدرة المتعاقد عليها	kW_e			
Installed power القدرة الاسمية الحالية	kW_e			
Consumption الاستهلاك	kWh	**Jan**		
		Feb		
		Mar		
		Apr		
		May		
		June		
		July		
		Aug		
		Sept		
		Oct		
		Nov		
		Dec		
Annual electricity cost تكلفة الكهرباء السنوية				

2. French questionnaire for Morocco and Tunisia

FORM A

Profil de la société:

Données	Valeurs	Notes
Nom de la société		
Localité		
Secteur d'activité		
Nombre d'employés		
Adresse		
Contact		
Téléphone N°		
Fax N°		
E-mail		

Paramètres	Unité	Valeur	Notes
Type du produit (1)			
Production annuelle (1)			
Type du produit (2)			
Production annuelle (2)			
Type du produit (3)			
Production annuelle (3)			
Type du produit (4)			
Production annuelle (4)			

FORM B

Analyse du procédé de production:

Cette partie du formulaire concerne les détails du procédé de production.

Le tableau n°1 comportera uniquement les opérations relatives à l'utilisation de l'énergie thermique et frigorifique.

Le tableau n°2 présentera la fréquence d'utilisation de chaque procédé mentionné dans le tableau n°1.

FORM B-1

Tableau 1

N. opération	Type de l'opération	Notes
1		
2		
3		
4		
5		

Tableau 2

Paramètre	Valeur	Notes
Nom du procédé (1)		
Type de l'énergie utilisée		
Nom du produit		
Température initiale du produit		
Température du produit durant l'opération		
Quantité du produit		
Durée de cette opération		
Emplacement de cette unité		
Matériau et épaisseur de l'équipement relative à ce procédé		
Température ambiante autour de cet équipement		

Paramètre	Valeur	Notes
Nom du procédé (2)		
Type de l'énergie utilisée		
Nom du produit		
Température initiale du produit		
Température du produit durant l'opération		
Quantité du produit		
Durée de cette opération		
Emplacement de cette unité		
Matériau et épaisseur de l'équipement relative à ce procédé		
Température ambiante autour de cet équipement		

Remarque: prévoir un tableau à part pour chaque procédé élémentaire.

FORM B2

Tableau des fréquences (heures de production)

			Jours de travail						Fonctionnement
Mois	semaine	Lun	Mar	Mer	Jeu	Ven	Sam	Dim	Nombre d'heures par jour
Jan	1								
	2								
	3								
	4								
Fév	1								
	2								
	3								
	4								
Mars	1								
	2								
	3								
	4								
Avr	1								
	2								
	3								
	4								
Mai	1								
	2								
	3								
	4								
Juin	1								
	2								
	3								
	4								
Juillet	1								
	2								
	3								
	4								
Août	1								
	2								
	3								
	4								
Sept	1								
	2								
	3								
	4								
Oct	1								
	2								
	3								
	4								
Nov	1								
	2								
	3								
	4								
Déc	1								
	2								
	3								
	4								

FORM C
Équipements de production de chaleur et de froid

Dans cette partie nous proposons de récolter quelques données techniques relatives aux équipements produisant l'énergie thermique et frigorifique pour le besoin de la société

Exemples des équipements possibles:

- *Chauffe-eau à gaz*
- *Chaudière à gaz*
- *Chaudière électrique*
- *Résistances chauffantes*
- *Compresseur électrique*
- *Réfrigérateur qui fonctionne par chaleur (machine à absorption)*
- *Machine de cogénération*

Équipement n° 1			
Paramètre	**Unité**	**Valeur**	**Notes**
Type			
Fabriquant			
Modèle			
Année de fabrication ou d'installation			
Combustible utilisé			
Puissance nominale			
Fluide utilisé			
Débit nominal du fluide produit			
Température nominale			
Fonctionnement (heure/an)			
Utilisation de l'équipement		.	

Équipement n° 2			
Paramètre	**Unité**	**Valeur**	**Notes**
Type			
Fabriquant			
Modèle			
Année de fabrication ou d'installation			
Combustible utilisé			
Puissance nominale			
Fluide utilisé			
Débit nominal du fluide produit			
Température nominale			
Fonctionnement (heure/an)			
Utilisation de l'équipement		.	

Remarque: prévoir un tableau à part pour chaque équipement.

FORM D

FORM D-1

Consommation et prix des combustibles

Paramètre	Unité	Valeur		Notes
Type de combustible				
Utilisé pour les équipements				
Consommation mensuelle	m^3 ou Kg	**jan**		
		fév		
		mar		
		avr		
		mai		
		jun		
		juillet		
		août		
		sep		
		oct		
		nov		
		déc		
Consommation annuelle du combustible	m^3/an ou Kg/an			
Coût de la consommation annuelle	DT/an			

FORM D-2

Consommation électrique et coût

Paramètre	Unité	Valeur		Notes
puissance	kW_e			
Puissance installée	kW_e			
Consommation	kWh	**jan**		
		fev		
		mar		
		avr		
		mai		
		jun		
		juillet		
		août		
		sep		
		oct		
		nov		
		déc		
Coût de la consommation annuelle	DT/an			