Field testing of an innovative solar powered milk cooling solution for the higher efficiency of the dairy subsector in Tunisia

Supported by GIZ:

Innovation Transfer into Agriculture – Adaptation to Climate Change (ITAACC)
&
Powering Agriculture – Sustainable Energy for Food

Business plan and feasibility analysis of an On-farm solar powered milk cooling system

Dhraief MZ, Zlaoui M, Jebali O and Ibidhi R.

National Institute for Agricultural Research of Tunisia (I.N.R.A.T)

Mars, 2018

Acronyms

BMZ	Federal Ministry for Economic Cooperation and Development.
BNA	National Agricultural Bank
BTS	Tunisian Solidarity Bank
CRDA	Regional Commission for Agricultural Development
DGPA	General Directorate of Agricultural Production
FAO	Food and Agriculture Organization of the United Nations
FNME	National Fund for Energy Conservation
GIVLait	Interprofessional grouping of red meat and milk
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HH	Household
ICARDA	International Center for Agricultural Research in the Dry Areas
INRAT	National Agronomic Research Institute of Tunisia
IRESA	Institution of Agricultural Research and Higher Education
L	Liter
M^3	Cubic meter
OEP	Office of Livestock and Pasture
RE	Renewable energy
SWOT	strengths, weaknesses, opportunities and threats
TND	Tunisian Dinar
VAT	Value Added Tax
APIA-RD	Agricultural Investment Promotion Agency-Regional Direction.
APIA	Agricultural Investment Promotion Agency.
ANME	Tunisian National Energy Management Agency (Agence Nationale pour la Maîtrise de l'Energie)
ANPE	Tunisian National Environmental Protection Agency (Agence Nationale de Protection de l'Environnement)
GW	Giga Watt
IPP	Independent Power Producer
kWh	Kilowatt hour
MIT	Tunisian Ministry of Industry and Technology (Ministère de l'Industrie et de la Technologie) now Ministry of Industry (Ministère de l'Industrie)
MSP	Mediterranean Solar Plan
Mtoe	Million tons of oil equivalent
MW	Megawatt
STEG	Société Tunisienne d'Electricité et du Gaz, the national Tunisian gas and electricity utility company
STEG ER	Société Tunisienne d'Electricité et du Gaz, Energies Renouvelables, STEG's renewable energies division
TSP	Tunisian Solar Plan
UNDP	United Nation Development Program

1. Introduction

Tunisia is an energy-dependent country with modest oil and gas reserves. Around 97 percent of the total energy is produced by natural gas and oil, while renewable energy contributes merely to 3% of the total energy used. The installed electricity capacity at the end of 2015 was 5,695 Mega Watt (MW) which is expected to sharply increase to 7,500 MW by 2021 to meet the rising power demands of the industrial and domestic sectors. Tunisia is also building additional conventional power plants and developing its solar and wind capacities to sustain economic development.

Tunisia has good renewable energy potential, especially solar and wind, which the government is trying to tap to ensure a safe energy future. The country has very good solar radiation potential which ranges from 1800 kilowatt-hour per square meter (kWh/m^2) per year in the North to 2600kWh/m^2 per year in the South. The total installed capacity of grid-connected renewable power plant was around 342 MW in 2016 (245 MW of wind energy, 68 MW of hydropower and 15 MW of PV) which is hardly 6% of the total capacity.

In 2009, the Tunisian government adopted "Plan Solaire Tunisien" or Tunisia Solar Plan to achieve 4.7 GigaWatts (GW) of renewable energy capacity by 2030 which includes the use of solar photovoltaic systems, solar water heating systems and solar concentrated power units. The Tunisian solar plan is being implemented by "STEG Énergies Renouvelables" (STEG Renewable Energy) which is a subsidiary of state-utility STEG (the national tunisian electricity company) and responsible for the development of alternative energy sector in the country.

The total investment required to implement the Tunisian Solar Program plan have been estimated at $2.5 billion, including $175 million from the National Fund, $530 million from the public sector, $1,660 million from private sector funds and $24 million from international cooperation. These funds should be spent over the period of 2012 – 2016. Around 40 percent of the resources will be devoted to the development of energy export infrastructure.[1]

Tunisia's good renewable energy status along its agricultural potential pushed the Government in association with other international partners to take advantage of this situation especially in the rural regions which are the most deprived of the country, with low rates of urbanization to implement new projects. It started in the early 2000's; solar power energy was introduced to the rural communities, especially for the most depraved families which are living out from the STEG grids as a governmental aid (small PV units and batteries for the HH lights). After being familiar with this concept (PV panels), the government alongside with international cooperation programs started the

[1]Solar Energy Prospects in Tunisia: S. Zafar April 7, 2017. Africa, Renewable Energy, Solar Energy, Wind Energy. https://www.ecomena.org/solar-tunisia/

implementation of pilot projects at small-scale levels as demonstrative experience for a given community to push them to adopt Green Technologies.

The dairy subsector in Tunisia suffers from many constraints. The production cost at the farm level is increasing from year to year due to the importation of almost all the needed inputs (mainly the concentrated fodder components such as maize and soya). This made the breeders sell the new born calves at an early age (weaning them after 3 months) in a continuous effort to sustain their small business. In addition, smugglers have taken control over the local and regional markets offering huge amounts of money to the most fragile breeders so they can smuggle the cattle to Algerian and Libyan territories. Besides of these threats, the milk collectors have neither a clear organization nor a legislative status; they are considered as the "*Necessary Evil*" of the milk value chain in Tunisia. The Milk Collection Centers (MCC's) are suffering from an instable and continuously changing politics and powerless Government under an increasing social pressure led essentially by the milk collectors. In overall, the dairy subsector in Tunisia is fragile from both the inside and the outside of its value chain; all the links are in conflict between each other making milk quality their last concern except for few stakeholders. This reality has made the adoption of new technologies crucial to sustain this chain and preventing it from imploding under a rising pressure.

In this context, the OEP (Office de l'Elevage et des Pâturages) launched numerous development programs with the support of several foreign countries (France, Belgium, Luxembourg, Germany…etc.) alongside with International organizations. These programs had a common goal; creating a dairy subsector capable of facing all the possible threats, in addition of being competitive at an international level. In order to reach these objectives, the dairy value chain in Tunisia has to be enhanced and stabilized to reach a higher level of efficiency. In this context, series of researches and experimental programs were launched by various stakeholders to introduce and develop the concept of cooling the milk on-farm. Obviously electricity was the most pertinent source of energy at first, but with an unreliable power grid dependent on peak hours, the use of solar energy in a country with more than 300 days of sunshine imposed itself. This innovative technology is the subject of our study in the context of the project "***Field testing of an innovative solar powered milk cooling solution for the higher efficiency of the dairy subsector in Tunisia"***.

This chapter focuses primarily on the development of a business model for three livestock projects in the region of Sidi Bouzid in order to compare their financial profitability and feasibility. These models were developed for different dairy farms: two of them are using the on-farm milk cooling system with two different energy sources: electricity and solar energy and the third one are a standard dairy farm. All the hypotheses that helped in developing these business models came from the studies and field surveys during the intervention of the MCSPS project in Sidi Bouzid. The other information were provided by the project partners; OEP, GIVLait and Délice. All the information required for the

development of a business model for the electrical system was collected by the INRAT from the national suppliers specifying the characteristics of the systems.

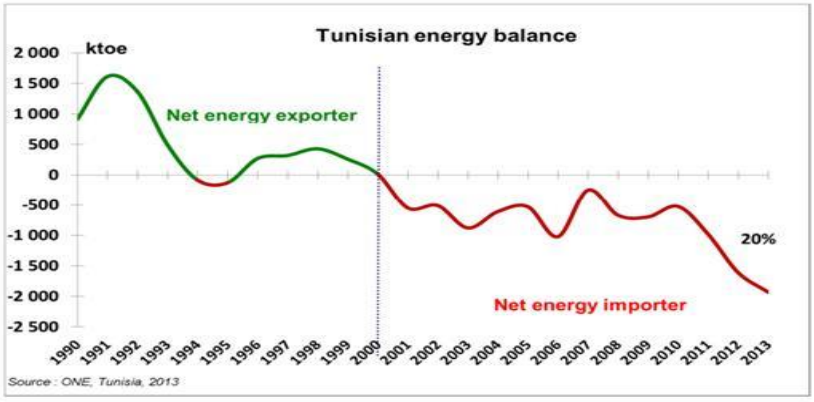
Then a financial analysis was conducted on the three models in order to determine which of the three systems is the most profitable for the farmers. Later, we compared the on-farm milk cooling systems using financial indicators mainly the NPV and the IRR in order to demonstrate which of the two energies is more profitable for this small business.

Eventually, a sensitivity analysis was conducted for the two on-farm milk cooling systems. This analysis aimed to highlight the impacts that would have any changes concerning the Milk Rejection Rates (MRR) and the Interest Rates (IR) on the project's profitability.

2. Energy status in Tunisia

During the last decade, Tunisia evolved in an extremely difficult energy context characterized by the stabilization of the resources in hydrocarbons, the increase of the energy consumption and the increase of oil price. This situation imposed to mobilize more to meet several challenges in terms of outside energetic dependence to produce electricity and reduce greenhouse gases. This policy allowed the reduction in the rate of growth of energy intensity of the country.

Originally, Tunisia was regarded as an oil and gas exporting country throughout the 70's and 80's. Since 2001, it has become an importer due mainly to an explosion in domestic consumption. Currently, its energy resources are principally made up of fossil fuels with the production of hydrocarbons (oil and natural gas).Tunisia face a significant drop in the production of these national primary energy resources which, seen in the context of a significant increase in consumption, is helping to aggravate the chronic national energy deficit estimated at 1 Mtoe in 2013. This trend is likely to be continued in 2018 creating an energy deficit of 2.4 Mtoe (Figure 1).

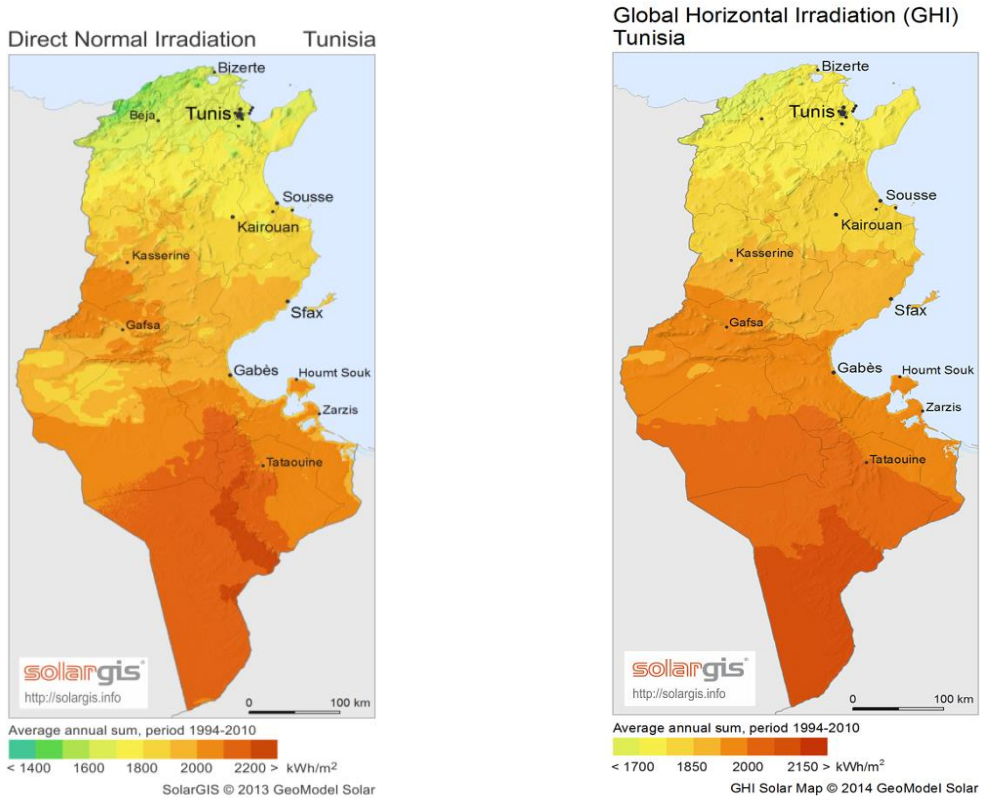


Source: Observatoire National de l'Energie (ONE), Tunisia 2013

Figure 1. Tunisian energy balance between 1990-2013 by 1000 tons of oil equivalent (ktoe).

3. Solar energy status in Tunisia

Tunisia has significant solar potential, with a mild climate throughout the winter and spring period with sunny days. The solar radiation varies from 1800 kW h/m^2/year (North) to 2800 kW h/m^2/year (South), with a low rate of rainy days (Saidi and Fnaiech, 2014).



Source:solargis.com[2]

Figure 2. Tunisia's Direct normal & Global Horizontal Irradiation

Tunisia has a high seasonal variation of solar radiation, the low rate of rainy days and the fact that cooling systems increases considerably its efficiency at low ambient temperatures, make viable the use of stand-alone systems for milk cooling throughout the year. Sidi Bouzid, the proposed site for the project implementation is placed about 200 km to the south of Tunis and about 350 m above sea level. It represents a feasible location in terms of ambient temperatures below 40°C and low variation of solar irradiance. Figure 3 presents the horizontal daily radiation and ambient temperature of Tunisia. A summary of data retrieved from a weather station in Sidi Bouzid is presented in Figure 3[3].

[2] https://solargis.com/products/maps-and-gis-data/download/tunisia

[3] Solar Powered Milk Cooling Information, ICARDA 2016.

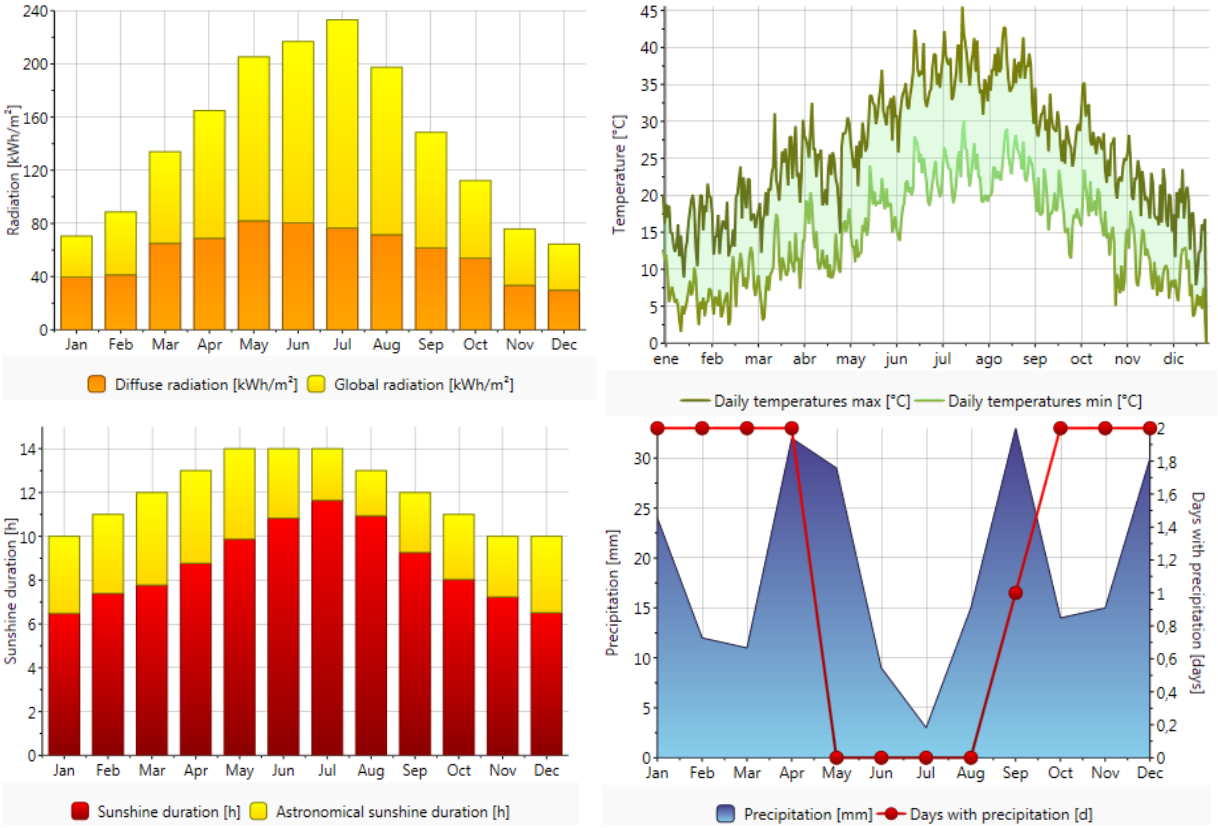


Figure 3. Sidi Bouzid weather based on *Meteonorm*[4]weather-station.

3.1. Solar Energy Governmental Programs

3.1.1. Tunisian Solar Program (PROSOL)

Tunisian Solar Program, launched in 2005, is a joint initiative of UNEP, the Tunisian National Agency for Energy Conservation, state-utility STEG and Italian Ministry for Environment, Land and Sea. The program aims to promote the development of the solar energy sector through financial and fiscal support. PROSOL includes a loan mechanism for domestic customers to purchase Solar Water Heaters and a capital cost subsidy provided by the Tunisian government of 20% of system costs. The major benefits of PROSOL are:

- More than 50,000 Tunisian families get their hot water from the sun; based on loans
- Generation of employment opportunities in the form of technology suppliers and installation companies
- Reduced dependence on imported energy carriers
- Reduction of Green House Gases (GHGs) emissions.

The Tunisian Solar Plan contains 40 projects with the objective to promote solar thermal and photovoltaic energies, wind energy as well as energy efficiency measures. The plan

[4]Meteonorm: Meteonorm Software. http://www.meteonorm.com/

also incorporates the ELMED project; a 400KV submarine cable interconnecting Tunisia and Italy.

In Tunisia, the solar PV total capacity at the end of 2014 was 15 MW composed mainly of small-scale private installations (residential as well as commercial) with a capacity ranging from 1 kW to 30 kW. As of early 2015, there were only three operational PV installations with a capacity of at least 100 kW: a 149 kWp installation in Sfax, a 211 kWp installation operated by the Tunisian potable water supply company SONEDE and a 100 kWp installation in the region of Korba both connected to the medium voltage and realized by Tunisian companies. The first large scale solar power plant of a 10MW capacity, co-financed by KfW and NIF (Neighborhood Investment Facility) and implemented by STEG, is due in 2018 in Tozeur.[5]

3.1.2. TuNur Concentrated Solar Power Project

TuNur CSP project is Tunisia's most ambitious renewable energy project. It consists of a 2,250 MW solar Concentrated Solar Power plant in Sahara desert and a 2 GW HVDC (High-Voltage Direct Current) submarine cable from Tunisia to Italy. TuNur plans to use Concentrated Solar Power to generate a potential 2.5GW of electricity on 100km^2 of desert in South West Tunisia by 2018. At present the project is at the fund-raising stage.[6]

3.2. International Cooperation Program: "Strengthening of the market for small and medium-sized PV systems"

The project "Strengthening of the market for small and medium-sized PV systems" commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ) supports the efforts of the Tunisian Government to expand the market for decentralized photovoltaic systems.[7]

The project works with its implementation partner, the National Agency for Energy Conservation (ANME) and other partners in the capital, the provinces and the municipalities to improve the general regulatory conditions and services.

The partners want to reduce bureaucratic barriers to investment in line with national and international recommendations. To this end, they intend to develop official support programs and to make the regulatory conditions more attractive to investors.

Stakeholders in the local solar energy market – including the Agency, the energy utility STEG, municipalities and governorates, company representatives, banks and consumer organizations – are cooperating in three focus regions to draw up and jointly implement action plans designed to promote investment. The lessons learned are made available to other regions and representatives of the national incentive policy.

The transparency and quality of the products and services on the market are being improved. Methods and instruments are being identified for this purpose and appropriate

[5&6]Solar Energy Prospects in Tunisia: Salman Zafar April 7, 2017. Africa, Renewable Energy, Solar Energy, Wind Energy.https://www.ecomena.org/solar-tunisia/

[7]Developing the solar energy market in Tunisia. https://www.giz.de/en/worldwide/24251.html

training measures are being planned and delivered for decision-makers, advisors and installation engineers.

3.3. Uses of solar energy in Agriculture

3.3.1. Water pumping

Photovoltaic (PV) water pumping systems may be the most cost-effective water pumping option in locations where there is no existing power line. Simple PV power systems run pumps directly when the sun is shining, so they work hardest in the hot summer months when they are needed the most. Generally, batteries are not necessary because the water is stored in tanks or pumped to fields and used in the daytime[8].

3.3.2. Space and water heating

Livestock and dairy operations often have substantial air and water heating requirements. Modern poultry farms raise animals in enclosed buildings, where it is necessary to carefully control temperature and air quality to insure good health and growth of the animals. These facilities need to replace the indoor air regularly to remove moisture, toxic gases odors, and dust. Heating this air, when necessary, requires a large amount of energy. With proper planning and design solar air/space heaters can be incorporated into farm buildings to preheat incoming fresh air. These systems can also be used to supplement natural ventilation levels during summer months depending on the region and weather. Solar water heating can provide hot water for equipment cleaning or for preheating water going into a conventional water heater.

3.3.3. Crop and grain drying

Using the sun to dry crops and grain is one of the oldest and most widely used applications of solar energy. The simplest and least expensive technique is to allow crops to dry naturally in the field or to spread grain and fruit out in the sun after harvesting. The disadvantages of these methods are that crops and grains are subject to damages by birds, rodents, wind, rain and contamination by windblown dust and dirt. More sophisticated solar dryers protect grain and fruit, reduce losses, dry faster and more uniformly and produce a better quality product than open-air methods. The basic components of a solar dryer are an enclosure or shed, screened drying trays or racks and a solar collector. In hot and arid climates, the collector may not even be necessary. The southern side of the enclosure itself can be glazed to allow sunlight to dry the material. The collector can be as simple as a glazed box with a dark colored interior to absorb the solar energy that heats air. The air heated in the solar collector moves, either by natural convection or forced by a fan, up through the material being dried. The size of the collector and rate of airflow depends on the amount of material being dried, the moisture content of the material, the

[8]Bulletin of Electrical Engineering and Informatics: Vol 2, No 3 September 2013.

humidity in the air and the average amount of solar radiation available during the drying season[9].

3.3.4. Solar energy use in dairy Industry

Due to high temperatures, especially in arid regions, the milk value chain suffers from a high rate of milk rejection at the farm level. In rural areas, small breeders are not connected to the national electricity grid. Therefore, they cannot cool milk on-farm. Accordingly, the possibility to use solar cooling systems starts to be considered as an attractive solution[10].

4. Legal and Institutional Framework

In light of this potential combined with the need to replace conventional energies, Tunisia has created a legislative framework for the implementation of a national energy and renewable energies development program.

The energy sector is managed by the Ministry of Energy, Mines and Renewable Energies. The Ministry defines the Government's energy policy and monitors the enforcement of legislation in terms of energy. The National Agency for Energy Control (ANME) is the institutional tool in charge of implementing the State's policy in terms of RE promotion and the rational use of energy. In addition, the Agency for the Promotion of Agricultural Investments supports the investment in the clean technologies in the agriculture sector such as water pumping for irrigation, water heating, cooling systems etc…

Figure3. The main institutions involved in the investment in agriculture using RE.

[9] US Department of Energy, Office Energy Efficiency Renewable Energy: Agricultural Applications of Solar Energy.
http://infohouse.p2ric.org/ref/24/23989.htm

[10&11]Application of Solar energy for sustainable Dairy Development: Deepak D Desai; J.B. Raol; Sunil Patel; Istiyak Chauhan. European Journal of Sustainable Development (2013), 2, 4, 131-140.

Tunisia has adopted a pro-active policy regarding attenuation and adaptation in order to reduce the risks connected with climate change. Therefore, Tunisia is planning to reduce the carbon emission in the energy sector down to 43% of the overall emissions in 2030. This reduction would entail the suppression of 207 million teoCO_2 from 2015 to 2030, a significant engagement for the energy sector that currently accounts for 75% of total national carbon emissions. To achieve this target, Tunisia has developed a strong strategy and policies of energy control structured around two main axes: the increase in energy efficiency and the development of renewable energy generation[11](Table 1).

Table 1 Chronological order of laws elaboration for electricity production from renewable energies.

Law text	Date	Content
Law No. 2005-82	*15/08/2005*	Setting up a system for financing the energy management system in order to "support measures designed to rationalize energy consumption, promote renewable energies and achieve energy substitution"
DecreeN°2009-362	*09/02/2009*	Introducing essential elements for promoting renewable energies, in particular for the production, transmission, and sale of electricity.
Decree N°2009-362	*09/02/2009*	Introduction investment aids for the realization of electricity production projects from renewable energy sources.
Decree N°2009-2773	*28/09/2009*	Fix conditions of power transmission, the sale of surpluses to STEG and the upper limits of these surpluses. A decision of the minister in charge of energy set the prices.
Grid code	*12/05/2011*	Technical specifications for the connection of cogeneration and renewable electricity production to the grid.
Law N°2015-12	*11/05/2015*	A new law is giving the legal framework for the development of renewable energy project.
Decree 2016	*August 2016*	Application Decree of the Law N°2015.
Government Order No. 389 of 2017	*September 2017*	The Ministry of Energy, Mines and Renewable Energies elaborate new technical documents for the investment in renewable energy.

❖ *Investment Incentives in Renewable Energies in the Agricultural Sector*

Direct aids are granted by the National Fund for Energy Conservation or FNME and the Agency for the Promotion of Agricultural Investments, they guarantee specific tax benefits for energy efficiency and renewable energies:

- ***Decree N° 2009-362:***

This type of investment is dedicated to the agricultural project not linked to the electricity network where the state provides a subsidy of 40% of the total cost of the project without exceeding the sum of 20.000 TND.

- ***Law N° 2015-12:***

The Law n. 2015-12 establishes that projects for the production of electricity from renewable sources are carried out within the framework of the needs and means determined by the national plan and can be either for self-consumption purposes, or to

[11]RES4MED: (Renewable Energy Solution For the Mediterranean), Country Profiles November 2016.

sell it, in full and exclusively, to the public body which undertakes to buy it or for export (Journal Officiel de la République Tunisienne, 2015). Farmers, companies and communities can also install PV generators on their roofs and benefit from the net metering system. The subsidies accorded to these categories of investment are presented in Table 2.

Table 2. Subsidies accorded to the investment in renewable energy.

Investment categories	Investment premium	ANME premium	Application
A (<60.000 TND)	25%	20%	CRDA
B (60.000-225.000 TND)	20%	20%	APIA-RD
C (> 225.000 TND)	7%	20%	APIA

- ***Government Order N° 389 of 2017:***

The state provide a subsidy of 50% for investment in clean technologies including milk cooling at farm scale but not exceeding the sum of 500.000 TND and 60% for the SMSA (mutual society of agricultural services) and GDA (Agricultural Development Group).

- Reduction of customs duties to the minimum rate of 10% (from a general rate of 18%) and exemption from VAT for imported equipment used for RE, for which no similar equipment is manufactured locally;
- Reduction of customs duties and exemption from VAT for imported raw materials and semi-finished products used for the production of equipment in the field of RE.

5. Business plan

"A business plan is like a map. It tells you what to expect and what alternative routes you can take to arrive at the same destination… Planning helps you work smarter rather than harder. It keeps you 'future orientated' and motivates you to achieve the results you want." – ***John English.***

The business plan is a written statement of the goals and objectives of a business. It Should:

- ✓ Cover the necessary steps to be taken to achieve both the business and the personal goals and objectives;
- ✓ Include information which justifies and explains the proposed strategy;
- ✓ Provide the information needed by others to understand the venture;
- ✓ Check the viability of the proposed business;
- ✓ Include alternative strategies;
- ✓ Combine all elements into a logical format;
- ✓ Help understand the various factors for success or failure;
- ✓ Be used continuously to monitor actual results and identify problems;

- ✓ Be regularly updated;
- ✓ Be compiled with reviews by the Business Advisor or Mentor.

In this case, the business plan provides to policy makers, farmers and financial institutions an estimation of the costs, financial and socio-economic benefits related to the introduction of the "On-farm solar powered milk cooling system". In addition, it motivates companies to disseminate the technology in other regions based on this business plan.

5.1. Methodology

The objective of this study is to analyze and compare three business plans of:

i. A standard milk production farm (*Project dairy farm*)
ii. An on-farm solar powered milk cooling system (*MCSPS Project*)
iii. An on-farm electric milk cooling system (*EMCS Project*)

In order to do this specific task we used the business model created by the INVESTA Project as a reference but we ran on it few adjustments so it could be coherent with the actual prices in Tunisian markets because of the latest changes which affected milk prices and VAT. The business plans realized were based on certain hypothesis made by the INRAT Socio-Economic team which will be quoted and explained as the model analysis progresses.

5.2. Business Plan of the Standard Dairy Farm Project:

In this section we will develop, explain and analyze the business model for a small and typical dairy farm in the Region of Sidi Bouzid based essentially on the observation and data from the conducted baseline survey during the first phase of the MCSPS project. Later this business plan will be the reference for the comparison between the two cold on-farm technologies.

5.2.1 Project description

It is a standard dairy cattle project in the region of Sidi Bouzid. We assume that this project is implemented in the community of "Zitouna". A farmer wants to start a small dairy cattle project composed from 5 heifers and using only standard technologies and equipments like the milking machine, milk cans etc. In the following sections we will present a detailed business plan of this project.

5.2.2 Investments and funding:

We assume that the farmer in "Zitouna" wishes to change his breeding speculation from small ruminants (sheep/goats) to dairy cattle considered in the collective consciousness of the region as more profitable.

First of all, the farmer has to identify the different component of his new small-scale project, starting with the most important: pregnant heifers. We will choose five of them because it best represents the categories of breeders with whom the project was launched in 2016. Then the equipments used which is generally a milking machine and two or three

milk cans. The farmer benefits from subsidies for both heifers and dairy equipment (Table3).

Table 3 Project components

Number of heifers	5
Buying price	5000
Insurance / Heifers	214
Self-financing	10%
Heifer subsidies	30%
Equipment subsidies	25%

Each component of the project has its depreciation period and value represented in table 4. The heifers are amortized for a period of five years which will be considered later as the theoretical project lifetime. The total amount of depreciation for the project components is almost 4300 TND.

Table 4 Depreciation value

Depreciation of heifers	5 years	3500
Depreciation of milk tank	10 years	649
Depreciation of milking machine	5 years	150
Total Depreciation	-	4299

To start this project, the farmer will need the following amount of money; 5,261 TND as a self financing and he must obtain a credit worth 16,550 TND. The total amount of subsidies allocated to this type of project by the government amounts to 7,750 TND. The total investment needed is 29,624 TND but the real amount needed is 21,874 TND and this means that the investor will inject 26.4% less money than the needed amount. This is very good news for a small holder with limited resources.

Table 5 Total investments

	Investment	**Self-financing**	**Subsidies**	**Credit**	**Total**
Heifers	25000	2500	7500	15000	25000
Milking machine	1000	100	250	650	1000
Insurance	1070	107		900	1070
Working capital	2554	2554			2554
Total investment	***29624***	***5261***	***7750***	***16550***	***29624***

5.2.3 The turnover

The total turnovers of the project for every year are presented in the table below. The calculation method is based on various hypotheses. The first and most important is the milk production that will increase then stabilize to reach 5,760 liters per cow and per year. The second assumes that milk prices in Tunisia will continue to increase annually. Then and based on the data from the Baseline survey (B.S.) we assumed that every cow will give birth to 0.86 calves per year with a mortality rate of 10%. Concerning the selling prices of the calves, we considered an increase rate on approximately 5% for each year because of the local currency discount rate. Finally, we assumed that the breeder will sell the manure produced by the five dairy cows and their calves for an average amount of 20 TND per ton.

Table 6 Project turnover

Hypothesis	First year	Second year	Third year	Fourth year	Fifth year
Number of cows	5	5	5	5	5
Milk production	5000	5800	6400	6400	6400
Milk rejection rate[12]	10%	10%	10%	10%	10%
Milk sold	4500	5220	5760	5760	5760
Milk selling price	0.766	0.786	0.806	0.826	0.846
0.86 calf per year	0.86	0.86	0.86	0.86	0.86
Mortality rate	10%	10%	10%	10%	10%
Calves selling price growth rate		5%	5%	5%	5%
Calves selling price	700	735	772	810	851
Manure production (in tons)	7	7	7	7	7
Manure selling price growth rate		6%	6%	6%	6%
Manure selling price	20	21.2	22.47	23.82	25.25
Milk sales	17235	20514.6	23212.8	23788.8	24364.8
Calves Sales	3010	3160.5	3318.5	3484.5	3658.7
Manure sales	700	742	786.5	833.7	883.7
TOTAL TURNOVER	20945	24417.1	27318	28107.0	28907.2

5.2.4 The Project Expenditures

In this section we calculated the different charges for each sub-activity made by the farmer based on the different hypothesis made in the previous sections. The major topics of this table are: the feed cost for both lactating and dry cows, the veterinary fees, the energy used only for the breeding activities i.e. milking the cows and illuminating the

[12]The MRR is estimated at 10% which is the maximum value observed in the region based on the field surveys.

sheds, and finally the water cost needed for drinking for the cows and cleaning the milking equipments and the cow sheds.

Table 7 Project expenditures

Hypothesis	First year	Second year	Third year	Fourth year	Fifth year
Number of working days	275	305	305	305	305
Dry cows number of days	90	60	60	60	60
Ordinary feeding cost	6.4	6.72	7.056	7.409	7.779
Dry cows feeding cost	3.15	3.308	3.473	3.647	3.829
Insurance	214	214	214	214	214
Veterinary fees	120	125	130	135	140
Milk production per cow	5000	5800	6400	6400	6400
Number of cows	5	5	5	5	5
Feed	10217.5	11240.3	11802.3	12392.4	13011.9
Depreciation heifers/equipments	3950	3950	3950	3950	3950
Financial expenses	1427	1170	959	787	645
Insurance	1000	1000	1070	1070	1145
Veterinary fees	600	625	650	675	700
Energy	600	624	650	675	700
Water	300	312	324	337	351
Miscellaneous costs	380	430	480	530	580
Operating social charges	520	520	520	520	520
Total Expenditures	18994.5	19871.3	20406.2	20936.6	21603

5.2.5 The financial results

All the financial results of the project are shown in the table below (table8). The project seems to be financially profitable. This latter will generate after its first year an annual revenue worth 8803.6 TND which will decrease to 3652.6 TND due to the first payment of the credit after a year of grace. Eventually, the annual revenue will be 6411.1 TND after five years of the project.

Table 8 Financial results of the project

	First year	Second year	Third year	Fourth year	Fifth year
Total Turnover	20945	24417.1	27318	28107	28907.2
Working capital	2554				
Total expenses	18994.5	19871.3	20406.2	20936.6	21603
Net results	4504.6	4545.8	6911.6	7170.4	7304.2
Depreciation	4299	4299	4299	4299	4299
Cash flow	8803.6	8844.8	11210.6	11469.4	11603.2
Credit refund		5192.125	5192.125	5192.125	5192.125
Net annual revenue	***8803.6***	***3652.6***	***6018.5***	***6277.2***	***6411.1***
Net monthly income	***733.6***	***304.4***	***501.5***	***523.1***	***534.3***

5.3 Business Plan of the MCSPS Project

In this section we will present the Business Model (BM) done by the INRAT Socio-Economic Team for the Tunisian version of the project implemented in Sidi Bouzid. The BM is focusing on a project of five dairy cows for small-holders since more than 85% of Tunisian breeders have less than five dairy cows.

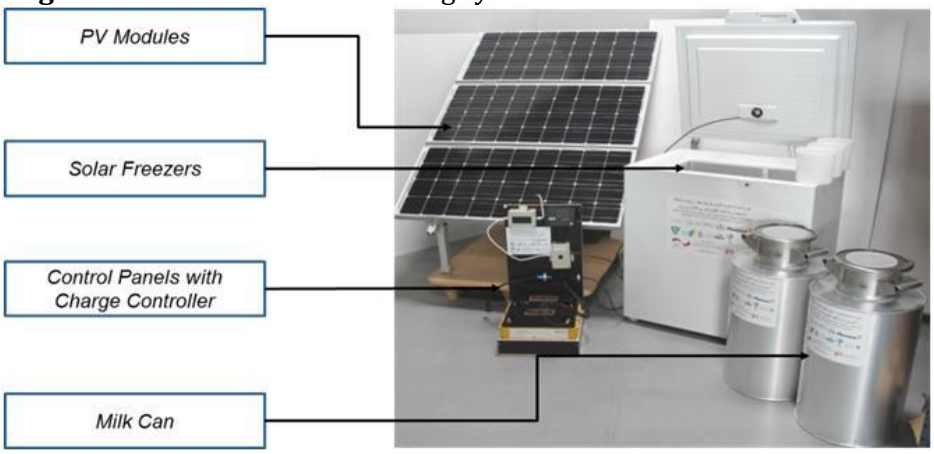
5.3.1 Description of the system: "Milk Cooling Solar Powered System Project"

The University of Hohenheim has developed a small-scale milk cooling system based on a commercially available DC Refrigerator equipped with an adaptive control unit. The developed smart ice-maker operates depending on the availability of solar energy and is capable of producing up to 20 kg ice per day. One System includes 25 ice-blocks of 2 kg capacity and two 30liters insulated milk cans with removable ice compartment. To cool down 30l of milk from 36°C to 15°C in one of the supplied milk cans, the systems needs 6kg of ice and less than 90 minutes.

The system consists of PV panels, a commercially available DC freezer equipped with a smart control unit (adaptive control unit, charge controller, data-logger and batteries) and two insulated milk cans with a 30 liters capacity each. The milk cans were designed with an integrated ice compartment which replaces the conventional lid and an external removable insulation (Figure 5). Twenty-five plastic containers of 2 liters volume each are filled with water and placed inside the freezer, which is 100 percent solar-powered, to form ice blocks. When solar energy is available, the freezer works at maximal power, while it goes into a "sleep mode" at night to conserve the ice produced. The freezer is able to store 50 kg of ice, assuring 4 days of autonomy. Thus, a single smart freezer allows the production of 12 to 16 kg of ice a day, cooling around 60 liters of milk a day all year round. The insulated milk cans that have been developed are filled with a maximum of 30 liters of milk, after which the ice compartment is placed inside the can. Up to four ice blocks fit into the compartment. The use of a removable insulation for the milk cans offers a flexible handling of the system. In the case of the morning milk, 30 liters of milk can be cooled down with 6 kg of ice (3 ice blocks) and preserved up to six hours. In the same milk-can model, 20 liters of the evening milk can be stored for up to twelve hours with the help of 8 kg of ice (4 ice blocks). Furthermore, it is possible to fill a clean insulated milk can with ice the night before and give it to the farmer to cool the morning milk. This also allows more farmers to use the insulated milk cans without owning the solar cooling system.[13]

[13]Torres, V; Salvatierra, A; Mrabet, F; Müller, J, Intersolar Europe Conference (Session: Off-Grid Productive Use).

Figure 4 Hohenheim's milk cooling system



5.3.2 Project Investment & Funding

The project is based on the dairy cattle project mentioned in the previous section with one difference; the use of an on-farm milk cooling system powered by solar PV.

The farmers will start with five heifers which will cost 5,000 TND each; each one of them is insured for 214 TND. The total investment will be 26,070 TND, an amount of money that small-holders do not have and that is why the government subsidized both the heifers and the dairy equipments. Heifers are subsidized by 30% and the equipments by 25% to 40% (Table 9).

Table 9 Project components (SPMCS project)

Components	Value
Number of heifers	5
Buying price	5000
Insurance / Heifers	214
Self-financing	10%
Heifers subsidies	30%
Equipment subsidies	25% to 40%

Table 10 Amortizations value (SPMCS project)

Depreciation	Duration	Value
Depreciation of heifers	5 years	3500
Depreciation of milk tank	10 years	649
Depreciation of milking machine	5 years	150
Total Depreciation		4299

To start the project, the breeders can benefit from numerous bank credits; the total of those credits is 19,462.5 TND according to our calculations. The total amount of subsidies

is 10,021.5 TND. Farmers have only to inject 5,837 TND to start a project worthy 35,384 TND which is a very good deal.

Table 11 Total project's investments in TND (SPMCS project)

	Investment	Self-financing	Subsidies	Credit	Total
Heifers	25000	2500	7500	15000	25000
PV Modules 600	1225	122.5	612.5	490	1225
Frame	280	28	140	112	280
Battery	756	75.6	387	293.4	756
Charger controller	707	70.7	353.5	282.8	707
Freezer	777	77.7	0	699.3	777
Control unit	606	60.6	303	242.4	606
Cables	210	21	105	84	210
2 Milk cans (60 l/day)	500	50	250	200	500
25 tins for ice blocks	38	3.8	0	34.2	38
Protection	241	24.1	120.5	96.4	241
Service	420	42	0	378	420
Milking machine	1000	100	250	650	1000
Insurance	1070	107		900	1070
Working capital	2554	2554			2554
Total investment	***35384***	***5837***	***10021.5***	***19462.5***	***35384***

5.3.3 The turnover

The turnover analysis is essentially built on various hypotheses. The project duration is five years. The milk production of each dairy cow for the first year is 5000 liters which will increase by time due to the age and to a more and more improved feeding calendar. The milk prices will be increasing by 0.02 TND per year, starting by its actual value 0.766 TND/liter to reach a hypothetical value of 0.846 TND/liter. And we assume that all the milk production will be sold to the MCC's since the milk is cooled on farm. In addition of that, we assume that the framers will benefit from a milk cooling premium of 0.01 TND given by the government to these breeders as a subsidy. This hypothesis was built on the OEP and GIVLait future strategies.

The calving interval of the cows is in average 13 to 18 months in Tunisia which will ensure to the breeders an average of 0.86 calves per year. An early weaning between 3 to 6 months will guarantee to the breeders a good market price. The hypothesis is essentially based on stable local markets with an increase of the selling prices in each year which is not the case in Tunisia and that is why we have chosen a relatively low price for the calves.

The most important by-product of a dairy cattle farm is probably manure. In fact, local breeders do not tend to sell this product; they offer it for a symbolic price because it is considered as animal waste. But in this project we consider that the farmers will have trainings for managing the dairy business in a more optimal way. Each cow has an average production of 7 tons per year; the selling price of one ton is 20 TND.

Eventually, the total turnover for the farmers will increase slowly but surely. The first year the total turnover will be estimated -based on the previous hypothesis- to 22,910 TND, reaching a value of 29,961 TND in the third year. In the fifth year the total turnover will be estimated to 31,678.4 TND.

Table 12 Turnover of the project (SPMCS project)

	First year	Second year	Third year	Fourth year	Fifth year
Number of cows	5	5	5	5	5
Milk production	5000	5800	6400	6400	6400
Milk selling price	0.766	0.786	0.806	0.826	0.846
Premium cooling milk	0.01	0.01	0.01	0.01	0.01
0.86 calf per year	0.86	0.86	0.86	0.86	0.86
Mortality rate	10%	10%	10%	10%	10%
Calves selling price growth rate		5%	5%	5%	5%
Calves selling price	700	735	772	810	851
Manure production (in tons)	7	7	7	7	7
Manure selling price growth rate		6%	6%	6%	6%
Manure selling price	20	21.2	22.47	23.82	25.25
Milk sales (with premium)	19200	22852	25856	26496	27136
Calves Sales	3010	3160.5	3318.5	3484.5	3658.7
Manure sales	700	742	786.5	833.7	883.7
Total TURNOVER	***22910***	***26754.5***	***29961***	***30814.2***	***31678.4***

5.3.4 Project Expenditures

The expenses of this project were calculated based on the previous hypotheses. Since the lactation period of a dairy cow will increase with aging making the dry period shorter, the working days will increase from 275 days initially to 305 days, which is a best case scenario.

The costs of feeding the five dairy cows were calculated according to their physiological stage: lactating and dry cows. The basic food ration is composed essentially from: hay, concentrated fodder (Soya, Maze, Lucerne), and green fodder for a lactating cow. While in the case of a dry cow, the food ration is composed from straw, hay and concentrated fodder made essentially from Maze and Barley. The daily feeding cost of a milking cow is the double of a dry one, 6.4 TND to 3.15 TND. Since all the components of the concentrated fodder are imported, we estimated that with the actual increase of the prices the feeding cost will eventually do the same.

The farmer will benefit from an insurance policy worth 214 TND per year. The veterinary costs were calculated based on the hypothesis that every cow will need at least two interventions per year; the first year the total veterinary charges are 600 TND, the third year it will reach the amount of 650 TND, then it will be 700 TND in the fifth year.

The energy costs were calculated for the milking machine only and not for the whole household consumption; this will make the model more realistic because mixing farming, breeding and housing consumption will not provide accurate data for the later comparison with the electric model of FAO. The annual energy cost for the system does not undergo a lot of change because the electricity is subsidized by the Government. The annual initial cost is estimated to 350 TND, which will reach 400 TND the third year. In the fifth year the energy cost will be 400 TND.

The drinking water is subsidized by the government but most of the rural communities do not have direct access to this resource. In fact, the most common mode of purchasing water is via cisterns and the cost of each one depends on the proximity of the household to the supply point. The annual cost of water was calculated based on the daily consumption of a dairy cow in addition of the quantity required to clean the milking equipments and the sheds. In the first year the amount would be 300 TND to reach eventually 351 TND.

The total annual charges of the project are relatively high because of the nature of the selected breeders. The first year, the total charges are estimated to 18694.5 TND. The third year of the project the charges will reach 20106.2 TND. In the fifth year the total amount of charges will be 21303TND.

Table 13 Project expenses (SPMCS project)

Hypothesis	First year	Second year	Third year	Fourth year	Fifth year
Number of working days	275	305	305	305	305
Dry cows number of days	90	60	60	60	60
Ordinary feeding cost	6.4	6.72	7.056	7.409	7.779
Dry cows feeding cost	3.15	3.308	3.473	3.647	3.829
Insurance	214	214	214	214	214
Veterinary fees	120	125	130	135	140
Milk production per cow	5000	5800	6400	6400	6400
Number of cows	5	5	5	5	5
Feed	10217.5	11240.3	11802.3	12392.4	13011.9
Depreciation heifers/equipments	3950	3950	3950	3950	3950
Financial expenses	1427	1170	959	787	645
Insurance	1000	1000	1070	1070	1145
Veterinary fees	600	625	650	675	700
Energy (Milking machine)	300	324	350	375	400
Water	300	312	324	337	351
Miscellaneous costs	380	430	480	530	580
Operating social charges	520	520	520	520	520
TOTAL Expends	***18694.5***	***19571.3***	***20106.2***	***20636.6***	***21303***

5.3.5 Financial results

Table 14 resumes all the projects outcomes; the turnover, expenses, net results and the annual revenue based on the numerous hypotheses. At a first look, the project seems profitable since it is generating a net annual revenue of 11068.6 TND in its first year with a net result of 922.4TND. At the fifth year, the project will be generating 9808.8TND of annual revenue for the farmers. The credit refund is fixed to 4866 TND per year and the amortization of the project equipments i.e. the PV system is estimated to 4299 TND.

Table 14 Project outcomes (SPMCS project)

	First year	Second year	Third year	Fourth year	Fifth year
Total Turnover	22910	26754.5	29961	30814.2	31678.4
Working capital	2554				
Total expenses	18694.5	19571.3	20106.2	20636.6	21303
Net results	6769.6	7183.2	9854.8	10177.6	10375.4
Depreciation	4299	4299	4299	4299	4299
Cash flow	11068.6	11482.2	14153.8	14476.6	14674.4
Credit refund		4866	4866	4866	4866
Net annual revenue	***11068.6***	***6616.5***	***9288.2***	***9610.9***	***9808.8***
Net monthly income	***922.4***	***551.4***	***774.0***	***800.9***	***817.4***

The BP had shown very good results at a first sight; it is feasible and profitable at the same time. In fact, the breeders won't be obliged to spend a lot of money to generate attractive profits that will push them to continue in this path.

5.4 Business Plan of the Electric Milk Cooling System

5.4.1 About the project:

This project has the exact and same components as the MCSPS project but with one difference that affects the energy component. In fact this project is using the electricity to cool the milk via a refrigerating milk tank related to the power grid.

Because of this tiny but very important difference, we will present on the next sections only the project's expenditures and the financial results.

Figure 5 Electrical milk cooling tank

5.4.2 Project expenditures

We mentioned before the difference between the MCSPS and the EMCS is the energy use as illustrated in the data of the table 15. All the other expenditures are the same for the two projects.

The annual energy cost for the system covers only the power consumption of the milk tank and the milking machine. These costs do not undergo a lot of change because the electricity is subsidized in Tunisia. The annual initial cost of the system is estimated at 600 TND, which will reach 650 TND by the third year. In the fifth year the energy cost will be 700 TND.

Table 15 Project expenditures (EMCS project)

Hypothesis	First year	Second year	Third year	Fourth year	Fifth year
Number of working days	275	305	305	305	305
Dry cows number of days	90	60	60	60	60
Ordinary feeding cost	6.4	6.72	7.056	7.409	7.779
Dry cows feeding cost	3.15	3.308	3.473	3.647	3.829
Insurance	214	214	214	214	214
Veterinary fees	120	125	130	135	140
Milk production per cow	5000	5800	6400	6400	6400
Number of cows	5	5	5	5	5
Feed	10217.5	11240.25	11802.26	12392.38	13011.99
Depreciation heifers/equipments	3950	3950	3950	3950	3950
Financial expenses	1427	1170	959	787	645
Insurance	1000	1000	1070	1070	1145
Veterinary fees	600	625	650	675	700
Energy	***600***	***624***	***650***	***675***	***700***
Water	300	312	324	337	351
Miscellaneous costs	380	430	480	530	580
Operating social charges	520	520	520	520	520
Total Expends	***18994.5***	***19871.3***	***20406.2***	***20936.6***	***21603***

5.4.3 Financial results

The financial net benefits generated by this project will be less than the solar powered system because of the electricity fees. But it is a tiny difference in the net results as shown in the next table (table 16).

Table 16 Financial results (EMCS project)

	First year	Second year	Third year	Fourth year	Fifth year
Total Turnover	22910	26754.5	29961	30814.2	31678.4
Working capital	2554				
Total expenses	18994.5	19871.3	20406.2	20936.6	21603
Net results	6469.6	6883.2	9554.8	9877.6	10075.4
Amortization	4299	4299	4299	4299	4299
Cash flow	10768.6	11182.2	13853.8	14176.6	14374.4
Credit refund		5192.125	5192.125	5192.125	5192.125
Net annual revenue	***10768.6***	***5990***	***8661.7***	***8984.4***	***9182.3***
Net monthly income	***897.4***	***499.2***	***721.8***	***748.7***	***765.2***

In the previous sections we presented the BP of three dairy farm projects with slight changes yet making a big difference for the future potential of each one. The use or not of the cold on-farm technology makes a difference in terms of milk rejection rate, the cooling premium and of course the milk quality. The energy source of the cooling system makes even more difference from a financial and social point of view but in more environmental terms. We will try to explain these main differences in the following sections.

6 Financial analysis

6.1 TRI and NPV analysis

In this section we will compare the profitability of the three projects using two financial indicators; the Internal Rate of Return (I.R.R.) and the Net Present value (N.P.V).

The Internal Rate of Return is a metric used in capital budgeting to estimate the profitability of potential investments. The Net Present Value is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. The IRR was calculated based on a discount rate of 10% for all the three BP making the comparison possible.

According to the results in the table below, the MCSPS project is the most profitable of the three with an NPV of 8497.87 TND and an IRR of 17%. The second most profitable is EMCS with an NPV equal to 3295 TND and an IRR which slightly exceeds the 10% threshold (10.4%). In the case of a conventional cattle breeding project the results are clear. The NPV is positive (2000.92) which makes the project financially worth doing it but the IRR is below the symbolic threshold of 10% meaning that pursuing this project would be an unnecessary financial risk.

Table 17 Financial indicators of the projects

Project	I.R.R	N.P.V
Standard dairy farm project	9%	2000.92
MCSPS Project	17%	8497.87
EMCS Project	10.4%	3295.31

6.2 Payback period analysis

The payback period is the length of time required to recover the cost of an investment. The payback period of a given investment or project is an important determinant of whether to undertake the project, as longer payback periods are typically not desirable for investment positions.

The following figures illustrate in a simplified way the payback period of each studied project with an interest rate set at 10%.

A quick reading of the three following figures show that the standard dairy cattle project has the highest period of payback stilted to four and half year. The solar powered on-farm milk cooling project has the shortest payback period estimated to three and half year. While in the case of electric power this period of time is four years.

These observations guide us to the same conclusions that were made in the previous sections which stipulate that the solar powered system is the most profitable one.

Figure 7 Payback Period of the standard dairy cattle project

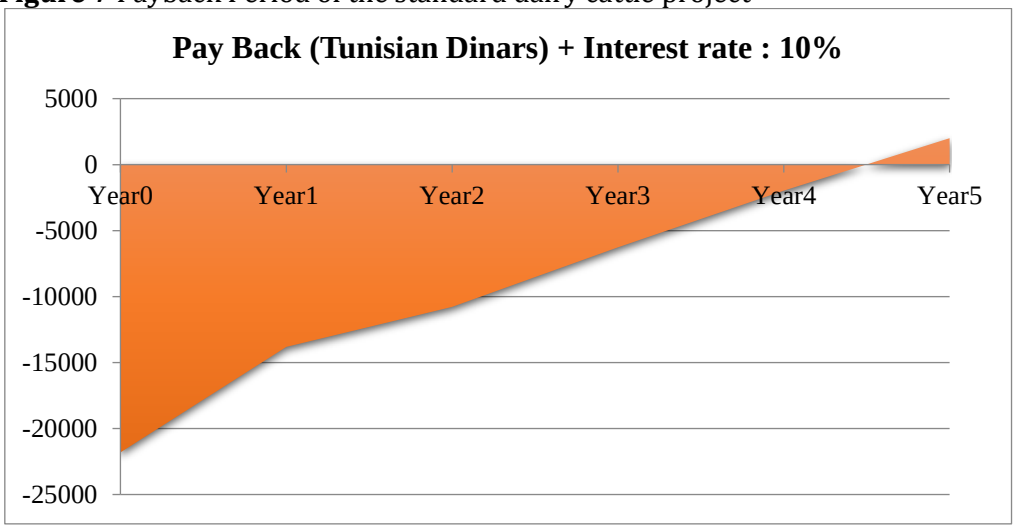


Figure 8 Payback Period of the MCSPS Project

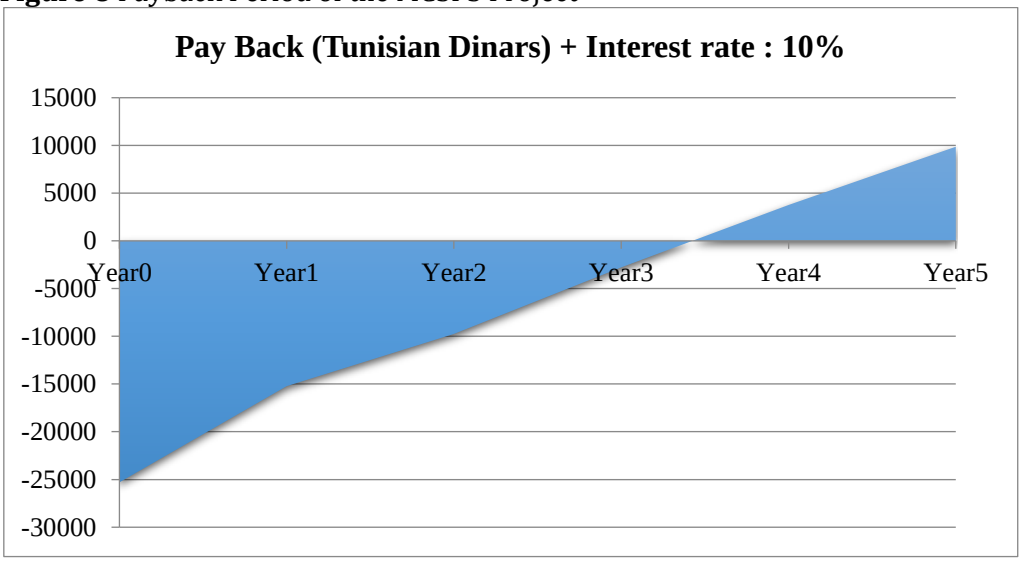
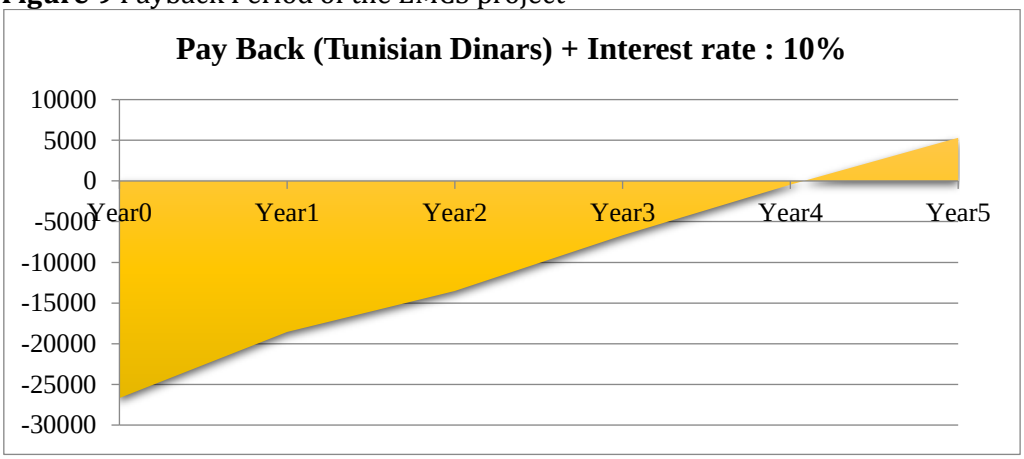


Figure 9 Payback Period of the EMCS project



6.3 Sensitivity Analysis

A sensitivity analysis is a technique used to determine how different values of an independent variable impact a particular dependent variable under a given set of assumptions.

In the followed section we will present the impact that have the milk rejection rate (MRR) and the interest rate (IR) on the NPV for the on-farm milk cooling with its two energy sources i.e. Electricity and PV system.

This sensitivity analysis is based on two major hypotheses; the first is the increase of the milk rejection due to a technical failure of the system (A big storm, an electrical blackout in the region etc.) which could not be repaired on time and therefore the milk is no longer proper for delivery. The second hypothesis is a major increase in the interest rate (in consequence of a new economic policy, the collapse of the national currency etc...). We

should precise that these hypotheses are not pure fiction, since a system failure occurred during the experimental phase of the MCSPS project. In addition of this some Tunisian association have an interest rate exceeding the 20% such as "*ENDA Tamweel*".

Figure 10 highlights the evolution of the NPV of the two projects according to the evolution of the MRR and the IR, baked up with the tables 18 and 19 which are presenting the NPV values for each potential changing. The two extreme cases were presented in those matrix i.e. the [MR 0%:IR 0%] case and the [MR 2%0:IR 20%].

Figure 10 Evolution of the NPV of the MCSPS & EMCS projects

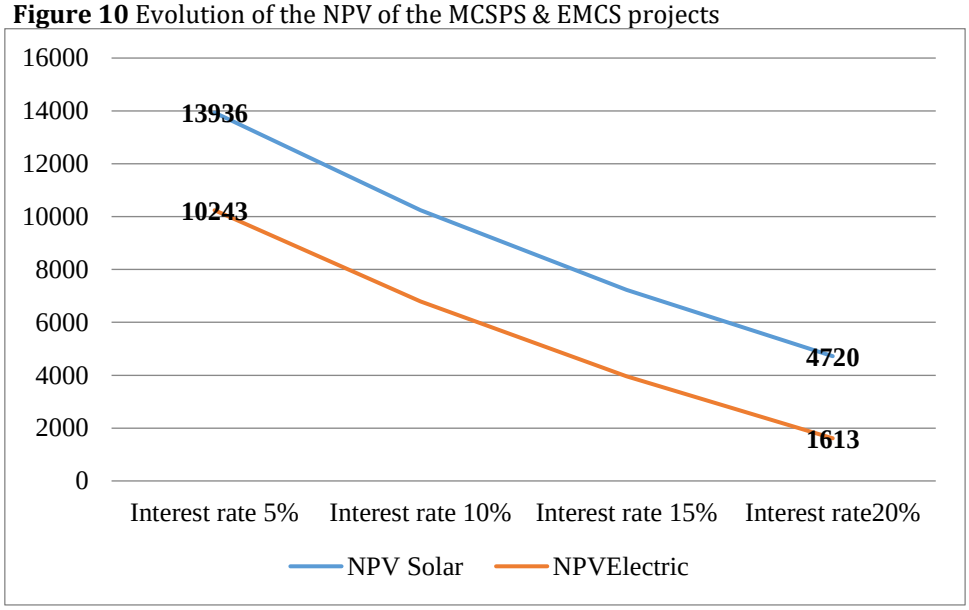


Table18 Evolution of the NPV based on Milk rejection & interest rate (MCSPS).

Milk Rejection (%) / Interest rate (%)	0	1	2	3	4	5	10	15	20
2	**16560**	16372	16183	15995	15807	15619	14678	13736	12795
5	13936	13753	13570	13387	13204	13021	12107	11193	10279
10	10243	10069	9894	9720	9545	9371	8498	7625	6752
15	7223	7056	6889	6722	6555	6388	5553	4719	3884
20	4720	4560	4400	4240	4080	3920	3120	2320	**1520**

Table 19 Evolution of the NPV based on Milk rejection & interest rate (EMCS).

Milk Rejection (%) / Interest rate (%)	0	1	2	3	4	5	10	15	20
2	**12699**	12511	12322	12134	11946	11758	10817	9875	8934
5	10243	10060	9877	9694	9511	9328	8414	7500	6586
10	6786	6612	6437	6263	6088	5913	5041	4168	3295
15	3958	3791	3624	3457	3290	3123	2288	1454	619
20	1613	1453	1293	1133	973	813	13	-787	**-1587**

6.3.1 Best case scenario:

In this case the breeder will benefit from a credit with a very low interest rate from the governmental banks in a national strategy which aims to subsidize and generalize the cold on-farm systems using any source of power. The rejection rate will be zero to a higher milk quality compared to the conventional breeding systems.

Table20 NPV and IRR Value (MR 0%, IR 2%)

Energy	NPV	IRR
Electric	12699	18.7%
Solar PV	16560	24%

6.3.2 Moderate scenario

This case is built on the field observations; in fact the Business Model was based on zero milk rejection rates and a relatively high interest rate (approximately 10%). In this case we will present the situation where the breeder will have a MRR equal to 2% and an IR of 7% adopted by the Tunisian National Bank of Agriculture (BNA). In fact the IRR of the MCSPS is higher by 5% than the one of the EMCS.

Table 21 NPV and IRR Value (MR 2%, IR 7%)

Energy	NPV	IRR
Electric	8414	15.9%
Solar PV	12007	21%

6.3.3 Worst case scenario

An extreme situation must be considered to measure the strength of our financial model. In this case we propose to study the case where the MRR and the IR reach their maximum i.e. 20% for each one. The main assumptions are a long term technical failure of the

systems; spare parts are not available for example and the farmer had to get his credit from the black market or an association with a very high IR.

The results are unexpected in the case of the solar powered system, the NPV is still positive because of its lower investment cost compared to the electrical system whose NPV is negative and equal to -1587 TND.

Table 22 NPV and IRR Value (MR 20%, IR 20%)

Energy	NPV	IRR
Electric	-1587	6.2%
Solar PV	1520	10%

7 Conclusion

This chapter aims to conduct a feasibility study and business model of an on-farm solar powered milk cooling system. For this purpose, three business models of milk production were developed: one without cooling system, one with solar powered cooling system and another with electric cooling system. The business models are adapted to the characteristics of Sidi Bouzid livestock system. The results show clearly the importance of milk cooling to reduce the milk rejection and consequently to increase monthly income. In this direction, cooling milk decreases also the veterinary fees and captures a cooling premium of 0,010 dinar per liter. Compared to basic business model without cooling system, the business models with cooling system show a higher profitability in terms of monthly income, NPV and IRR.

Compared to the electric milk cooling system, the business model of solar power shows higher profitability taking into account the same level of rejection milk and interest rate. For example, considering a non-rejection of milk following the installation of a cooling system and an interest rate of 10%, the NPV and IRR of solar powered milk cooling system were 16595 TND and 22% while they are 12609 TND and 17% for electric system.

Apart from higher profitability, the solar power technology (green technology) is more adapted than electric technology in the context of the region of Sidi Bouzid due to the frequently power outages. In addition, this problem may cause the rapid defection of the milk cooling tank. The profitability of green technology will be higher with the progressive decrease of investment costs due to the development of local manufacturers. Contrariwise, the electric technology will cost more with the increase of electric price and the cost of the imported milk cooling tank.

Otherwise, the adoption of solar powered milk cooling system need more encouragements from Tunisian government such as increasing the premium of milk cooling, guarantee the availability of this technology and mostly providing low interest credits to small farmers. Also, the development of milk cooling system depends closely on

the development of milk cooling value chain where the cooled milk will not be mixed with the uncooled. In this direction, all stakeholders must collaborate to develop a relevant strategy of milk cooling system taking into account the advantages of the green energy in rural areas.

8 Annex

Annex 1 Electrical model investment and financing

Electrical project components

Number of heifers	**5**
Buying price	5000
Insurance / Heifers	214
Self-financing	10%
Heifer subsidies	30%
Equipment subsidies	25%

Depreciation values

Depreciation of heifers	**5 years**	**3500**
Depreciation of milk tank	10 years	649
Depreciation of milking machine	5 years	150
Total Depreciation	-	4299

Electrical system investment and financial sources

Investment		Self-financing	Subsidies	Credit	Total
Heifers	25000	2500	7500	15000	25000
Refrigeration tanks	6490	649	1622,5	4218,5	6490
Milking machine	1000	100	250	650	1000
Insurance	1070	107		900	1070
Working capital	2554	2554			2554
Total investment	36114	5910	9372,5	20768,5	36114

TURNOVER

Hypothesis	First year	Second year	Third year	Fourth year	Fifth year
Number of cows	5	5	5	5	5
Milk production	4500	5220	5760	5760	5760
Milk selling rice	0,766	0,786	0,806	0,826	0,846
0.86 calf per year	0,86	0,86	0,86	0,86	0,86
Mortality rate	10%	10%	10%	10%	10%
Calves selling price growth rate		5%	5%	5%	5%
Calves selling price	700	735	772	810	851
Manure production (in tons)	7	7	7	7	7
Manure selling price growth rate		6%	6%	6%	6%
Manure selling price	20	21,2	22,47	23,82	25,25
Milk sales	17235	20514,6	23212,8	23788,8	24364,8
Calves Sales	3010	3160,5	3318,5	3484,5	3658,7
Manure sales	700	742	786,5	833,7	883,7
Total turnover	20945	24417,1	27318	28107,0	28907,2

Annex 2 Calculation of the financial indicator

IRR EMCS						
Years	0	1	2	3	4	5
Revenue	0	8949	6090	8762	9084	9282
Cost	-26678,5	-895	-609	-876	-908	-928
Sold	-26678,5	8054	5481	7886	8176	8354
	IRR	**12,63%**				

IRR MCSPS						
Years	0	1	2	3	4	5
Revenue	0	9248,6	6716,5	9388,2	9710,9	9908,8
Cost	-25299,5	-925	-672	-939	-971	-991
Sold	-25299,5	8324	6045	8449	8740	8918
	IRR	**17.39%**				

NPV EMCS			
Years	**Cash flow**		
0	-26678,5	-26678,5	-26678,5
1	8948,6	8135,045455	-18543,4545
2	6090,0	5033,079339	-13510,3752
3	8761,7	6582,792126	-6663
4	9084,4	6204,786598	-458,252901
5	9282,3	5763,562825	5305,309924
	VAN	**5040,77**	

NPV MCSPS			
Years	**Cash Flow**		
0	-25299,5	-25299,5	-25299,5
1	9248,6	8407,772727	-16891,7273
2	6716,5	5550,847934	-11340,8793
3	9388,2	7053,490849	-4287,38849
4	9710,9	6632,694527	2345,306037
5	9908,8	6152,570034	8497,876071
	VAN	**8497,876071**	

Pay Back (Tunisian Dinars) + Interest rate : 10%	
Year0	-26679
Year1	-18543
Year2	-13510
Year3	-6663
Year4	-458
Year5	5305

Pay Back (Tunisian Dinars) + Interest rate : 10%	
Year0	-25300
Year1	-16892
Year2	-11341
Year3	-4287
Year4	2345
Year5	8498

Annex 3 SPMC NPV Variations according to MRR and the IR

MRR / IR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	18515	18323	18131	17939	17747	17555	17363	17171	16979	16787	16595	16403	16211	16019	15827	15635	15443	15251	15059	14867	14675
1	17515	17325	17135	16945	16755	16565	16375	16185	15995	15804	15614	15424	15234	15044	14854	14664	14474	14284	14094	13903	13713
2	16560	16372	16183	15995	15807	15619	15430	15242	15054	14866	14678	14489	14301	14113	13925	13736	13548	13360	13172	12983	12795
3	15646	15460	15274	15087	14901	14714	14528	14341	14155	13969	13782	13596	13409	13223	13037	12850	12664	12477	12291	12105	11918
4	14772	14588	14403	14219	14034	13849	13665	13480	13295	13111	12926	12742	12557	12372	12188	12003	11819	11634	11449	11265	11080
5	13936	13753	13570	13387	13204	13021	12839	12656	12473	12290	12107	11924	11741	11559	11376	11193	11010	10827	10644	10461	10279
6	13134	12953	12772	12591	12410	12229	12047	11866	11685	11504	11323	11142	10961	10779	10598	10417	10236	10055	9874	9693	9512
7	12366	12187	12007	11828	11648	11469	11289	11110	10930	10751	10572	10392	10213	10033	9854	9674	9495	9315	9136	8957	8777
8	11629	11451	11274	11096	10918	10740	10563	10385	10207	10029	9851	9674	9496	9318	9140	8963	8785	8607	8429	8251	8074
9	10922	10746	10570	10394	10218	10041	9865	9689	9513	9337	9161	8985	8808	8632	8456	8280	8104	7928	7752	7575	7399
10	10243	10069	9894	9720	9545	9371	9196	9022	8847	8672	8498	8323	8149	7974	7800	7625	7451	7276	7102	6927	6752
11	9591	9418	9245	9072	8899	8726	8553	8380	8207	8034	7861	7688	7516	7343	7170	6997	6824	6651	6478	6305	6132
12	8964	8793	8621	8450	8279	8107	7936	7764	7593	7421	7250	7079	6907	6736	6564	6393	6221	6050	5879	5707	5536
13	8361	8192	8022	7852	7682	7512	7342	7172	7002	6832	6662	6492	6323	6153	5983	5813	5643	5473	5303	5133	4963
14	7781	7613	7445	7276	7108	6939	6771	6602	6434	6266	6097	5929	5760	5592	5423	5255	5087	4918	4750	4581	4413
15	7223	7056	6889	6722	6555	6388	6221	6054	5887	5720	5553	5386	5219	5053	4886	4719	4552	4385	4218	4051	3884
16	6685	6520	6354	6188	6023	5857	5692	5526	5361	5195	5030	4864	4699	4533	4368	4202	4037	3871	3706	3540	3375
17	6167	6003	5838	5674	5510	5346	5182	5018	4854	4690	4526	4362	4197	4033	3869	3705	3541	3377	3213	3049	2885
18	5667	5504	5342	5179	5016	4853	4691	4528	4365	4203	4040	3877	3714	3552	3389	3226	3064	2901	2738	2575	2413
19	5185	5024	4862	4701	4539	4378	4217	4055	3894	3733	3571	3410	3249	3087	2926	2765	2603	2442	2281	2119	1958
20	4720	4560	4400	4240	4080	3920	3760	3600	3440	3280	3120	2960	2800	2640	2480	2320	2160	2000	1840	1680	1520

Annex 4 SPMC NPV Variations according to MRR and the IR

MRR / IR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	14529	14337	14145	13953	13761	13569	13377	13185	12993	12801	12609	12417	12225	12033	11841	11649	11457	11265	11073	10881	10689
1	13593	13403	13213	13023	12833	12643	12452	12262	12072	11882	11692	11502	11312	11122	10932	10742	10551	10361	10171	9981	9791
2	12699	12511	12322	12134	11946	11758	11569	11381	11193	11005	10817	10628	10440	10252	10064	9875	9687	9499	9311	9122	8934
3	11844	11657	11471	11285	11098	10912	10725	10539	10353	10166	9980	9793	9607	9421	9234	9048	8861	8675	8489	8302	8116
4	11026	10841	10657	10472	10287	10103	9918	9734	9549	9364	9180	8995	8810	8626	8441	8257	8072	7887	7703	7518	7334
5	10243	10060	9877	9694	9511	9328	9146	8963	8780	8597	8414	8231	8048	7866	7683	7500	7317	7134	6951	6768	6586
6	9492	9311	9130	8949	8768	8587	8406	8225	8043	7862	7681	7500	7319	7138	6957	6776	6594	6413	6232	6051	5870
7	8773	8594	8414	8235	8056	7876	7697	7517	7338	7158	6979	6800	6620	6441	6261	6082	5902	5723	5543	5364	5185
8	8084	7906	7728	7550	7373	7195	7017	6839	6661	6484	6306	6128	5950	5773	5595	5417	5239	5061	4884	4706	4528
9	7422	7246	7069	6893	6717	6541	6365	6189	6013	5836	5660	5484	5308	5132	4956	4780	4603	4427	4251	4075	3899
10	6786	6612	6437	6263	6088	5913	5739	5564	5390	5215	5041	4866	4692	4517	4343	4168	3993	3819	3644	3470	3295
11	6176	6003	5830	5657	5484	5311	5138	4965	4792	4619	4446	4273	4100	3927	3754	3581	3408	3235	3062	2889	2716
12	5589	5417	5246	5074	4903	4732	4560	4389	4217	4046	3874	3703	3532	3360	3189	3017	2846	2674	2503	2332	2160
13	5024	4854	4684	4514	4345	4175	4005	3835	3665	3495	3325	3155	2985	2815	2645	2476	2306	2136	1966	1796	1626
14	4481	4313	4144	3976	3807	3639	3470	3302	3134	2965	2797	2628	2460	2292	2123	1955	1786	1618	1449	1281	1113
15	3958	3791	3624	3457	3290	3123	2956	2789	2622	2455	2288	2122	1955	1788	1621	1454	1287	1120	953	786	619
16	3454	3289	3123	2958	2792	2627	2461	2296	2130	1965	1799	1634	1468	1303	1137	972	806	640	475	309	144
17	2969	2805	2641	2476	2312	2148	1984	1820	1656	1492	1328	1164	1000	835	671	507	343	179	15	-149	-313
18	2501	2338	2175	2013	1850	1687	1524	1362	1199	1036	874	711	548	385	223	60	-103	-265	-428	-591	-754
19	2049	1888	1726	1565	1404	1242	1081	920	758	597	436	274	113	-48	-210	-371	-532	-694	-855	-1016	-1178
20	1613	1453	1293	1133	973	813	653	493	333	173	13	-147	-307	-467	-627	-787	-947	-1107	-1267	-1427	-1587

Annex 5 SPMC IRR Variations according to MRR and the IR

MRR / IR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	24,9%	24,6%	24,3%	24,0%	23,7%	23,5%	23,2%	22,9%	22,6%	22,3%	22,0%	21,7%	21,5%	21,2%	20,9%	20,6%	20,4%	20,1%	19,8%	19,5%	19,3%
1	24,4%	24,1%	23,9%	23,6%	23,3%	23,0%	22,7%	22,4%	22,1%	21,8%	21,6%	21,3%	21,0%	20,7%	20,5%	20,2%	19,9%	19,7%	19,4%	19,1%	18,9%
2	23,9%	23,7%	23,4%	23,1%	22,8%	22,5%	22,2%	21,9%	21,7%	21,4%	21,1%	20,8%	20,6%	20,3%	20,0%	19,8%	19,5%	19,2%	19,0%	18,7%	18,4%
3	23,4%	23,2%	22,9%	22,6%	22,3%	22,0%	21,8%	21,5%	21,2%	20,9%	20,7%	20,4%	20,1%	19,8%	19,6%	19,3%	19,1%	18,8%	18,5%	18,3%	18,0%
4	23,0%	22,7%	22,4%	22,1%	21,8%	21,6%	21,3%	21,0%	20,7%	20,5%	20,2%	19,9%	19,7%	19,4%	19,1%	18,9%	18,6%	18,4%	18,1%	17,8%	17,6%
5	22,5%	22,2%	21,9%	21,6%	21,3%	21,1%	20,8%	20,5%	20,3%	20,0%	19,7%	19,5%	19,2%	18,9%	18,7%	18,4%	18,2%	17,9%	17,7%	17,4%	17,2%
6	22,0%	21,7%	21,4%	21,1%	20,9%	20,6%	20,3%	20,1%	19,8%	19,5%	19,3%	19,0%	18,7%	18,5%	18,2%	18,0%	17,7%	17,5%	17,2%	17,0%	16,7%
7	21,4%	21,2%	20,9%	20,6%	20,4%	20,1%	19,8%	19,6%	19,3%	19,1%	18,8%	18,5%	18,3%	18,0%	17,8%	17,5%	17,3%	17,0%	16,8%	16,5%	16,3%
8	20,9%	20,7%	20,4%	20,1%	19,9%	19,6%	19,4%	19,1%	18,8%	18,6%	18,3%	18,1%	17,8%	17,6%	17,3%	17,1%	16,8%	16,6%	16,3%	16,1%	15,9%
9	20,4%	20,2%	19,9%	19,7%	19,4%	19,1%	18,9%	18,6%	18,4%	18,1%	17,9%	17,6%	17,4%	17,1%	16,9%	16,6%	16,4%	16,1%	15,9%	15,7%	15,4%
10	19,9%	19,7%	19,4%	19,2%	18,9%	18,6%	18,4%	18,1%	17,9%	17,6%	17,4%	17,1%	16,9%	16,7%	16,4%	16,2%	15,9%	15,7%	15,5%	15,2%	15,0%
11	19,4%	19,2%	18,9%	18,7%	18,4%	18,2%	17,9%	17,7%	17,4%	17,2%	16,9%	16,7%	16,4%	16,2%	16,0%	15,7%	15,5%	15,2%	15,0%	14,8%	14,5%
12	18,9%	18,7%	18,4%	18,2%	17,9%	17,7%	17,4%	17,2%	16,9%	16,7%	16,4%	16,2%	16,0%	15,7%	15,5%	15,3%	15,0%	14,8%	14,6%	14,3%	14,1%
13	18,4%	18,2%	17,9%	17,7%	17,4%	17,2%	16,9%	16,7%	16,4%	16,2%	16,0%	15,7%	15,5%	15,3%	15,0%	14,8%	14,6%	14,3%	14,1%	13,9%	13,7%
14	17,9%	17,6%	17,4%	17,2%	16,9%	16,7%	16,4%	16,2%	16,0%	15,7%	15,5%	15,3%	15,0%	14,8%	14,6%	14,3%	14,1%	13,9%	13,7%	13,4%	13,2%
15	17,4%	17,1%	16,9%	16,6%	16,4%	16,2%	15,9%	15,7%	15,5%	15,2%	15,0%	14,8%	14,6%	14,3%	14,1%	13,9%	13,7%	13,4%	13,2%	13,0%	12,8%
16	16,9%	16,6%	16,4%	16,1%	15,9%	15,7%	15,4%	15,2%	15,0%	14,8%	14,5%	14,3%	14,1%	13,9%	13,6%	13,4%	13,2%	13,0%	12,8%	12,5%	12,3%
17	16,3%	16,1%	15,9%	15,6%	15,4%	15,2%	14,9%	14,7%	14,5%	14,3%	14,0%	13,8%	13,6%	13,4%	13,2%	12,9%	12,7%	12,5%	12,3%	12,1%	11,9%
18	15,8%	15,6%	15,3%	15,1%	14,9%	14,7%	14,4%	14,2%	14,0%	13,8%	13,6%	13,3%	13,1%	12,9%	12,7%	12,5%	12,3%	12,0%	11,8%	11,6%	11,4%
19	15,3%	15,1%	14,8%	14,6%	14,4%	14,2%	13,9%	13,7%	13,5%	13,3%	13,1%	12,8%	12,6%	12,4%	12,2%	12,0%	11,8%	11,6%	11,4%	11,2%	11,0%
20	14,8%	14,5%	14,3%	14,1%	13,9%	13,7%	13,4%	13,2%	13,0%	12,8%	12,6%	12,4%	12,1%	11,9%	11,7%	11,5%	11,3%	11,1%	10,9%	10,7%	10,5%

Annex 6 EMCSIRR Variations according to MRR and the IR

MRR / IR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	19,6%	19,4%	19,1%	18,8%	18,5%	18,3%	18,0%	17,7%	17,5%	17,2%	17,0%	16,7%	16,4%	16,2%	15,9%	15,7%	15,4%	15,2%	14,9%	14,7%	14,4%
1	19,2%	18,9%	18,6%	18,4%	18,1%	17,8%	17,6%	17,3%	17,0%	16,8%	16,5%	16,3%	16,0%	15,8%	15,5%	15,3%	15,0%	14,8%	14,5%	14,3%	14,0%
2	18,7%	18,4%	18,2%	17,9%	17,7%	17,4%	17,1%	16,9%	16,6%	16,4%	16,1%	15,8%	15,6%	15,3%	15,1%	14,8%	14,6%	14,4%	14,1%	13,9%	13,6%
3	18,3%	18,0%	17,7%	17,5%	17,2%	16,9%	16,7%	16,4%	16,2%	15,9%	15,7%	15,4%	15,2%	14,9%	14,7%	14,4%	14,2%	14,0%	13,7%	13,5%	13,2%
4	17,8%	17,5%	17,3%	17,0%	16,8%	16,5%	16,2%	16,0%	15,7%	15,5%	15,2%	15,0%	14,8%	14,5%	14,3%	14,0%	13,8%	13,5%	13,3%	13,1%	12,8%
5	17,3%	17,1%	16,8%	16,6%	16,3%	16,1%	15,8%	15,6%	15,3%	15,1%	14,8%	14,6%	14,3%	14,1%	13,8%	13,6%	13,4%	13,1%	12,9%	12,7%	12,4%
6	16,9%	16,6%	16,4%	16,1%	15,9%	15,6%	15,4%	15,1%	14,9%	14,6%	14,4%	14,1%	13,9%	13,7%	13,4%	13,2%	13,0%	12,7%	12,5%	12,3%	12,0%
7	16,4%	16,1%	15,9%	15,6%	15,4%	15,2%	14,9%	14,7%	14,4%	14,2%	13,9%	13,7%	13,5%	13,2%	13,0%	12,8%	12,5%	12,3%	12,1%	11,9%	11,6%
8	15,9%	15,7%	15,4%	15,2%	14,9%	14,7%	14,5%	14,2%	14,0%	13,7%	13,5%	13,3%	13,0%	12,8%	12,6%	12,4%	12,1%	11,9%	11,7%	11,4%	11,2%
9	15,4%	15,2%	15,0%	14,7%	14,5%	14,2%	14,0%	13,8%	13,5%	13,3%	13,1%	12,8%	12,6%	12,4%	12,2%	11,9%	11,7%	11,5%	11,3%	11,0%	10,8%
10	15,0%	14,7%	14,5%	14,3%	14,0%	13,8%	13,6%	13,3%	13,1%	12,9%	12,6%	12,4%	12,2%	12,0%	11,7%	11,5%	11,3%	11,1%	10,8%	10,6%	10,4%
11	14,5%	14,3%	14,0%	13,8%	13,6%	13,3%	13,1%	12,9%	12,6%	12,4%	12,2%	12,0%	11,7%	11,5%	11,3%	11,1%	10,9%	10,6%	10,4%	10,2%	10,0%
12	14,0%	13,8%	13,6%	13,3%	13,1%	12,9%	12,6%	12,4%	12,2%	12,0%	11,7%	11,5%	11,3%	11,1%	10,9%	10,7%	10,4%	10,2%	10,0%	9,8%	9,6%
13	13,5%	13,3%	13,1%	12,9%	12,6%	12,4%	12,2%	12,0%	11,7%	11,5%	11,3%	11,1%	10,9%	10,6%	10,4%	10,2%	10,0%	9,8%	9,6%	9,4%	9,2%
14	13,1%	12,8%	12,6%	12,4%	12,2%	11,9%	11,7%	11,5%	11,3%	11,1%	10,9%	10,6%	10,4%	10,2%	10,0%	9,8%	9,6%	9,4%	9,2%	9,0%	8,8%
15	12,6%	12,4%	12,1%	11,9%	11,7%	11,5%	11,3%	11,0%	10,8%	10,6%	10,4%	10,2%	10,0%	9,8%	9,6%	9,4%	9,1%	8,9%	8,7%	8,5%	8,3%
16	12,1%	11,9%	11,7%	11,4%	11,2%	11,0%	10,8%	10,6%	10,4%	10,2%	10,0%	9,7%	9,5%	9,3%	9,1%	8,9%	8,7%	8,5%	8,3%	8,1%	7,9%
17	11,6%	11,4%	11,2%	11,0%	10,8%	10,5%	10,3%	10,1%	9,9%	9,7%	9,5%	9,3%	9,1%	8,9%	8,7%	8,5%	8,3%	8,1%	7,9%	7,7%	7,5%
18	11,1%	10,9%	10,7%	10,5%	10,3%	10,1%	9,9%	9,7%	9,4%	9,2%	9,0%	8,8%	8,6%	8,4%	8,2%	8,0%	7,8%	7,6%	7,4%	7,3%	7,1%
19	10,6%	10,4%	10,2%	10,0%	9,8%	9,6%	9,4%	9,2%	9,0%	8,8%	8,6%	8,4%	8,2%	8,0%	7,8%	7,6%	7,4%	7,2%	7,0%	6,8%	6,6%
20	10,1%	9,9%	9,7%	9,5%	9,3%	9,1%	8,9%	8,7%	8,5%	8,3%	8,1%	7,9%	7,7%	7,5%	7,3%	7,1%	7,0%	6,8%	6,6%	6,4%	6,2%

Annex 7 Example of bill of milk tank (Aurasol)

AURASOL L'énergie solaire photovoltaïque	Offre Financière	Code : DAS-COM-37 Date : 26/10/2016 Version : 01

Date: 19/07/17

OfferN°: AUR - IO - O1609092

Objet:

Système Photovoltaique pour le refoidissement du lait à la ferme (Avec Un contrôleur de batteries)

Client:

INRAT

N°:	Description	Qty	Unt	P.U.H.T	VAT (%)	TOTAL H.T
1	Module PV :AURASOL Auraminate 60f-250Wc	2	Pcs	612,500	6%	1 225,000
2	Régulateur de charge : Victron Energy Blue Solar MPPT 100/30	1	Pcs	707,000	18%	707,000
3	Batterie ASSAD Gel 70 AH/12V	2	Pcs	378,000	6%	756,000
4	Système Monotoring (Batterie Monitor BMV 700)	1	Pcs	606,200	18%	606,200
5	fixation et structure de pose	1	Ens	280,000	18%	280,000
6	Câblage (DC et mise à la terre) et Chemin de câble et divers access	1	Ens	210,000	18%	210,000
7	Coffret de protection (DC) pré-câblé	1	Pcs	240,800	18%	240,800
8	Installation et mise en service	1	Pcs	420,000	18%	420,000
					TOTAL H.T	**4 445,000 TND**
					FODEC(1%)	**12,250 TND**
					TVA	**563,115 TND**
					TOTAL TTC	**5 020,365 TND**
					Droit de Timbre	**0,500 TND**
					Net à payer	**5 020,865 TND**

Commentaire

Travaux Génie civil non inclus dans l'offre

Les prix sont des prix export : TVA (0%)

Modalité de payement

A covenir avec le client

AURASOL:

Le Responsable Commercial

AURASOL SA
Pôle Technologique de la Mancuba 2010
MF : 1194781X/A/M/000
RC : B2464392011

Annex 8 Example of bill of milk tank (Stel)

الشركة التونسية لتجهيزات الحليب
STE TUNISIENNE D'EUIPEMENT LAITIERS

FACTURE PROFORMA N°0015/2018

DATE 05/01/2018

CLIENT: DHRAIEF MED ZIED
NGP: 8418 6900400

Désignations	Quantité	P. U.H.T	P.T.H.T
Tank de refroidissement de lait de marque **FIC** origine Italie avec groupe frigorifique monophasé capacité 100 litres.	01	5 000.000	5 000.000
TOTAL **TVA 19 %** **P.T.T.C**			**5 000.000** **950.000** **5 950.000**

Arrêtée la présente Offre de prix à la somme Cinq mille neuf Cent cinquante dinars.

- **1 an de garantie pièces et main d'œuvre.**
- **Matériel disponible en stock**
- **Offre valable 1 mois**

SOCIÉTÉ TUNISIENNE D'EQUIPEMENTS LAITIERS
S.T. E. L
RUE AHMED SEKILLI 3000 SFAX –TUNISIE
Tél : 00216 74 407 201 Fax : 00216 74 416 436

MF:1377609/A/B/M/000 RC:808238222014
Rue Ahmed Sekilli en face hôtel les Arcades 3000 Sfax - Tunisie
Tél.:+216 74407 201- Fax:+216 74416436
E-Mail:contact@stel.com.tn
www.stel.com.tn

References

Saidi, L., & Fnaiech, F., 2014. Experiences in renewable energy and energy efficiency in Tunisia: case study of a developing country. Renewable and Sustainable Energy Reviews. 32, 729-738.

Journal Officiel de la République Tunisienne. 2015. Loi n° 2015-12 du 11 mai 2015, relative à la production d'électricité à partir des énergies renouvelables. 12 mai 2015. N. 38 page. 926

ICARDA, INRAT & GIZ. 2016. Socio-economic Team: Dhraief MZ, Souissi A, Jebali O. Analysis report of the baseline survey for the project "Field testing of an innovative solar powered milk cooling solution for the higher efficiency of the dairy subsector in Tunisia".

FAO USAID, 2016Investing in Energy Sustainable Technologies in the Agrifood Sector (INVESTA): http://www.fao.org/energy/agrifood-chains/energy-sustainable-technologies/en/

Torres, V; Salvatierra, A; Mrabet, F; Müller, J, 2017. Dairy value chains supported by Solar! Field experience in implementing a small-scale PV milk cooling system in Tunisia and Kenya:https://www.uni-hohenheim.de/organisation/publikation/dairy-value-chains-supported-by-solar-field-experience-in-implementing-a-small-scale-pv-milk-cooling-system-in-tunisia-and-kenya

GIZ, 2017Strengthening of the market for small and medium-sized PV systems: https://www.giz.de/en/worldwide/24251.html

Energypediahttps://energypedia.info/wiki/Solar_Milk_Cooling_with_Insulated_Milk_Cans.
https://energypedia.info/wiki/Analysis_of_the_Regulatory_Framework_for_Renewable_Energy_in_Tunisia

https://energypedia.info/wiki/Promotion_of_Renewable_Energies_and_Energy_Efficiency_in_Tunisia

https://energypedia.info/wiki/International_Conference_on_Renewable_Energy_Development_%26_Applications_for_a_Sustainable_Agriculture_(RE_%26_Agri)

https://energypedia.info/wiki/Developing_the_Solar_Energy_Market_in_Tunisia
Salman ZAFAR, 2017. Solar Energy Prospects in Tunisia: https://www.ecomena.org/solar-tunisia/

M. HARRABI, 2012Renewable Energy Development in Tunisia: http://slideplayer.com/slide/1547373/

GIZ, 2014Analysis of the regulatory framework Governing network access for producers

of electricity from renewable energy sources in Tunisia

FAO, 2017: Flammini A., Bracco S., Sims R., Cooke J., Gomez San Juan M. Costs and benefits of clean energy technologies in the milk, vegetable and rice value-chains.