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CABO VERDE

MARKET REPORT ON SOLAR THERMAL WATER HEATING AND DRYING OF AGRICULTURAL PRODUCTS

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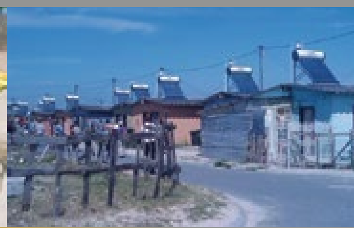

SOLtrain West Africa

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Cabo Verde Market Report on Solar Thermal Water Heating and Drying of Agricultural Products

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1 General Energy Background

Cape Verde is a small island state of ten islands and some islets with a land area of 4,033 km^2 located off the west coast of Africa and between the parallels 17^0 12′ 5″ and 14^0 48′ of latitude north and the meridians of 22^0 44′ and 25^0 22′ West of Greenwich. Cape Verde gained independence 40 years ago from Portuguese rule and since then it embarked on a development path with huge implications in energy demand. The islands of Cape Verde have excellent renewable energy potentials. The average solar radiation is estimated to be 5.71 kWh/m^2/day and average wind speed topples 7 m/s in innumerous sites around the archipelago, however, the country is plagued with scarce water resource due to little and erratic rain fall for many years now, thus, desalination stands out as the viable and handy alternative for the water supply to the population.

Figure 1: Map of Cape Verde

Today, the resident population tops 520.000 inhabitants (cf. census 2010 www.ine.cv – National Institute of Statistics) unevenly distributed among 9 inhabited islands posing a great challenge in pattern of energy consumption particularly with regard to the distribution system, be it oil and gas or electricity. It is worth pointing out that Cape Verde imports almost all its energy needs and it is burden in the country's balance of payment. Biomass, solar and wind forms of energy are harnessed locally.

The greatest challenge the country faces today and in the near future is the efficient and rational use of energy. This is mainly because of uncertainty of supply and demand in the international market. For example, in 2013, Cape Verde oil and gas imports exceeded 13% of the GDP corresponding to 20% of all imports (cf. DGE 2013).

According to INE, the GDP of Cape Verde at current price in 2013 was estimated to be 1,440.5 billion Euros providing an income per capita of 2,812.50 €. Recent macro-economic data indicates that the economy is growing very slowly, probably less than the demographic growth rate.

Final energy consumption has been slowing since 2010 but electricity per capita consumption has experienced modest increase. In 2013 the per capita consumption of electricity was 599.3 kWh/capita/year. The nationwide electrification rate stands today at 98%.

Data from 2010 to 2013 shows that total final consumption of energy has decreased slightly. See table 1:

Year	Total Final Consumption of Energy (GWh)
2010	1,688.2
2011	1,820.3
2012	1,750.2
2013	1,714.0

Table 1: Final consumption of energy from 2010 to 2013 (available data)
Source: National Plan of Action for Energy Efficiency, 2014

2 Share of Renewables

The table 2 shows the production of electricity in GWh from 2008 to 2014 and the respective share of renewable sources, such as solar and wind. It stands out that in 2014, 383 GWh_e of electricity were generated from 15 thermal power station, 5 wind farms and 2 PV parks. The contribution of renewable source in the generation of electricity was 21.1% or 81 GWh_e. However, it must be said, that the goal to be 100% renewable in the generation of electricity by 2020. This is an ambitious projection.

Year	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Total (T+S+W)	285	295	318	325	330	373	383*
Solar (% of Total)	0	0	2.1 (0.7)	8.96 (2.8)	7.5 (2.3)	7.5(2.0)	6.7(1.7)
Wind (% of Total)	5.5(1.9)	4.7(1.6)	2.0(0.6)	15.6(4.8)	61.4(18.6)	73.8(19.8)	74.3(19.4)
Total RE (S+W)	5.5(1.9)	4.7(1.6)	4.1(1.3)	24.56(7.6)	68.9(20.9)	81.3(21.8)	81.0(21.1)

Table 2: Nationwide electricity generated and contribution from renewable source (solar and PV)

Source: www.electra.cv and ARE. *) Production from APP Power Station (based in Sal) was estimated, but the error is less than 1%.

Several off the grid and grid connected photovoltaic systems used in small hotels, private homes and remote communities have been installed in last 5 years and their contribution was not taken into account.

Electricity is generated from thermal source in Diesel-Generator sets burning gasoil, IFO and HFO distributed in 15 power stations of different capacities, from 5 wind farms providing 26 MW_e of installed power and two solar PV parks providing 6.6 MW_e of installed power.

From the mix of electricity generation, every MWh_e of electricity produced gives off an emission 0.697 ton of CO_2. Cf. at UNFCCC CDM website for Cape Verde.

Along with energy, water stands in the forefront of the problems the country must find sustainable solutions. Since most of water consumption comes from desalination, energy plays an important role in that respect. Water generation from small to medium units requires approximately 4kWh/m^3. Electricity for water generation is regulated by the Economic Regulation Agency and is depicted in the electricity schedule shown below.

Butane gas consumption in domestic sector (units of 3, 6 and 12.5 kg –see table below) has experienced a decline in 9%, 6% and 0.6%, respectively, from 2011 to 2014. The decline is mainly explained by the cost hike that took place during same period. This has implications in the consumption of fire wood and biomass causing deforestation because of excessive cutting of trees.

Table 3 presents information on energy consumption by sector and category expressed in GWh for the year 2013.

2013	Butane (GWh)	Kerosene (GWh)	Gasoline (GWh)	Gasoil (GWh)	JET A1 (GWh)	Electricity (GWh)	Fire-wood (GWh)	Char-coal (GWh	Total Sectors (GWh)
Road Transport	0	0	84.1	578.5	0	0	0	0	662.6
Maritime Transport	0	0	0	62.3	0	0	0	0	62.3
Aviation	0	0	0	0	208.6	0	0	0	208.3
Water Production	0	0	0	0	0	19.1	0	0	19.1
Economic Activities	54.4	0	0	0	0	142.7	11.8	6.4	215.3
Residential	79.8	5.7	0	0	0	101.5	358.1	0.9	546.0
TOTAL	134.2	5.7	84.1	640.8	208.6	263.3	369.9	7.3	1,714.0

Table 3: Energy consumption by sector and category for year 2013 in Cape Verde; Source NPAEE, 2014.

Energy prices are regulated by the Economic Regulation Agency (cf. www.are.cv). ARE set up to be an independent public entity that reviews prices of energy according to pre-defined set of criteria. The sectors regulated comprise electricity, oil and gas, road transport and water.
Present electricity tariffs came into effect since April 1st 2015. Table below shows tariffs for different consumers. A VAT at a rate of 15.5% applies to all categories.

	PREVIOUS TARIFF		TARIFF IN EFFECT since April 1st, 2015			
ELECTRICITY VARIABLE TARIFF	Tariff w/o VAT ($) ECV c€	Tariff with VAT ($) ECV c€	New tariff w/o VAT ($) ECV c€	Var. (%)	VAT ($) ECV c€	New tariff w VAT ECV c€
Domestic Low Voltage						
1st Step up to 60 kWh/month	30.03 27.23	34.53 31.32	26.09 23.66	-13.13	3.91 0.04	30.00 27.20
2nd Step greater than 60 kWh/month	36.89 33.46	42.42 38.47	32.95 29,88	-10.68	4.94 0.04	37.89 34.36
Low Voltage Special						
Single Step	33.04 29.96	38.00 34.46	29.10 26.39	-11.94	4.36 0.04	33.46 30.35
Medium Voltage						
Single Step	28.72 26.05	33.03 29.96	24.78 22.47	-13.73	3.72 0.03	28.49 25.84
Public Lighting						
Single Step	28.29 25.66	32.53 29.50	26.09 23.66	-7.79	3.91 0.04	30.00 27.21
In house consumption for Water Generation						
Single Step	29.54 26.79	29.54 26.79	22.60 20.50	-23.51	-	22.60 20.50

Table 4: Electricity tariffs in effect in Cape Verde in Cape Verde Escudo (ECV) and Euro-cent (c€)

To convert ECV to Euro divide the figures in table by 110$265 (fixed rate)

Remark: Public lighting consumption in kWh is calculated from actual consumption multiplied by 3.56%. Example: if a customer consumes 100 kWh of electricity in one month he/she must pay 3.56 kWh of electricity for public lighting at a fixed rate of 30$00 ECV/kWh which is equivalent to 106$80 ECV for that month.

The reduction in tariffs is explained by the drop in prices of oil product in the international market.

Unlike electricity tariffs, oil products and butane gas prices are reviewed every two months on the 8th day of even months. The last price review took place on August 8th and the next one will be on 8th of October (August and October are even months of the year). Table 5 shows prices of June 2015 and August 2015 (in effect):

Bottles (kg)	Price without VAT ($) ECV/€	VAT ($) ECV/€	Price with VAT ($) ECV/€	Round off Price ($) ECV/€
3	347.45/3.15	8.97/0.08	356.41/3.23	356.00/3.23
6	731.46/6.63	18.88/0.17	750.34/6.80	750.00/6.80
12.5	1523.88/13.82	39.33/0.36	1563.21/14.17	1563.00/14.17
55	6705.09/60.81	173.04/1.57	6878.13/62.38	6878.00/62.38
Bulk (kg)	121.91/1.11	3.15/0.03	125.06/1.13	125.10/1.13

Table 5: Price schedule for butane gas from June to August, 2015. Prices in Cape Verde Escudo (ECV) and Euro-cent (c€)

Bottles (kg)	Price without VAT ($) ECV/€	VAT ($) ECV/€	Price with VAT ($) ECV/€	Round off Price ($) ECV/€
3	324.20/2.94	8.37/0.08	332.56/3.02	333.00/3.02
6	682.52/6.19	17.61/0.16	700.14/6.35	700.00/6.35
12.5	1421.92/12.9	36.70/0.33	1458.62/13.23	1459.00/13.23
55	6256.46/56.74	161.46/1.46	6417.92/58.20	6418.00/58.21
Bulk (kg)	113.75/1.03	2.94/0.03	116.69/1.06	116.70/1.06

Table 6: Price schedule for butane gas from August to October, 2015. . Prices in Cape Verde Escudo (ECV) and Euro-cent (c€)

Oil products: Gasoline, Kerosene, Gasoil (Auto), Gasoil (Electricity), Gasoil (Marine), Fuel Oil 380 centistoke and Fuel Oil 180 centistoke – June price schedule valid till August, 2015.

	Gasoline ($/liter)	Kerosene ($/liter)	Gasoil (Auto) ($/liter)	Gasoil Electricity ($/liter)	Gasoil (Marine) ($/liter)	Fuel Oil 380 cst. ($/kg)	Fuel Oil 180 cst. ($/kg)
Last Price	118.90	85.00	97.90	83.30	70.00	51.30	59.50
Variation	7.80	2.30	4.60	4.60	3.90	4.10	4.20
%Variation	6.56	2.71	4.70	5.52	5.57	7.99	7.06
Sales price	126.7/1.15	87.3/0.79	102.5/0.93	87.9/0.80	73.9/0.67	55.4/0.55	63.7/0.54

Table 7: Price schedule for oil product from June to August, 2015

Oil products: Gasoline, Kerosene, Gasoil (Auto), Gasoil (Electricity), Gasoil (Marine), Fuel Oil 380 centistoke and Fuel Oil 180 centistoke – August price schedule valid till October, 2015.

	Gasoline ($/€/liter)	Kerosene ($/€/liter)	Gasoil (Auto) ($/€/liter)	Gasoil Electricity ($/€/liter)	Gasoil (Marine) ($/€/liter)	Fuel Oil 380 cst. ($/€/kg)	Fuel Oil 180 cst. ($/€/kg)
Last Price	126.70	87.30	102.50	87.90	73.90	55.40	63.70
Variation	1.30	-3.70	-4.40	-4.40	-3.70	-3.00	-3.20
%Variation	1.03	-4.24	-4.29	-5.01	-5.01	-5.42	-5.02
Sales price	128.0/1.16	83.6/0.76	98.1/0.89	83.5/0.76	70.2/0.64	52.4/0.48	60.5/0.55

Table 8: Price schedule for oil products from August to October, 2015

Main utilization of oil products in Cape Verde:

Gasoline is mostly used in motor vehicles and motorbike; a small quantity is used by outboard engine in the propulsion of wooden boat in the activity of artisanal fishing, possibly a tiny quantity can be used to run motor generator set;
Gasoil is essentially used in road transport (heavy truck, buses and vehicles), maritime transport (ships) and in generation of electricity in small size power stations. Minor quantities can be used in motor generator set, motor pump, boilers in production of steam or hot water;
Butane gas is mostly used domestically in preparation of food and used in boilers to prepare hot water and steam and in some rare cases in dryers (hotels);
Fuel oil 380 centistoke is mostly used in generation of electricity in only one power station – on the island of S. Vicente – and in boiler for the production of steam and hot water, also only in S. Vicente;
Fuel oil 180 centistoke is mostly used in generation of electricity in the power stations of Praia, Sal and Boavista and in boilers in Praia and Sal for preparation of steam and hot water;
Kerosene is used at home for various applications but the quantities are not significant.

3 Solar Thermal Heating Market

3.1 Installed capacity

There is no data available with regard to installed capacity of solar collector expressed in m^2 or kW_{th}. Most of solar collectors to harness solar thermal energy are installed in hotels, residential accommodation, boarding rooms and hostels, and a few on private homes. Data from the Customs Authorities can help estimate the installed capacity within an acceptable margin of error. The error might come from the fact that some units may enter the country informally and, as such, they are not included in the statistics, though, these cases are rare.

Available Customs Authorities data are expressed in terms of weight (kg) and value of import (ECV), the latter being the cost of product and freight. Such information can be cross-checked with the information provided by major importers/resellers in terms of number of units imported.

As mentioned above, solar thermal energy is mostly used in hot water service of hotels, residential accommodation, boarding rooms and hostels, and a few private homes, for this reason an inquiry/survey was conducted, either personally or over the phone, to find out which of these establishments uses solar hot water services. Results were studied in a way to identify the type of system used particularly with regard to brand names and collector area. Survey covered all accommodation facilities located in S. Vicente, Boavista and S. Nicolau, half of the facilities located in Praia and Sal and a handful facilities in the remaining 17 municipalities. Photos and technical details of systems were recorded.

Table 9 shows imports of solar water heaters from 2002 to 2013 expressed in kg. Knowing the type of system from the survey, i.e., thermo syphon or forced circulation, it is estimated that every thermo syphon unit of 200 liters has a gross area 2.5 m^2 and weights 150 kg. These estimates include all accessories found in the system. Forced system relation between weight and capacity is lower than the thermo syphon but it is considered the same and, consequently, the overall estimate is a conservative one. The quantities of imports don't follow a trend, and, in fact, they are quite erratic. No explanation could be found for this situation; however, it is believed that the data from Customs Office are accurate.

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
kg	1085	1553	691	4197	13198	4507	6855	10298	4399	7280	10714	6093	**70870**
N.º Units	7	10	5	28	88	30	46	69	29	49	71	41	**473**
m^2	17.5	25.0	12.5	70.0	220.0	75.0	115	172.5	72.5	122.5	177.5	102.5	**1183**
kW_{th}	12.5	17.5	8.8	49.0	154.0	52.5	80.5	120.8	50.8	85.8	124.3	71.8	**828**

Table 9: Estimate of installed solar collector in kW_{th} and m^2

From table 9 it is calculated that the average yearly import is 69.0 kW_{th} and taking into account that the life time of high quality tested solar system is 20 years, this shows that the total capacity installed as of today to be about 1380 kW_{th}. This estimation incudes thermo syphon, forced and direct systems.

The money spent in imports of electrical heaters is much higher than that spent in solar collectors and, if one considers the sales price of both types of heaters, the electrical heater overwhelmingly outnumbers the solar collectors. Since electrical heaters are so inefficient in a way that energy is degraded, and should have been taxed differently to bear the degradation of energy it entails and the money gathered from this measure would be directed in lowering the VAT for solar collectors, this policy measure would probably bring an overall benefit for the country. It is stressed that for every square meter of solar collector installed, it prevents the importation of 70 kg of butane gas or 100 liters of gasoil per year.

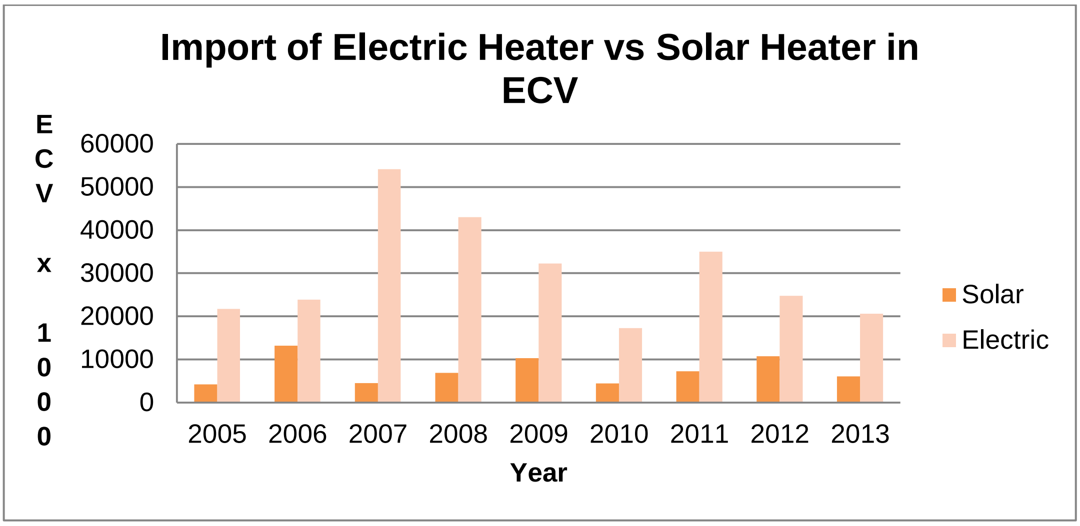

Figure 2: Moneywise analysis of imports of solar$_{th}$ collectors versus electrical heaters during a nine year period.

Another aspect is the life cycle of electrical heater compared to that of solar heater which is four times less, therefore, is much more advantageous to acquire a solar heater than an electrical one. However, the cost electrical heater is, on average, ten times less than that of solar nature. Electrical heaters of 30 or 50 liters capacity sell in the market of S. Vicente for 160€.

3.2 Estimation of area (m²) and installed power (kWth) capacity from data available in weight (kg)

3.2.1 Technical details of major solar water heaters systems sold in Cape Verde

SOLARHART: 2 collectors with gross area of 4.6 m2, when empty, weights 84 kg and 3 collectors with 6.8 m2, when empty, weights 126 kg. For the same brand, a tank of 270 liters with electric boost as those commercialized in Cape Verde weights 146 kg. From these data one conclusion seems evident, there is, for SOLARHART system every square meter of collector weights 18.3 kg for 2 collectors system and 18.5 kg for 3 collectors system, or simply 18.4 kg/m2. The tank analysis gives a figure of 0.54 kg/liter. A complete system of 270 liters with 4.6m2 weight 230 kg or 0.85 kg/liter (cf. www.solarhart.com.au);
VULCANO: one empty collector with gross area of 2.549 m2 weights 53 kg, thus 21 kg/m2 and tanks of 150, 200 and 300 liters weigh 71, 78 and 95 kg, providing 0.47 kg/l, 0.39 kg/l and 0.32 kg/l, respectively. A complete system of 200 liters with an area 2.549 m2 weighs 131 kg or 0.66 kg/l (cf. http://www.vulcano.pt/consumidor/documentacao/catalogo_de_produtos/catalogodeprodutos). Vulcano products have energy certification from Bosch (cf. http://www.bosch-certificacao-energetica.pt/files/201210181107450.Apresenta%C3%A7%C3%A3o1.pdf)

SOLIUS: one empty collector of with gross area of 2.09 m2 weighs 41 kg and one collector with 2.49 m2 weighs 50 kg, thus, 19.6 kg/m2 and 20.1 kg/m2, respectively. (cf.www.solius.pt/solar);
INSUATHERM: a complete system of 200 liters of 2.6 m2 gross area weighs 155 and a system of 320 liters of 4 m2 weighs 215 kg, or 0.78 kg/liter (complete →collector and tank) and 0.67 kg/liter (complete→collector and tank) (cf. http://www.insuatherm.com/SistemaTermossifao.html).
DISCOTERM: direct type system has capacity of 135 liters and is estimated to be equivalent to 1.7 m2 of flat plate collector type and weighing approximately 80 kg (64 kg plus accessories). Technical details provided. DISCOTERM systems are certified by "Solar Keymark" in compliance with EN 12976.
From above figures, it is proposed to consider a complete thermo syphon system of 200 liters with and gross area of 2.5 m2 including accessories such as expansion tank (if fitted), piping, valves, controllers, etc. to weigh on average 150 kg and with this figure one can estimated, within an acceptable margin of error, the capacity installed from the data provided by the Customs Authority.

3.2.2 Systems in operation

The most used system in Cape Verde is thermo syphon of indirect type found in private house and small hotels of about 20 rooms or 40 beds. Direct type is also used in those small hotels. Pumped systems are found in a few big hotels, namely those of 40 or more rooms. Detailed cases are attached as annexes.
Thermo syphon indirect type normally have collector are of 2 m2 with storage of 150 liters and the storage is fitted with electrical resistance as back up means when hot water is in high demand or when there is a lack of solar radiation (cloudy days). Storage of 200 and 300 liters are also found and the area of collector is 2.5 m2 and 2 x 2m2, respectively.

Figure 3: 150 liters thermo syphon indirect type solar collector mounted in small hotel

Alternatively, some small hotels use direct type solar water heater of 135 liters.

Figure 4 – DISCOTERM (technical data annexed) 135 liter direct type solar water heater (details in annexes)

Three hotels in S. Vicente, of large size, use indirect type circulated systems comprising of flat panels collectors and storage tanks. In one hotel, a system serving a block of 56 rooms or 112 beds capacity has 12 collectors, from CPC AO SOL (technical data annexed), with an individual area of 2.24 m^2 (27 m^2 or equivalent to 19 kW) and three storage tanks of 1000 liters each boost by electricity.

Figure 5: Circulated system, indirect type using CPC AO SOL Collector (FOYA BRANCA Hotel, in S. Vicente

Figure 6: 3 x 1,000 liters storage tanks for above system (FOYA BRANCA Hotel, S. Vicente).

Similar systems exist in two other hotels, MINDEL Hotel and DOM PACO Hotel located in the city center of Mindelo. The systems are working reasonably well, however, except for the problem of proper insulation. Previous insulation was not UV resistant, and over time has been faded away.

Figure 7: DOM PACO Hotel (44 rooms with capacity for 80 guests) – 15 collectors from CPC AO SOL with individual area of 2.51 m2, or 37.65 m2 equivalent to 26.4 kW. The system supplies hot water to rooms, laundry and kitchen services.

Next to DOM PACO there is MINDEL Hotel with 70 rooms with capacity for 140 guests with laundry service, kitchen and a couple of big restaurants and bars. This hotel is already 15 years old and maintenance is the biggest challenge. The hot water service is provided for by 26 solar collectors with an area of 2.04 m^2 each, thus 53.04 m^2 equivalent to 38.6 kW. Hot water from collectors is store in 3x1500 liters tanks. In this case insulation of pipes is deficient causing huge loss of thermal energy in distribution system and during mid-afternoon there is a shading problem from the southwest side.

Figure 8: MINDEL Hotel flat plate solar collector (1.7 x 1.2 m) unbranded Italian made

Figure 9: MINDEL Hotel, poorly insulated copper piping carrying hot water to storage tank

Figure 10: MINDEL Hotel – storage tanks and distribution piping uninsulated

In the city of Praia, capital city and the third touristic destination, the majority of hotels and residential houses now have solar collectors as a means to cater for hot water services. As in the city of Mindelo, small hotels are fitted with thermo syphon system whereas large hotels are fitted with circulated system.

Figure 11: Rotterdam Hotel in Praia – 1 x 180 liter solar SOLARHART collector

Figure 12: 1 x 300 liter SOLARHART system installed at SANTIAGO Hotel in Praia

PESTANA TRÓPICO Hotel (94 rooms and 179 beds) and PÉROLA Hotel (60 rooms and 120 beds) are fitted with circulated system and have storage capacity of 4000 and 2000 liters respectively. PESTANA TROPICO Hotel system is relatively new and is working well achieving temperatures higher than 70 ^{0}C. Below some pictures of the system and this system can be considered as a model for big hotels. The system comprises 45 solar collectors with an absorber area of 1.87m^2 or a gross area of 2.01m^2. Thus, the capacity for the system is estimated at 59 kW. PÉROLA Hotel uses solar collector from TERMOBRASA (Portuguese brand).

Figure 13: Partial view of PESTANA TRÓPICO Hotel; collectors are roof mounted

Figure 14: Two rows of solar collectors at PESTANA TROPICO Hotel

Figure 15: Well insulated storage tank PESTANA TROPICO HOTEL

Figure 16: Temperature controller PESTANA TROPICO HOTEL

Figure 17: Thermosyphon system found on single family house of 4 persons with storage of 190 liters. On the 13 of September, 2015 at 13:50 local time a temperature of 69.2 ^{0}C was recorded from the outlet of storage tank. Positioning of the collector is not optimized (>45 degrees) because of lack of space.

Figure 18: Parameters of collector shown in figure above. Storage tank for this system weights 83 kg (empty) and have capacity for 190 liters.

3.2.3 Collector types used

From the inquiry carried out, majority of collector types are by far the flat-plate type followed by direct type whereby the water is heated up in an acrylic bowl and sent directly for use. Evacuated tube collectors were not found anywhere else, however, if they do exist the numbers would be very small and limited to private domestic use. Plastic absorber is non-existent and besides there is no need for such a type of collector since most of its use would be for swimming pools and the average outside air temperature in Cape Verde is around 22 ^{0}C. See pictures above for types of collectors found in Cape Verde.

3.2.4 Imported systems

Since there is no local production in Cape Verde all of the collectors in use are in fact imported. Most of these imports originate from European Countries particularly Portugal, Spain and Italy; however, other origins are possible. Portuguese products include VULCANO, CPC AO SOL, RESUL, etc. (catalog attached as annex), Australian products include SOLARHART system. Spain and Canary Island and Italy are makers of DISCOTERM which is also imported directly.

Several local companies are engaged in importing solar collectors for 15 years, though others are more recent, say between 5 and 10. On the other hand, it could happen that private enterprises would engage in direct imports for their own use to benefit from fiscal breaks in case of foreign investment.

For this research, four companies were interviewed; two in Praia and two in Mindelo and the figures in fact show that solar thermal collectors are not a good business in Cape Verde. For instance, one major player based in Praia imports 10 x 180 liters units and 5 x 300 liters per year; and another company with four year existence has sold only 10 x 150 liters units and 8 x 300 liters units. Figures from S. Vicente are in the same order of magnitude, for example, with regard to direct type systems and flat-plate type collectors, one of the importers, from 2011 to 2015, ordered 45 x 135 liters and 6 x 180 liters, respectively. Normally, other operators import around 5 to 10 units a year. Figures from

Customs Authority corroborate the trends and the estimation presented above is aligned with this information.

As far as the prices are concerned, one must bear in mind that prices vary from island to island and from brand to brand. Thus, in Praia a SOLARHART unit of 180 liters sells for 2,585.00 € and a 300 liters unit fetches for 2,869.00€. On the other hand, a VULCANO system of 150 liters sells for 1,360.00€ in Praia and 1,600.00€ in Mindelo, S. Vicente.

Prices of several brands commercialized in Cape Verde are shown in table 10 below.

Brand	Local	Area (m^2)	Capacity (lt)	Price (€)	Type
Solarhart	Praia	2	180	2585	Thermo syphon
Solarhart	Praia	4	300	2869	Thermo syphon
Vulcano	Praia	2	150	1360	Thermo syphon
Vulcano	S. Vicente	2	150	1596	Thermo syphon
AO SOL	Praia	2	200	2000	Thermo syphon
AO SOL	Praia	4	300	3083	Thermo syphon
Saunier Duval	S. Vicente	4	250	2243	Thermo syphon
Discoterm	S. Vicente		135	1451	Direct

Table 10: Sales Prices of common brands of solar collector found in local market

All prices include a 15.5% VAT. Renewable energy goods are exempt from duty tax but other taxes, namely, ecological tax, statistic tax, etc. and freight rate makes prices a bit on the high side. One should not underestimate the local cost of money which can be as high as 15% for short period (45 to 180 days). But, since the electricity price is high, the use of solar energy for high consumption of hot water by far offsets the cost of electricity, for this reason, in the last two years solar water heater is gaining ground for hot water services in hotels, residential accommodation and high consumption installation.

3.2.5 Local production

In Cape Verde, there is no local production. Everything that exist it is imported.
It could be possible that an assembly be line be arranged locally to lower freight costs, provide some local jobs, and, most importantly, make the systems affordable to a larger segment of population.
If industrial application of solar hot water is implemented together with demand for hotels and similar accommodation facilities and possibly private use the solar water heater market might become attractive. As mentioned earlier Cape Verde is a resourceful country in solar energy and that potential can be easily harnessed depending on the political will of decision makers, for example, providing incentives that award buyers of solar systems and penalize users of electrical heaters.

3.3 Main Applications

3.3.1 Domestic house and private use of hot water

Hot water preparation for single family homes relies mostly on butane gas whereby water is simply heated on a stove to satisfy the need at hand. The majority of houses are not fitted with segregated hot water piping. Only a few houses, those owned by people in higher financial brackets may be able to afford hot water systems installed in their houses, and, when this happens the system used is an electrical hot water heater of 15, 30 or 50 liters capacity. It is very seldom solar hot water heaters installed in homes. Again, this fact can be derived from the import figures of solar water heater (see above). According to INE (2010), cf. www.ine.cv, there were 141,761 households in Cape Verde, and 5.2% of which were considered secondary or seasonal accommodation and 15.2% were treated as empty, therefore the figure of 113,409 households can be accepted as the number of houses occupied. Family houses fitted with solar hot water are less than one percent of above figures. The same data indicate that 7% of those households are fitted with electrical thermal accumulator. The biggest challenge for the use of solar water heater for single family is price. After the electricity price hike of 2006, the new challenge became the cost of using electricity for hot water when homes are fitted with electrical hot water heater. Therefore, either people don't use hot water or they heat water in gas burn stoves for their daily needs.

3.3.2 Hotels, hostels, residential housing and accommodation facilities

With respect to hotels and facilities alike, according to the Annual Inventory of Hotels and Tourism Resorts carried out by National Institute of Statistic (INE), in 2014, there were in activity 229 units of tourist accommodation, 3.2% more than previous year. These accommodations provided 10,839 rooms (+19.7% with respect to 2013) with capacity for 18,188 beds (+13.7% with respect to 2013). Hot water service for hotels and tourism resorts in Cape Verde is mixed. In the islands of Sal and Boavista which account for 73.9% of beds available, the source of energy for hot water service is electrical energy and rooms are fitted with 50 liters electrical thermo accumulator. In the islands of Santiago and S. Vicente offering 14.9% of rooms, the most used source of energy is solar, however the two biggest hotels in each of those island (Porto Grande in S. Vicente and Praia-Mar in Praia) use butane gas as source of energy. In the rest of the country the hotels, hostel, boarding rooms, etc. use electrical thermo accumulator of various sizes and the use of solar water heater is scarce despite the high price of electricity. Hot water service for laundry service and kitchen service frequently is generated from boilers fed by automotive gasoil or butane gas (price above). For example, in Boavista, one of the largest 5-star Hotel & Resort with more than 500 rooms providing a capacity for over 1,000 beds and with yearly occupancy rate higher than 70% has in each bathroom of each room an electric water heater of 50 liters capacity. The annual power demand for this system is estimated to be in the range of 270 MWh which is equivalent to the consumption of electricity of 73,000.00 €, probably $^{1}/_{3}$ or ¼ of the cost for a district heating system of 30 m^3 storage with the benefit of reducing the carbon footprint of environmentally conscious guests. Note that, since tourism is somehow linked to hot water service and consumption of energy, the most recent statistics point out that from the period of January to June this year 278,888 guests visited tourism accommodation spending 1.8 million overnight stay and 73% of those guests stayed in Sal and Boavista where usage of solar water heater is very "timid". This fact is very well mirrored by the per capita electrical energy consumption of those two islands. Table below shows that the combined population of the islands of Sal and Boavista makes up 7.8% of the total of the country but generates about 21% of the whole electricity produced nationwide. It seems evident that the economic activity of tourism in those two islands is responsible for this discrepancy but it must be said that electricity is used irrationally, for example, in heating sanitary water with electricity.

	2012		2013		2014	
	Electricity Gen. (GWh)	Population	Electricity Gen. (GWh)	Population	Electricity Gen. (GWh)	Population
Sal (%)	40 (12.12)	28677 (5.7)	55(14.74)	30254 (5.9)	61 (15.9)	31918 (6.2)
Boavista (%)	29 (8.8)	10647 (2.1)	31 (8.31)	11477 (2.3)	30 (7.8)	12373 (2.4)
C. Verde	330		373		383	

Table 11: Comparison of energy generated in Sal and Boavista with the country relative to population size of same islands.

3.3.3 Real Estate Enterprises

The real estate market is one of the economic sectors that require utilization of hot water and, consequently, solar heaters have the potential for application in this respect. Several investments in real estate that took place in the boom years of 2000's in Cape Verde, particularly those located in the eastern islands of Sal, Boavista and Maio, did not use or install solar water heaters or efficient energy appliances in their projects, possibly, due to lack of awareness, lack or relaxed regulations and poor planning from local and central authorities. Also planners did not take into consideration the implications of such investments on the needs of local communities as far as the supply of electricity is concerned. For instance, the peak electrical load consumption in the island of Maio in 2008 was a mere 0.52 MW_e and in Boavista just 1.216 MW_e. Thus, fitting those real estate's investments with electrical heaters and other inefficient electrical appliances could aggravate the electrical grid to the point of being unable to supply the communities with adequate power without further investment in the power supply. In fact, in one case, on the island of Sal, one developer involved in a real estate investment opted to install electrical thermo accumulators (of 1,600 W) and electrical ovens (of 4,000 W and 6000 W) with total capacity in the vicinity of the peak electrical load consumption of the of the island. In this case, the island of Sal had a peak load consumption of electricity of 6.7 MW and that real estate enterprise contemplated 81 villas, 96 townhouses and 1,045 apartments of one, two and three bedrooms, in all 1,222 housing units (cf. http://www.presstur.com/site/news.asp?news=49415) all fitted with electrical thermo accumulator and electric oven, not to mention other electrical appliances, such TV's, micro wave oven, refrigerators, freezers etc., etc. Ironically, in some cases, those investments were awarded Eco Friendly prizes for their achievement (cf. http://www.sal4rent.com/vila_verde_resort_sal.asp).

Real estate of such magnitude could very well be fitted with a built in district heating system since they can accommodate more than 1,200 families or more than 4,000 people. Such a system can be operated in a condominium like scheme or privately operated development providing a business opportunity and creating environmentally friendly jobs. Later, it has become public that the real estate investment defaulted to its creditors and is still in the process of liquidation, otherwise, it would have been a nightmare to the local residents of the island of Sal if an additional load of 4, 5 or 7 MW would be added to the existing grid without advance investment in production, which, as a matter of fact, has not taken place since 2008. We are of the opinion that this example illustrates well the potential the solar water market offers to Cape Verde.

3.3.4 Public Institutions, hospitals, medical clinics, school, etc.

It has been said time and again that one must lead by example. If so, the Government of Cape Verde or the State must set the example so the common people could follow. Well, regrettably, that is not the case in Cape Verde. We found that in public hospitals, health centers and private medical clinics none of them use solar hot water; instead, when such a service exists, it is provided for by electricity. Today, Cape Verde counts 6 public hospitals, two of the main ones, are located in Praia and Mindelo and the other four, regional ones, are located in the interior of Santiago, Santo Antão, Fogo and Sal. Additionally, there is a couple dozen Health Centers distributed all over the country (cf. National Health Report of 2013 published in Nov. 2014). From the survey carried out by personal visit or over the phone we found that none of those hospitals have solar water heaters and, in one of them, there is no hot water service at all. They all use electrical thermo accumulator of various sizes for the preparation of hot water. Worst of all, in the recently inaugurated regional hospital of Sal fitted with 50 liters electrical water heaters, half of them are inoperative due to poor quality of water. The public hospitals and health centers, in all, offer 1,072 beds with an overall weighted average occupancy rate of 75%. For a typical hot water consumption of 50 liters per day per bed and a difference of temperature of 30 ^{0}C, the yearly energy need is 511 MWh, equivalent to 150,000.00€ taking into account the local tariff of electricity. Therefore, a centralized force circulation hot water system can easily be installed in every hospital over a six year period (one per year). This analysis excludes private clinics based in Praia (Santiago), Mindelo (S. Vicente) and Santa Maria (Sal) and innumerous other institutions like prisons, military facilities, police academy, police precincts, publics schools, etc., however, it is uncertain if some of those institutions use hot water service at all.

3.3.5 Industrial Applications of Solar Hot Water.

The industrial sector in Cape Verde industry is very limited and its contribution to the GDP is also limited. Consequently its energy consumption is equally limited. However, industrial application of hot water can provide huge savings to producers.

Notwithstanding, for the few industrial units that exist, some measures can be taken to improve the overall energy consumption as far as hot water and steam production is concerned.

From the survey, we gathered that there are two oil & gas operators in S. Vicente that deal with heavy fuel oil requiring heating and this is achieved by steam boiler burning fuel oil. If pre-heating of feed water can be done to the range of 150 ^{0}C huge savings can be attained. Normally, fuel oil tanks are heated by steam line of 250 ^{0}C to increase the tank temperature to around 40 ^{0}C so the oil can be handled properly in pumping operations. Providing continuous hot water to those steam line might help maintain the tank temperature within adequate range for pump operations. Hundreds of tons of fuel oil are burnt every year to provide tank heating, thus solar hot water presents an alternative with the potential to save money and help curb emissions.

In Praia there are two soft drinks plants that require steam and high temperature hot water (150 ^{0}C) for washing and cleaning purposes as well as brewing plant that requires large quantity of hot water or steam and a dairy plant, in all cases, boilers burning IFO and gasoil are used. Fuel consumption for one of the soft drink plant is approximately 45,000 liters per year which is equivalent to 40,000.00 €. The brewing plant has an average yearly consumption of 600 ton of IFO 180 centistoke which is equivalent to 330,000.00 € at current price of that fuel grade. In both plants there is an untapped potential in the use solar hot water - with great benefits to the bottom line of the firms as well as to reducing emissions.

In S. Vicente, a large fish canning factory burns 590 and 625 ton of IFO 180 in 2013 and 2014, respectively. Same measures as above can be applied to possibly eliminate those costs. Likewise in S. Nicolau, a small fish canning factory burned 36.8 and 48.0 m3 of gasoil, 2013 and 2014, respectively.

As well, in S. Vicente, a small soap factory burns 55.6 ton IFO 180 in 2013 and 42.2 in 2014.

In all, there are several boilers in service that produce relatively modest temperature that can be easily achieved by solar collectors. Possibly, lack of awareness or information prevents these innovative technologies from taking off.

Applications of solar hot water utilization as described above have been suggested in the National Action Plan for Energy Efficiency as well as the National Plan of Action for Renewable Energy.

	2013	**2014**	**Type of fuel**	**Expenditures (2 years- €)**
Soap factory (S. Vicente)	55.6	42.2	IFO 180 (ton)	53,661
Bottling water and soft drink (Praia)	43.4	44.9	Gasoil (m^3)	78,558
Soft drink and brewing (Praia)	617.4	428.3	IFO 180 (ton)	573,753
Fish canning (S. Vicente)	590	625	IFO 180 (ton)	666,644
Fish canning (S. Nicolau)	36.8	48.0	Gasoil (m^3)	75,444
Dairy Plant (Praia)	9.0	13.5	Gasoil (m^3)	21,011
Fuel Depot (S. Vicente 1 of 2)	-	90	FO 380 (ton)	42,770
Fuel Depot (S. Vicente 2 of 2)	500	500	FO 380 (ton)	500,000
			Total →	2,011,841

Table 12: Boilers in use in industry providing hot water and steam for various processing tasks.

Solar hot water applications in industry have a potential of saving over one million Euros a year and reduction in CO_2 emissions that can be credited in international market for further financial benefits, thus, it is an option worth considering.

3.3.6 Conclusion of Main Application of Solar Hot Water

In a nutshell, investments in solar hot water systems for all the above mentioned applications would have positive implications in the promotion of an efficient economy.

Energy must be used in the most efficient way possible to minimize consumption costs and to protect the environment. At the same time renewable energy should be used as much as possible to reduce dependency on fossil fuels, to protect the environment, and importantly, to meet international targets on reducing CO_2 emissions.

In fact, using solar thermal energy is a very effective method of displacing other primary energy to provide hot water.

We should all take advantage of the fact that the archipelago of Cape Verde receives approximately 2100 kWh of solar energy per square meter land area each year. This is sufficient energy to meet up to 100% hot water demand all year around.

Month	Air temp.	Relative humidity	Daily solar radiation – horizontal	Atmospheric pressure	Wind speed	Earth temp.	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	22.4	73.6%	4.61	101.1	7.1	23.6	0	384
February	22.2	75.9%	5.26	101.1	6.5	22.7	0	342
March	22.8	76.8%	6.28	101.0	6.0	22.6	0	397
April	23.3	76.7%	6.71	101.0	6.0	22.8	0	399
May	24.1	77.3%	7.31	101.0	6.0	23.1	0	437
June	25.0	77.8%	7.18	101.1	5.2	24.0	0	450
July	25.6	78.6%	6.29	101.0	3.6	25.6	0	484
August	26.4	81.0%	5.81	100.9	3.5	27.0	0	508
September	26.9	82.9%	5.39	100.9	4.0	27.6	0	507
October	26.7	79.5%	5.06	100.9	5.1	27.6	0	518
November	25.5	75.5%	4.52	100.9	5.7	26.7	0	465
December	23.6	74.8%	4.13	101.0	6.5	25.1	0	422
Annual	24.6	77.5%	5.71	101.0	5.4	24.9	0	5,312

Table 13: Climatic data for the city of Praia, Cape Verde (wind speed measured at 10 m height). Source: Retscreen.net

Table 14 analyses the cost of hot water in Cape Verde as per current tariffs in effect of different energy sources. Installation efficiency and lower heating values of butane gas (49,500 kJ/kg), gasoil (42,000 kJ/kg) and fuel oil 180 centistoke (39,810) were estimated. Regardless of precision of estimations, one conclusion is outright; cost of heating from electricity in Cape Verde is nearly three times as much when compared to other sources of energy, namely gasoil and butane gas.

Energy source	Average tariff "housing" (Sept. 2015) Euro (incl. VAT)/kWh	Installation efficiency (%)	Cost of heating from 20 to 55 °C Euro (incl. VAT)/m^3
Electricity	0.3436	90%	15.52
Butane gas	0.0771	60%	5.22
Gasoil	0.0763	60%	5.17
Fuel Oil 180	0.0497	60%	3.37

Table 14: Cost of hot water from different sources of energy at current tariffs (lower heating values were estimated)

Thus, it is appropriate to say: LET’S GO SOLAR!

3.4 Cost

Cape Verde, as an archipelagic state with an asymmetric population distribution, the price of imported goods varies from island to island. Hence, solar collectors are no exception and indeed vary significantly from place to place and they are as high as 30% more when compared to the sales prices of city of Praia, the capital of Cape Verde. Thus, price found in the market is around 700.00€ to 850.00€ per square meter, all included (storage tank, pipes, valves, installation, etc.).

The most common type of imported solar collector is the indirect thermo syphon system of flat plate ranging from 150 liters to 300 liters; normally the 150 liters units have 2 m^2 of area. Direct type collector of 160 liters capacity is also imported but mostly in S. Vicente, the second most populous island.

In Cape Verde there is no local production of solar water heaters. A person or two may build their own collector for their own use.

3.5 Customers

The main customers of solar thermal systems are the hotels and single family's homes. Again, from the imports figures one can see the size of the market which is partly conditioned by its high price relative to the purchasing power of the homeowners.

3.6 Companies involved

3.6.1 Companies involved in the production or assembling of solar thermal systems

Not Applicable to Cape Verde

3.6.2 Companies involved in import of solar thermal systems

COMPANY	MANAGER	E-MAIL	CONTACT
Carlos Veiga, Lda.	Carlitos Veiga	cv.lda@cvtelecom.cv or carlitos@cvlda.cv	9912203/Praia
Lobosolar, Lda.*	Emilio Benrós	emilio.benros@sita.cv	9597897/Praia
Anjos Mundilar		anjosmundilar1@gmail.com	2613302/Praia
SEFI, Lda.	Osvaldo Monteiro	sefi@cvtelecom.cv	2312276/Mindelo
Alexandre Benoliel de Carvalho, Lda.	Not available	abc@cvtelecom.cv	2321754/Mindelo
Circuitos, Lda.*	Gilson Correia	gilson_afro@hotmail.com	9835338/Mindelo
Drogaria PIKNIN, Lda.	Not available	drogariapiknin@cvtelecom.cv	2324738/Mindelo
NEDCABO*	Euclides M.M. Araújo	euclidesmmaraujo@gmail.com	Based in Praia
BWS*	Artur Silva (SV)	ajrrs@hotmail.com or ajs_silva@hotmail.com	9993578/Praia (rep. S. V.)

Table 15: List of available operators in the country (* deals mostly with PV systems)

Note: Anyone with an importer license can import and sell solar collectors. There is no specific shop or company that deals exclusively with the commercialization and distribution of such products.

3.6.3 Companies involved in the installation of solar thermal systems

No companies were identified in supplying installation service of solar thermal systems. The sellers, as shown above, would take care of installation of systems. Some private people have been offering the service but they are pipe fitters and do not do the installation exclusively.

4 Political Support Mechanisms

The Common Customs Tariff considers renewable energy goods imported into the country as free of duties. Yet, VAT at a rate of 15.5% of taxable base must be paid at the Customs Office before clearance. Other minor taxes are applied.

Decree-law number 1/2011 of 3rd of January created a juridical regime for licensing renewable energy production and defined a framework of incentives. Articles 13 and 14 of said decree-law, regarding fiscal and customs benefits, were revoked and updated with a new code of fiscal benefits in the Law number 26/VIII/2013 (article 12 tax reduction on investment). Later on, in 2014, Decree-Law 1/2011 was altered by decree-law 18/2014 in a way to provide great involvement of Economic Regulation Agency in partnership with Directorate General of Energy.

Ministry of Tourism, Industry and Enterprise Development (MTIDE) is the government entity responsible to look after the implementation of above mention mechanism but there is an interface with the Ministry of Finance which supervises the Customs Office and the Internal Revenue Office (Tax Office). At the level of MTIDE the Directorate General of Energy and (DGE) and Economic Regulation Agency (ARE) are responsible for evaluating projects and implementing the measures foreseen by law.

5 Test- and Research Institutes

There is no research and development or testing institute in Cape Verde for the control of solar thermal systems. Thus, the absence of such institution gives an opportunity to create such an important component of the solar thermal market of Cape Verde. It appears that the Department of Engineering and Marine Science of the University of Cape Verde (DECM-UniCV) together with the Center for Renewable Energy and Industrial Maintenance (CERMI) could be equipped to embrace this challenge, by providing the country with a testing laboratory to verify the solar thermal systems. This institute would, among other things, have the mission to protect consumers by serving as national standardized method to compare solar equipment, assist solar thermal system designers by providing accurate and dependable ratings of performance, assist policy and planning at the government level by providing a means to manage the quality of incentive programs as well as the basis for setting codes and standards.

It must be stressed that a dependable measure of quality and function makes the solar thermal industry stronger, by providing an unbiased evaluation of a collector's quality and performance.

As stated above, in many situations the solar thermal systems have been facing criticism of poor performance partly due to poor operating condition and poor equipment and so jeopardizing the potential the systems can bring about energy efficiency and saving energy.

Only an unbiased and dependable evaluation of the quality of these products by such an institute can guarantee the dependability of variety of solar energy supplies that are marketed in Cape Verde.

We strongly believe that there are human resources available at DECM-UniCV and possibly at CERMI to put together such an endeavor. In order to move forward with this initiative some modest investment might be required particularly in capacity building of personnel and procurement of some relevant equipment.

This undertaking could start with an agreement between the institutions by signing a memorandum of understanding defining the roles and functions of the parties involved and distributions of responsibilities. Possibly, this testing laboratory would render services to Directorate General of Energy (DGE) and Economic Regulation Agency (ARE) and, obviously, third parties.

6 Solar Drying Market

6.1 Systems in operation

Open air fish drying activities has been done for more than a century in Cape Verde. In fact, due to lack of refrigeration system fish drying, for many years, was the only way to conserve excess fish catches, particularly, in the remote islands. Today, outdoor fish drying is still taking place almost everywhere in the country. Normally fish is chipped and salted and laid down on the ground or terrace and in some instances hanged to avoid unwanted access of stray animals (dogs and cats).

There is no documented experience of usage of solar dryer, though recently a local NGO, Atelier Mar, based in S. Vicente is trying to promote its usage as fruit dehydrator. Cf. https://ateliermar.wordpress.com/about/ for further information. This NGO was very active in the creation of a local cooperative, PARES, in Porto Novo, Santo Antão engaged in fruit and vegetables dehydration using homemade solar driers. As per information provided the accumulated experience is about 10 years now and it is mostly done as trial and error process until the proper design is adopted.

Figure 19: Products dehydrated in solar dryers in Porto Novo on sales at Alternativa Galeria in S. Vicente (in addition, quince and apple are also dehydrated as well as tea (leaves and stems). Photo taken at Alternativa Galeria, S. Vicente.

Fruit drying is a promising market since cold conservation is scarce or expensive in places around the archipelago. Fruits like mango, cashew, grapes, papaya and other crops like a variety of beans, sweet potatoes very often get rotten due to lack of conservation. Apparently, it seems it is an awareness issue that if properly addressed could have huge economic benefit for the local population

Figure 20: Fruit dehydrator used by a NGO in S. Vicente to dry fruits (experimental) – photo taken at Mindelo International School of Arts

Figure 21: Solar dryer for home use (fruit drying) – photo provided by owner of dryer (Ms. M.M. Estrela)

6.2 Main Applications

In Cape Verde, drying is applied to all kind of agricultural products, namely, cereal, beans, fruits, herbs, fish, meat, and other agricultural products such as hot pepper, tobacco leaves, etc. In all cases, drying takes place in open air and uncontrolled environment and under drying or over drying can occur, as well as unwanted infestation and losses due to uninvited invaders such as stray dogs and cats are common.

Figure 22: Common agricultural products dried in Cape Verde (aromatic herbs and hot pepper). Photo taken Municipla Market in S. Vicente.

Solar drying, in fact, offers a great potential that should be tapped since it can provide alternative means to food conservation and avoid waste because of deterioration. Besides, if drying is carried out in solar driers it is controlled and contributes to the reduction of losses and wastage and is more hygienic than open air drying.

There are different fruits harvesting seasons in Cape Verde, strawberry, orange, mango, avocado in some places and seasons are overwhelming abundant that price gets very low because quite often refrigeration is either unavailable or expensive In those situation drying should .

6.3 Cost

Solar drying systems are not sold in Cape Verde. The few that exist are locally built

6.4 Customers

Possible main customers and users of solar thermal drying systems would be fishermen or their intermediaries in the chain supply and farmers. As noted above, in Cape Verde many crops are dried up before reaching the market, however, this is done very randomly.

6.5 Companies involved

6.5.1 Companies involved in the production or assembling of solar drying systems

No information regarding this item was gathered, notwithstanding the effort. As mentioned above, the sole initiative known from the research is the case of NGO "ATELIER MAR" which operates from Porto Novo, Santo Antão.

6.5.2 Companies involved in import of solar drying systems

Data form Customs Authorities has no entry regarding imports of solar driers.

6.5.3 Companies involved in the installation of solar drying systems

The research carried out revealed that there is no specific company which is involved in the installation of solar drying system.

6.6 Know-how on Solar Drying

Of the higher education institutions contacted, none formally provided any know-how on drying.

This shortcoming could possibly be overcome by Department of Engineering of Marine Science at University of Cape Verde working in collaboration with other department within the structure of UniCV namely the School of Agricultural Studies and the Center of Renewable Energy and Industrial Maintenance both based in Praia. The initiative could come from DECM-UniCV as earliest as possible during the life time of the training and demonstration program SOLTRAIN West Africa which started in April, 2015.

6.7 Awareness and Incentives

No awareness campaign was identified for the promotion of solar drying and so open air solar drying is not known to common people. The ministry of energy through its Directorate General of Energy does not have an awareness campaign and there has never been a campaign on this subject.

Incentives related to energy aspects never mention solar drying and Law/VIII/2013 on fiscal benefits does not include solar drying in any way or form.

7 Solar Cooling

7.1 State of the art of solar cooling in Cape Verde for comfort of buildings

Cooling of building in Cape Verde, particularly, public institutions and hotels, is almost entirely, carried out by split type air conditioning mounted on windows or openings in the façade of building itself. The most common size used is rated at 9,000 BTU/hour (2.64 kW) and 12,000 BTU/hour (3.52 kW) and cooling season runs from July to October when outside air temperature is around 28 ^{0}C, or higher, and humidity above 70%. However, it must be said that the need for most cooling stems from poor architecture at design level of individual projects and poor planning at municipal level at the phase distributing land for construction purposes. It is far too common to find buildings with glazing facing south and west orientation with abnormally large areas, poor or non-existent shading areas, dark color painting of building, black coated roof and terraces, poor ventilation setting due to not taking advantage of prevailing wind direction, poor natural lighting and having to recur artificial lighting increasing thermal load, poor choice of building materials, etc. In Praia, the capital city of Cape Verde, or elsewhere in Cape Verde, a few glass houses stand out as emblems of great technological achievement.

Figure 23: VIP PRAIA Hotel 79 rooms fitted with electrical hot water heaters, innumerous compression type AC units and all façades (west, south, etc.) made of glass.

Figure 24: Passenger Maritime Station of Porto Novo, Santo Antão – south and west façade glassed. The installed AC units revealed inadequate during operation. AC Condensers placed in the searing heat of the roof.

7.2 Cost of traditional cooling system of building

Prices on the local market of compression type AC units (WESTPOINT) of different sizes are shown on table 15 below. Prices of renowned brands such as SAMSUNG and LG can be twice as much as those on table 15. An estimation of yearly operational cost is shown for four months cooling season and five hours per day utilization. The units of 12,000 BTU/h are the most popular size sold. Our research indicated that thermal load of cooling spaces is seldom calculated and customers simply walk into the stores and request an AC unit capable of providing cooling. It is also common that condensers of those AC units are poorly located, i.e. they are exposed to intense solar radiation, hot spots and deprived of ventilation and connection between evaporator and condenser are too long.

Life time of AC units has been estimated to be in the range of 5 to 8 years and maintenance costs are high because of leakage of refrigerant.

Capacity (BTU/h/kW)	**Price (ECV/€)**	**Price €/kW capacity**	Conservative Estimation of Operational cost for 600 h/year @ BT tariff (ECV/€)
24000/7.0	98800 / 896	128	55000/**500**
18000/5.3	88000 / 800	151	40000/**360**
12000/3.5	57600 / 522	149	26600/**242**
9000/2.6	49000 / 444	171	20000/**180**

Table 16: Price of compression type AC units in one shop in S. Vicente (prices vary within the country between 10 to 20%)

According to import data from Customs Authorities, every year millions of Euros are devoted to importing countless units of compression type AC to provide cooling of buildings and much more millions are spent to run them. For example, an AC unit of 12000 BTU/h (1200 W power consumption) running for 6 hours a day during the cooling season, i.e. for six months, would require ca. 1300 kWh/year of electricity equivalent to 435.00 € worth of electricity in current tariffs. Table and figure below show data and graph relative to imports of compression type AC units (all types).

Year	Weight (ton)	Amount (Euro x 1000)	Units Imported (estimated)
2005	140	583	2809
2006	171	703	3413
2007	278	1014	5568
2008	193	887	3856
2009	175	1004	3496
2010	327	1396	6532
2011	225	1194	4503
2012	228	1579	4563
2013	242	1383	4845
2014	128	700	2552
Total→	2107	10443	42137

Table 17: Import information of compression type Air Conditioning unit; Source: INE

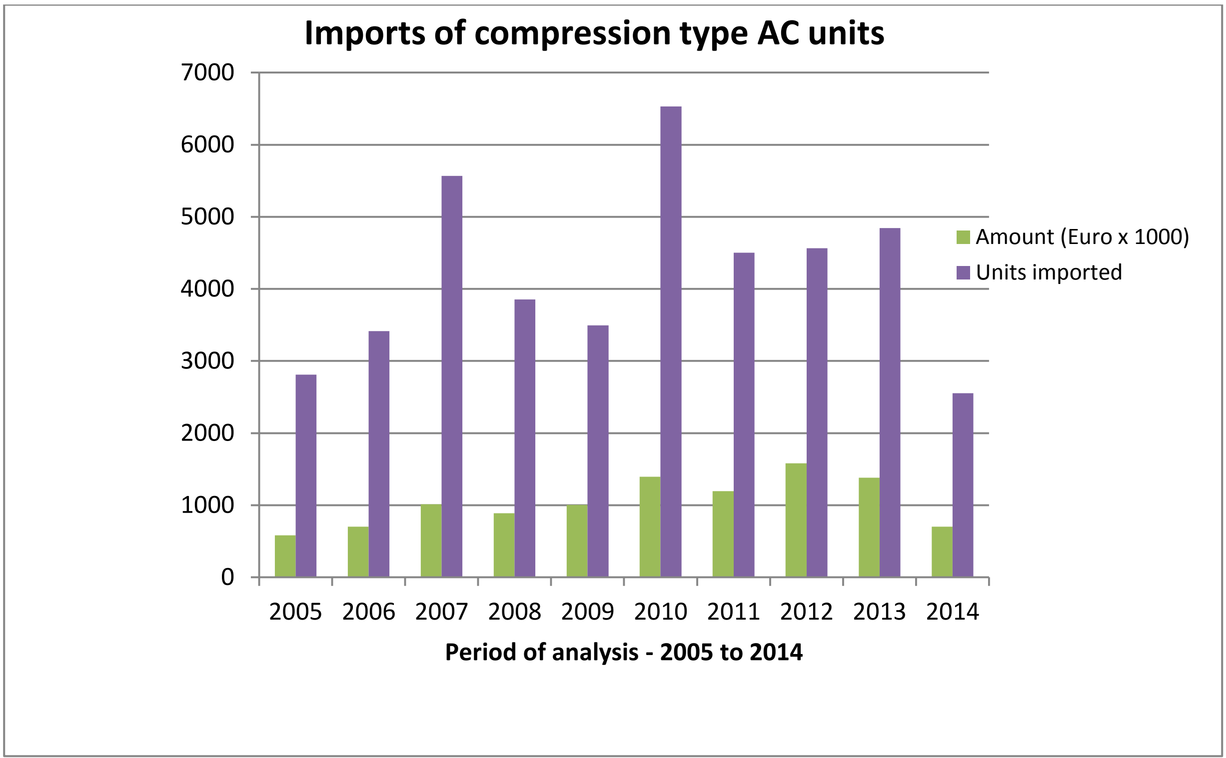

Figure 25: Data from Customs Authority regarding import of compression type AC units 05/14

As it can be seen from the table 16 above Cape Verde imported during 2005 to 2014 approximately 10.5 million Euros worth of AC units totaling more than 42,000 units of different capacity, 18,000; 12,000; 9,000 and 7,000 BTU/h. The units of 12,000 and 9,000 were the most common size of units that were imported.

If cooling is unavoidable, there is an alternative to cooling that doesn't require too much energy consumption. For instance, absorption chillers of mature technology is now widely used in place with climatic conditions very similar to Cape Verde as is the case of Canary Islands located some 800 nautical miles to the north.

There are two brands of absorption chillers that can be found in the market that can constitute an alternative to compression air conditioning units used in Cape Verde, namely Yazaki and Thermax absorption chillers. The capital investment for those systems is much higher but the operating cost is much smaller than their competitors and in a few years is possible to have a high return on the investment. Table 15 shows different prices for different models and different capacity of above mention absorption chillers. (Cf. http://www.yazaki-airconditioning.com/fileadmin/templates/pdf_airconditioning/data_sheets/FT_WFC_SC_SH_20_en.pdf and http://www.thermaxglobal.com/Absorption-Cooling/About-Abosorption-Cooling/Absorption-Technology-Basics.aspx).

In the absence of heat source, above-mentioned absorber chillers requires a source of heat for their operation and it is proposed to use solar water heaters with an estimated price of 0.0470€/kWh$_{th}$ or 5,076.00€per year.

Make and model	Capacity (kW)	Price (€/kW)	Overall Price(€)
Yazaki WFC SC05	17.5	1784	31220
Yazaki WFC SC10	35.2	1126	39635
Yazaki WFC SC20	70.3	730	51319
Yazaki WFC SC30	105.0	567	59535
Yazaki WFC SC50	176.0	483	85008
Thermax LT 06	229	483	110607
Thermax LT 08	281	350	98350
Thermax LT 10C	351	300	105300
Thermax LT 12C	422	260	109720

Table 18: Absorption chillers available in the market and respective price vs. capacity.

When analyzing data from table 15 versus the price of compression type AC units the following can be concluded:

1) One Yazaki solar cooling unit model WFC SC20 provides a cooling capacity of 70.3 kW which is equivalent to 20 compression type AC unit of 12000 BTU/h cooling capacity. So the cost difference in capital investment between the two systems is 40,994.00 € in disadvantage to the solar cooling system;
2) The operating cost per year of compression type AC unit is 8,685.00€ versus 5,076.00 € for the solar cooling model;
3) The useful life time of solar cooling system is twice as that of compression type AC unit, thus, the investment requirement is halved from the amount in 1);
4) In choosing the solar cooling system the yearly saving is equal to difference indicated in 2) or 8,685.00€ -5,076.00€=3,069.00€;
5) The simple payback period (investment over savings) is 5.6 years for Yazaki WFC SC20. Maintenance costs of both systems were considered to be similar or whatever their difference might be would have no significant effect on the payback period. Since prices are not uniform around the country, some discrepancies in calculations are possible, but the bottom line is unchanged.

In all scenarios, there is a CO_2 emission reduction of 18.0, 9.0 and 4.5 tons, respectively, just for a single unit. As stated above, Cape Verde had at the end of 2014, 229 hotels and most of them have capacity well above 25 rooms.

Therefore, for hotels of more than 25 rooms or institutions requiring more than 70 kW of cooling capacity, it justifies investing in solar cooling systems. Probably, if skepticism prevails, it would be worth trying a pilot system to verify how the system in fact works in practice.

According to INE (2010), 4% of households are fitted with compression type air conditioning units. But, since then, it is believed that many of those units are by now out of service or simply turned off because of the hike in electricity tariff that has made utilization unbearable.

Figure 26: Condensers of compression type AC units being mounted in a hotel in S. Vicente (damaging the façade aesthetic)

Figure 27: Condensers of compression type AC units in real estate investment in S. Vicente

8 Sources of Information

The report based on the following sources of data and information:
Survey/inquiry carried out to hotels and similar accommodations facilities in all islands. On the islands of Boavista, S. Nicolau and S. Vicente all hotels were visited personal and data compiled in a file. Room capacity and beds provided were recorded and occupancy rate was obtained from statistics published freely on the internet (www.ine.cv). During the visits hot water system was reviewed and pictures taken and brand, type of system and number of collectors installed were all recorded. Same surveys were conducted on the islands of Santiago, Santo Antão, Sal and Brava, but only half of the numbers of hotels were covered. On the islands of Fogo and Maio only a few hotels were visited.
Customs Statistical information was gathered from the site http://www.alfandegas.cv and from National Institute of Statistic (INE) – www.ine.cv.
Electricity generation per island in different power stations was provided from the site www.electra.cv under balance sheet and was complemented by information provided by Economic Regulation Agency and Directorate General of Energy.
Tariffs of electricity and oil products are freely published on the net in the site www.are.cv.
Relevant information regarding the utilization of energy in Cape Verde was obtained from document National Action Plan for Energy Efficiency for the period 2015/2030.
Fuel consumption for boilers used in industrial applications was kindly provided by respective companies that operated them.
Data on hospitals and health centers, occupancy rate and capacity were obtained from National Health Report of 2013.

www.ine.cv (statistics on census of population, tourism, and economic data);
http://www.ine.cv/dadostats/dados.aspx?d=2 (tourism)
http://www.ine.cv/dadostats/dados.aspx?d=1 (population and economic conditions)

www.are.cv (tariffs of oil products and electricity);
http://www.are.cv/images/stories/combustiveis/novo_preo_combustvel_080815.pdf
http://www.are.cv/images/stories/banner2/tabela_de_preos_de_electricidade_e_gua_para_electrajvf_s.pdf (electricity tariffs)

www.electra.cv (balance sheet until 2012);
http://www.electra.cv/index.php/2014-05-20-15-47-04/relatorios-sarl

https://www.dnre.gov.cv/dnre/pt-pt/direcao-das-alfandegas; (import statistics)

http://www.governo.cv/documents/politica_energetica.pdf (energy policy)

http://www.governo.cv/documents/PANAII-sintese-final.pdf (national plan of action for the environment)

http://www.minsaude.gov.cv/index.php/documentos/cat_view/34-documentacao/61-relatorio-estatistico (statistics on hospitals and health centers, 2013)

9 Attachment

9.1 Annex1 – Case study of three hotels using solar, butane gas and electricity to meet the head demand

9.1.1 Hotel DOM PACO Mindelo – S. Vicente – CAPE VERDE

Solar hot provided by a circulated system of indirect type

Figure 28: CPC AO SOL collector field mounted in a metal structure on the terrace of Dom Paco Hotel

The Hotel is located at city center just across the street from the PPT Office.
Hotel comprises of 44 rooms proving 80 beds. Yearly occupancy rate is estimated to be 60%. Highest demand occurs in summer months (July and August) and in February. It is rated as a 3-star Hotel.
Sanitary Hot water service is provided by a set of 15 flat-panel collectors from CPC AO SOL, a Portuguese brand popularly commercialized in Cape Verde.
CPC AO SOL SOLAR collector is a concentrating collector, of the type CPC (Compound Parabolic Concentrator) stationary. It concentrates the radiation on a V shape absorber through a set of aluminum mirrors whose geometry is a technological state of the art worldwide.
Collector aperture area is 1.98 m^2 and has optical efficiency of 0.74 and thermal losses of 4.6 W/m^{20}C.
Testing was carried out by INETI (a local national institute in Portugal) according the European Norms – EN 12975.

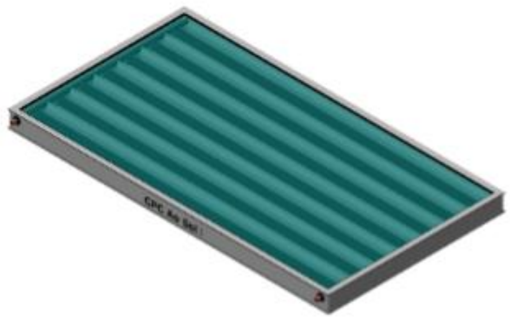

Figure 29: Photo of CPC AO SOL solar collector.

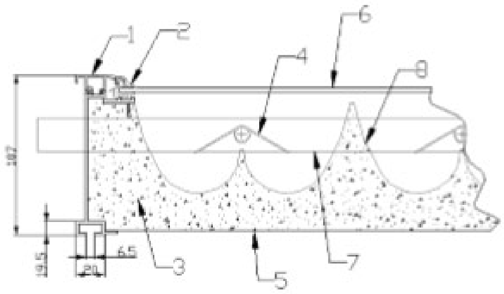

Figure 30: Cross section view of collector

Source: www.luso**sol**.com/pdf/ManualUtilizador-K1903e.pdf
Electric energy is used as backup system to provide hot water service when the solar energy is unavailable (cloudy skies, high demand, etc.).
Primary fluid from collectors are forced circulated and send to storage to exchange heat to secondary fluid.
Hot water service is circulated by a pump to all 44 rooms, kitchen, laundry and other services at reasonable pressure and is set at 50 degrees Celsius (bear in mind that average local temperature in Cape Verde is around 24 degrees Celsius). Hot water is store in three 1,000 liters vertical cylindrical tanks (see pictures attached).
Same hot water is also used for the kitchen and laundry service.
Copper piping from collectors to storage tanks are not properly insulated and probably there is additional loss. It is not known if distribution piping is insulated.
It is estimated that the 15 collectors provides an area of 29.7 m2 (20.79 kW) and supplies 20.5 MWh of energy considering all types of losses. The heat demand for a 40 liters per day per guest is 26.7 MWh, thus the solar fraction is 77% (calculation simulated by RETScreen).
Estimating a cost of the system to be around 800.00€ per square meter and a 20 year lifetime the cost of solar energy for this hotel is 0.0615€/kWh and payback period of the investment is just 2.2 years. Maintenance and running costs are excluded in the analysis.

9.1.2 Porto Grande Hotel

Located in the city center of Mindelo at Praça Nova (public plaza), it comprises 48 rooms and 2 suites and rated as 4-star. The occupancy rate is estimated to be the same as of Dom Paco Hotel and hot water service also supplies all service. In this case the total heat needed is 30.4 MWh and it is supplied by butane gas boiler of thermal efficiency of 60% (estimated). The annual consumption is 3,791 kg equivalent to approximately 4,000.00€ and lifetime of boiler is limited to 8 to 10 years. The cost of kWh is 0.132€. This figure excludes cost of boiler and lifetime
Another hotel in Praia, property of same hotel chain as Porto Grande, also burns butane gas for hot water service despite an initiative to provide free contribution grant to promote change over to solar under GEF (Global Environmental Fund) program.

9.1.3 One of the hotel in Sal or Boavista of 500 rooms and rated 5-star

In all, there are 4 hotels with more than 500 rooms in Sal and Boavista that don't use solar collector. In one of them, there is in every room a 50 liter electric heater.
For occupancy rate of 80% and 40 liters per guest daily consumption the annual heat demand is 405 MWh. To meet the heat demand by electricity at current tariff the overall yearly cost is 153,057.00€ plus cost of heaters (500 x 160.00€) with a lifetime of 5

years. The unit cost for this scenario is 0.532€/kWh including cost of electric heaters and 5 years period.

9.1.4 Conclusions

From the three scenarios above, the solar case is by far the most attractive. Many people consider initial cost of solar systems as a disadvantage, but for big hotels this is not an issue because this cost is marginal if one considers a USD $50,000.00/per room for a 5-star hotel. Besides the concern of climate change with emission of greenhouses gases from diesel power plants, electricity consumption should be rationed since it is not available for everyone, every time, particularly in an island context and with very low population, as is the reality of island of Boavista.