WP3: Testing, Activity 3.15

RES in rural environments - Sesimbra

Deliverable 3.15.1: Renewables for development of Sesimbra Nature park: nature protection and area development

Final version, December 2018

Project co-financed by the European Regional Development Fund

European Union
European Regional Development Fund

WP3 (TESTING) LEADER

Technical University of Crete, School of Environmental Engineering, Renewable and Sustainable Energy Systems Lab (TUC ReSEL)

RESPONSIBLE PARTNER: Energy and Environment Agency Arrabida (ENA)

DELIVERABLE 3.15.1: Renewables for development of Sesimbra Nature park: nature protection and area development, FINAL VERSION, December/2018

AUTHORS: Orlando Paraíba, Cristina Daniel

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1. INTRODUCTION

Deliverable number	Deliverable title	Type of deliverable	Target value	Finalisation month
3.15.1	Renewables for development of Sesimbra Nature park: nature protection and area development	Method	1 Unit produced	02.2018
	Description	Report will focus on the **socio-economic approach implemented** and **lessons learned** with the **replicability recommendations and impact assessmen**t of the pilot activity.		

The Sesimbra Natura Park is a project integrated in a rural exploitation area, aiming the development of eco-tourism and pedagogic according to the principles of sustainability of the local resources.

The vision and motives of the pilot operator/beneficiary are the establishment of a living lab that will be used for demonstrating the viability and success of RES and EE in rural areas among the local community, contributing for the valorisation of local energy resources, the energy independence and the development of new green business.

In order to promote the sustainability of Sesimbra Natura Park's activities, it is the objective of this pilot project to use RES to replace conventional forms of energy, for which the energy needs, the availability of RES and the economic viability of thr solutions were evaluated.

There are several uses of energy associated with the activities carried out at Sesimbra Natura Park. This uses where evaluated:

- Hot water for bathing, with big seasonality in the usage. The available wood chips are out of size to use in a conventional boiler;

- Water for irrigation, but with a complex distribution scheme, any intervention will be very expensive;

- Heat for buildings, with big seasonality in the usage and reduced consumption.

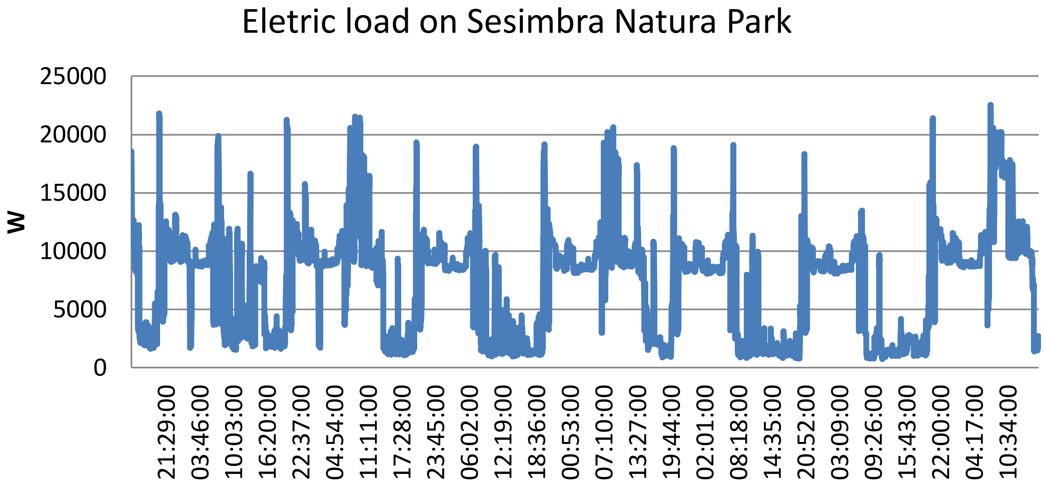
- Electricity for various uses, usable load profiles for self-consumption and resource available.

Considering the evaluation carried out, the production of electricity for self-consumption via photovoltaic it appeared as the most adequate solution.

An exhaustive measurement of the consumptions was carried out and the project to install the photovoltaic plant was developed. The PV plant as the following characteristics:

- 44 PV modules
- Unit nominal Power: 27 Wp
- Total power: 11,88 kWp
- Total used area: 71,9 m2

- Inverter: 10 kWac



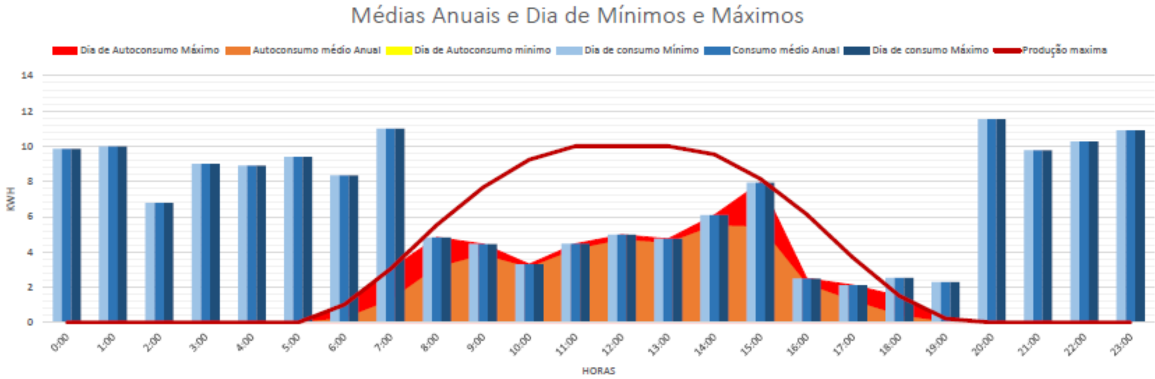
The expected energy production and the consumption in the self-consumption regime, considering the initial load profile, is given by the following.

12kW

Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E Load MWh	E User MWh	E_Grid MWh
January	75.3	10.95	109.0	103.1	1.191	5.142	0.965	0.189
February	87.8	12.13	113.5	107.6	1.232	4.644	0.949	0.245
March	138.4	14.23	164.4	156.3	1.762	5.142	1.235	0.469
April	179.8	15.30	195.8	186.3	2.066	4.976	1.255	0.617
May	221.7	18.23	225.5	214.2	2.349	5.142	1.492	0.776
June	232.5	21.36	229.7	218.5	2.360	4.976	1.432	0.786
July	244.9	22.81	245.1	233.4	2.502	5.142	1.532	0.882
August	216.9	23.37	230.4	219.5	2.353	5.142	1.466	0.805
September	164.9	21.31	190.3	181.5	1.968	4.976	1.218	0.589
October	118.3	18.59	150.2	142.7	1.583	5.142	1.147	0.384
November	79.5	13.90	112.6	106.7	1.213	4.976	0.925	0.249
December	63.6	11.63	95.5	90.0	1.038	5.142	0.850	0.155
Year	1823.7	17.01	2062.0	1959.9	21.619	60.538	14.465	6.145

Legends:
- GlobHor — Horizontal global irradiation
- T Amb — Ambient Temperature
- GlobInc — Global incident in coll. plane
- GlobEff — Effective Global, corr. for IAM and shadings
- EArray — Effective energy at the output of the array
- E Load — Energy need of the user (Load)
- E User — Energy supplied to the user
- E_Grid — Energy injected into grid



As can be seen from the graph, there are significant energy consumptions at night, as such not fed by the photovoltaic plant. These nocturnal energy consumptions are related to the irrigation system. As this irrigation system uses the drip irrigation technology, irrigation can easily be transferred to the daytime period, without negative consequences in terms of water consumption and plant health and so use all the energy produced in the PV plant.

Once the feasibility of the project was verified, the photovoltaic plant was installed.

Pictures 1 and 2 – PV system for electrical energy production and consumption

In order to monitor, evaluate and communicate the results obtained, a system for monitoring consumption and energy production was also installed in Sesimbra Natura Park.

Picture 3 – PV control system

Project co-financed by the European Regional Development Fund

Picture 4 – Dashboard with data produced through the monitoring system

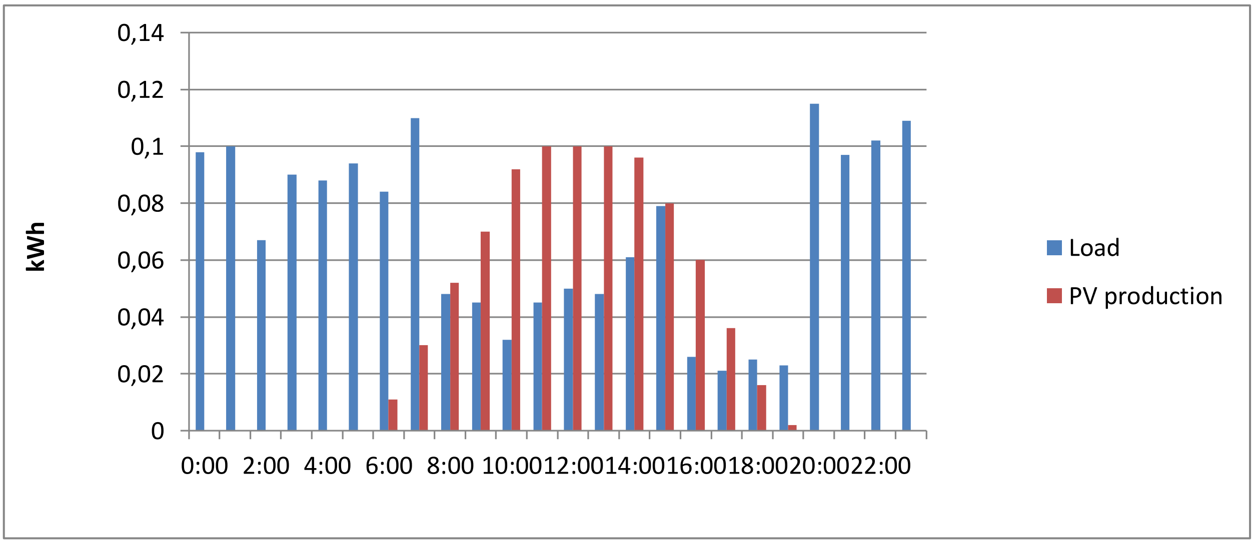
2. MAIN LESSONS LEARNT

In order to promote the sustainability of rural entities, it is important to identify the usable renewable energy sources, to understand how they can meet the energy needs of the organization and whether they are suitable for use.

In the case of Sesimbra Natura Park, biomass is widely available in chip form, there are heating needs that can be suppressed with the use of biomass, however the available chip format is not suitable for use in conventional boilers and its conversion is very expensive, therefore, biomass is not an adequate option to promote the sustainability of this rural entity.

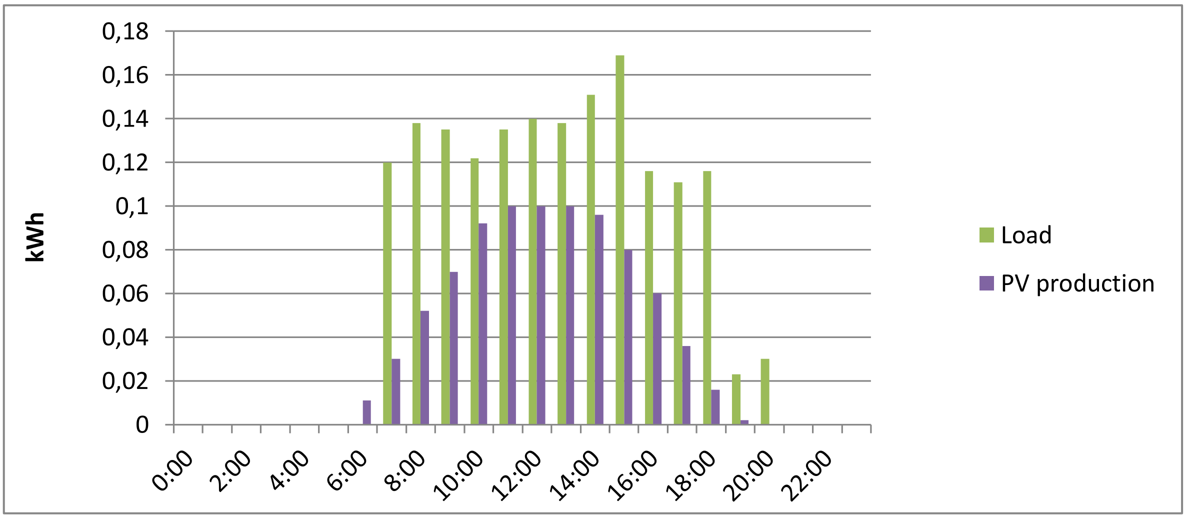
In addition to identifying the most appropriate source of renewable energy, it is also very important to tailor the use of energy to ensure maximization of the use of the renewable source.

For Sesimbra Natura Park, photovoltaic electricity production was identified as adequate to promote its sustainability. Analysing the load profile we verify that there is a high consumption in the nocturnal period (around 9 kWh), as a result of the use of drip irrigation systems. The pumping system represents 66% of al electrical needs. For this load profile, the production of photovoltaic energy would only supply 30% of the electricity needs of Sesimbra Natura Park.



To ensure the maximum utilization of PV production the irrigation schedule will be changed to the daytime period. This change does not negatively affect the development of plants nor the consumption of water because it is a drip irrigation system.

This change in the load profile of the facility will allow that 51% of the energy used will be supplied by photovoltaic.



The proper adjustment between the renewable energy source and the energy use in the system is fundamental to maximizing the overall efficiency of the system.

Technological measures of energy efficiency should always be complemented by behavioural measures and organizational measures.

3. REPLICABILITY RECOMMENDATIONS AND IMPACT ASSESSMENT

Given the seasonality of photovoltaic production and irrigation needs, the impact of this pilot project can only be truly evaluated after a period of one year. For this purpose, a monitoring system has been installed to mediate the energy produced and the energy consumed in irrigation and other uses.

With the results of the monitoring it will be possible to continue the dissemination actions, but now with consistent information on the impact of the PV installation on the reduction of consumption of Sesimbra Natura Park.

Sesimbra Natura Park as a large number of visitors who use the facilities annually and so efficiency message will be widely disseminated. Locally are installed one monitor that, in real time, informs about the energy produced via PV and the energy consumed in pumping and other uses.

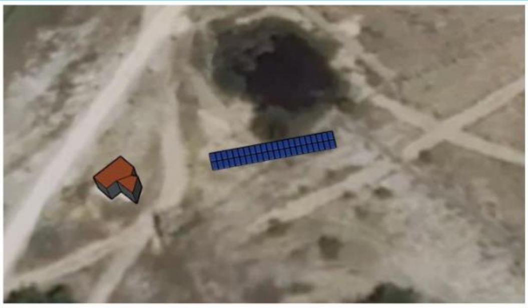
For agricultural purposes, water pumping often has the main consumption of electricity. If the irrigation system is suitable for daytime irrigation or there is storage capacity for surface water, the use of photovoltaic energy can have a significant impact on the sustainability of the farm.

4. ANNEXES

ANNEX I: Financial analysis

VISÃO GLOBAL DO PROJETO	
P Instalada (*kWp*)	12.0
P Nominal (*kW*)	10
Ciclo/Tarifa	13.Semanal com Feriados TETRA-HORARIA
Simulador	PVsyst®
Base de Dados	Meteonorm® 6.1
Encargo anual original (sem autoconsumo)	5 415.43 €

IMPLANTAÇÃO



	Modelo	Quant.	Garantia
Paineis	Módulo Futura 270Wp	44	15
Inversores	Inversores Kaco	1	7
Estrutura	Estrutura para fixação de paineis fotovoltaicos apoiados	1	10
Monotorização	SolarLog	1	2

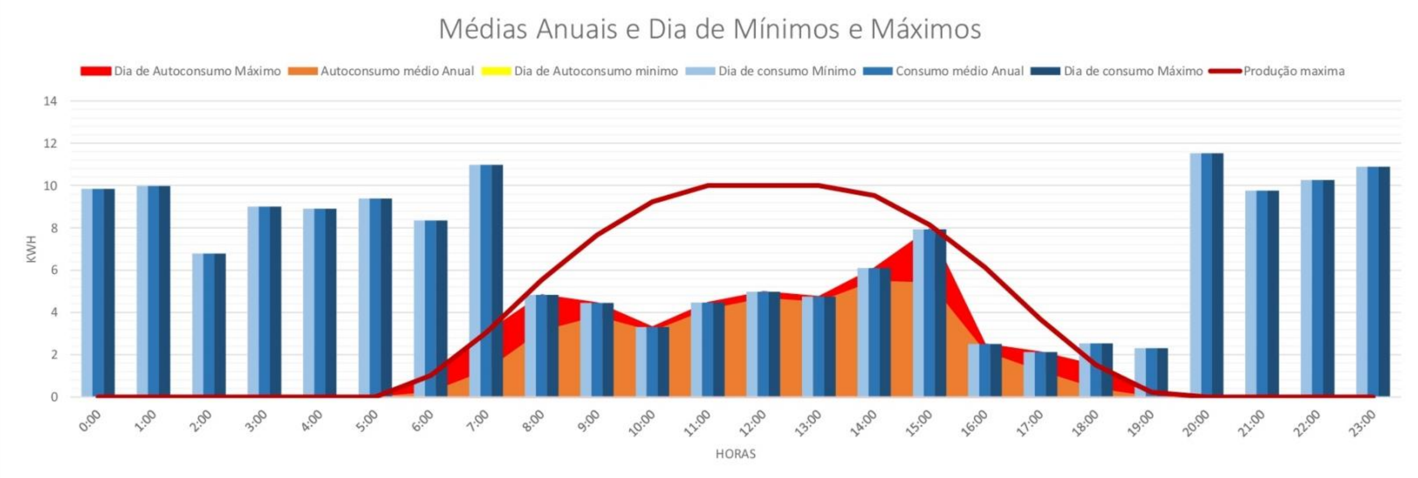
Indicadores de Performance Solar	
Performance Ratio - Desempenho do sistema em relação ao máximo teórico (%)	84.1%
Fração Solar - Contributo do sol para os consumos energéticos globais (%)	23.9%
Produção Específica no primeiro ano (kWh/kWp)	1735

Considerações técnico-financeiras	
Período de análise [Anos]	25 Anos
Taxa de atualização de capital	2.00%
Aumento do custo de energia	2.00%
Depreciação da produção anual	0.50%
Comparticipação	0%

Desempenho Financeiro

Investimento Total s/IVA (€)	16865.00
Poupança no primeiro ano (€)	1 985.83
VAL - Valor Atualizado Líquido (€)	24410.69
TIR - Taxa Interna de Rentabilidade (%)	11.2%
Retorno de Investimento (€)	1.45
Payback c/ atualização de capital	9 Anos e 11 Meses
LCOE - Levelized Cost of Energy (€/kWh)	0.046
Tarifa Média Evitada (€/kWh)	0.101
Custo por Wp instalado (€)	1.41

Tarifa em vigor	
Vazio Normal	0.07250 €
Super Vazio	0.07130 €
Cheias	0.10770 €
Pontas	0.11780 €



ANNEX II: Technical study

Grid-Connected System: Simulation parameters

Project : **Sesimbra Natura Park**

Geographical Site **Sesimbra, maçã** Country **Portugal**

Situation Latitude 38.5°N Longitude 9.1°W
Time defined as Legal Time Time zone UT Altitude 122 m
Albedo 0.20

Meteo data: **Sesimbra** Synthetic - Meteonorm 7.1 (1991-2010), Sat=65%

Simulation variant : **12kW**
Simulation date 29/11/17 18h43

Simulation parameters

Collector Plane Orientation Tilt 20° Azimuth 0°

Models used Transposition Perez Diffuse Erbs, Meteonorm

Horizon Free Horizon

Near Shadings No Shadings

PV Array Characteristics
PV module Si-poly Model **FU 270P**
Custom parameters definition Manufacturer Futura

Number of PV modules In series 22 modules In parallel 2 strings
Total number of PV modules Nb. modules 44 Unit Nom. Power 270 Wp
Array global power Nominal (STC) **11.88 kWp** At operating cond. 10.85 kWp (50°C)
Array operating characteristics (50°C) U mpp 633 V I mpp 17 A
Total area Module area **71.9 m²**

Inverter Model **Powador 12.0 TL3**
Manufacturer Kaco new energy
Characteristics Operating Voltage 200-800 V Unit Nom. Power 10.0 kWac

Inverter pack Nb. of inverters 1 units Total Power 10.0 kWac

PV Array loss factors
Array Soiling Losses Loss Fraction 2.0 %
Thermal Loss factor Uc (const) 29.0 W/m²K Uv (wind) 0.0 W/m²K / m/s
Wiring Ohmic Loss Global array res. 812 mOhm Loss Fraction 2.0 % at STC
Module Quality Loss Loss Fraction 0.0 %
Module Mismatch Losses Loss Fraction 1.0 % at MPP
Incidence effect, ASHRAE parametrization IAM = 1 - bo (1/cos i - 1) bo Param. 0.05

System loss factors
Wiring Ohmic Loss Wires: 3x1.5 mm² 22 m Loss Fraction 2.0 % at STC
Unavailability of the system 3.6 days, 3 periods Time fraction 1.0 %

User's needs : daily profile Constant over the year
average 166 kWh/Day

	0 h	1 h	2 h	3 h	4 h	5 h	6 h	7 h	8 h	9 h	10 h	11 h	
	12 h	13 h	14 h	15 h	16 h	17 h	18 h	19 h	20 h	21 h	22 h	23 h	
Hourly load	9.85	9.98	6.77	9.00	8.90	9.38	8.35	10.98	4.83	4.44	3.30	4.46	kW
	4.98	4.75	6.09	7.94	2.51	2.12	2.53	2.31	11.52	9.76	10.25	10.88	kW

Grid-Connected System: Detailed User's needs

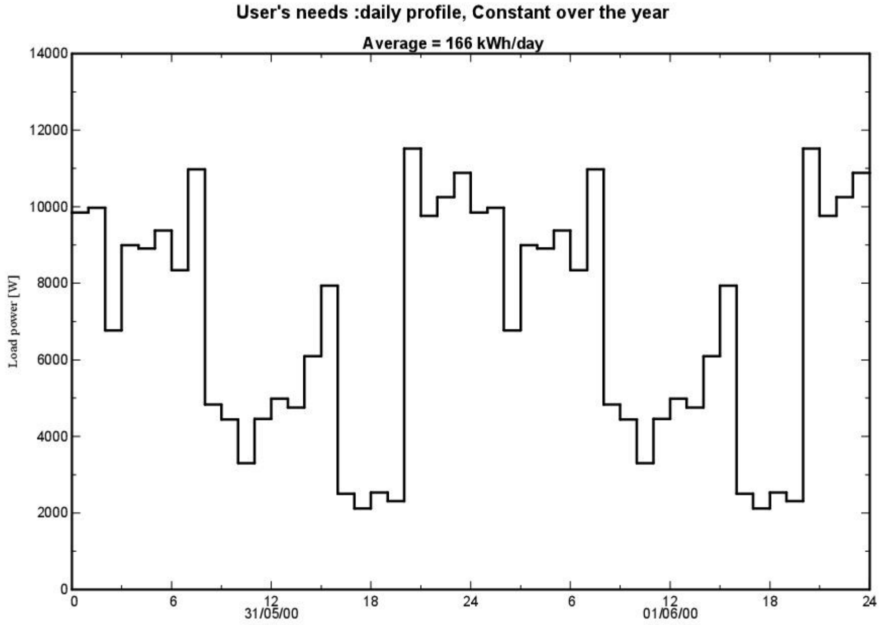
Project : **Sesimbra Natura Park**

Simulation variant : **12kW**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	20°	azimuth	0°
PV modules	Model	FU 270P	Pnom	270 Wp
PV Array	Nb. of modules	44	Pnom total	**11.88 kWp**
Inverter	Model	Powador 12.0 TL3	Pnom	10.00 kW ac
User's needs	daily profile	Constant over the year	global	60.5 MWh/year

daily profile, Constant over the year, average = 166 kWh/day

	0 h	1 h	2 h	3 h	4 h	5 h	6 h	7 h	8 h	9 h	10 h	11 h	
	12 h	13 h	14 h	15 h	16 h	17 h	18 h	19 h	20 h	21 h	22 h	23 h	
Hourly load	9.85	9.98	6.77	9.00	8.90	9.38	8.35	10.98	4.83	4.44	3.30	4.46	kW
	4.98	4.75	6.09	7.94	2.51	2.12	2.53	2.31	11.52	9.76	10.25	10.88	kW



Grid-Connected System: Main results

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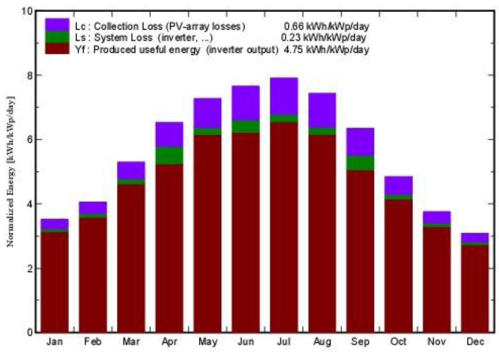
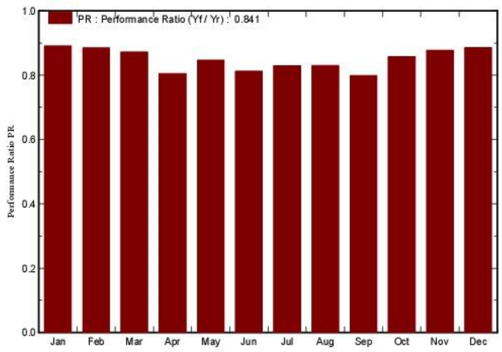
Main simulation results				
System Production	**Produced Energy**	**20.61 MWh/year**	Specific prod.	1735 kWh/kWp/year
	Performance Ratio PR	84.1 %	Solar Fraction SF	23.9 %

Normalized productions (per installed kWp): Nominal power 11.88 kWp



Performance Ratio PR



12kW

Balances and main results

	GlobHor	T Amb	GlobInc	GlobEff	EArray	E Load	E User	E_Grid
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Legends:				
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Grid-Connected System: Loss diagram

Project : **Sesimbra Natura Park**

Simulation variant : **12kW**

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Inverter	Model	Powador 12.0 TL3	Pnom	10.00 kW ac
User's needs	daily profile	Constant over the year	global	60.5 MWh/year

Loss diagram over the whole year