Mitigation Enabling Energy Transition in the MEDiterranean region

Role of Energy Manager & Energy management and monitoring

(Amádis, Santos, Energy Expert, Adene)

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Resume

1

Theorical Session

I. Role of energy manager;
II. How to manage energy:
- Tools for energy management.

III. Energy monitoring:
- Example: Energy Barometer.

IV. Measurement and Verification (M&V).

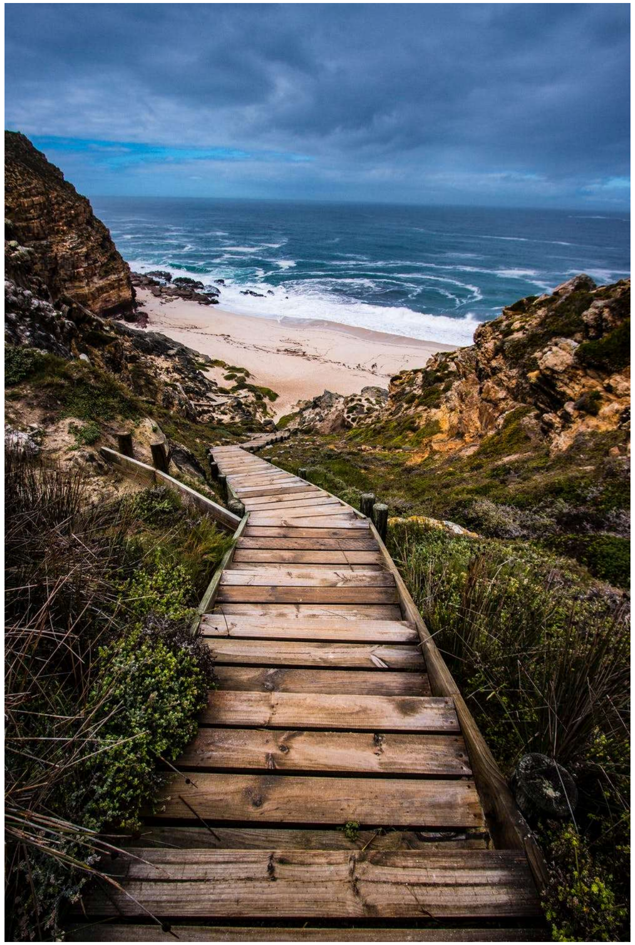
2

Practical Session

V. Energy Audit example;
VI. Energy efficiency measures study:
- Lighting;
- HVAC;
- Motors;
- Equipments;
- Etc.

VII. Measurement and Verification (M&V) example.

Module 2



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- Energy efficiency measures study;
- Measurement and Verification (M&V) exemple.

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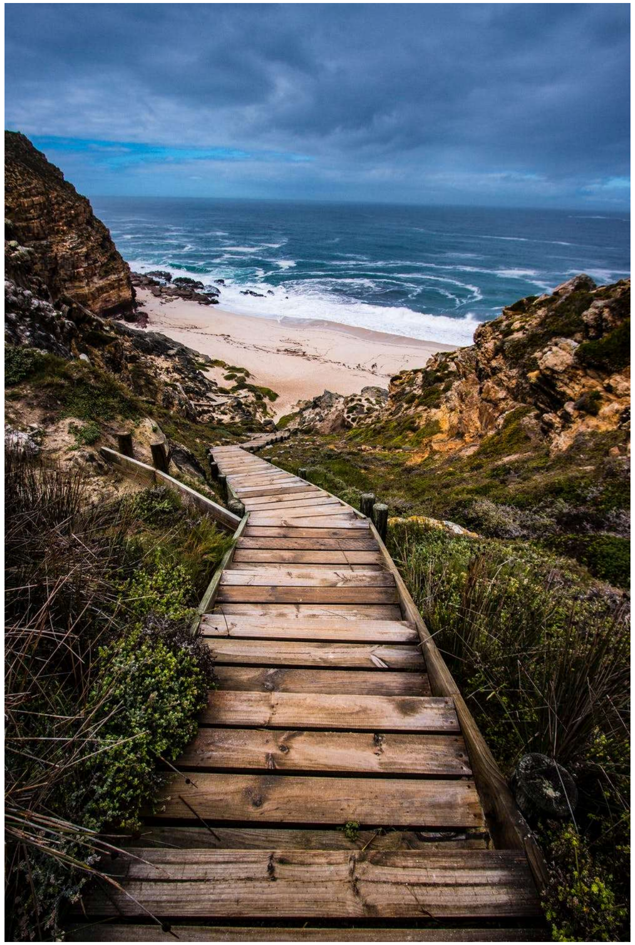

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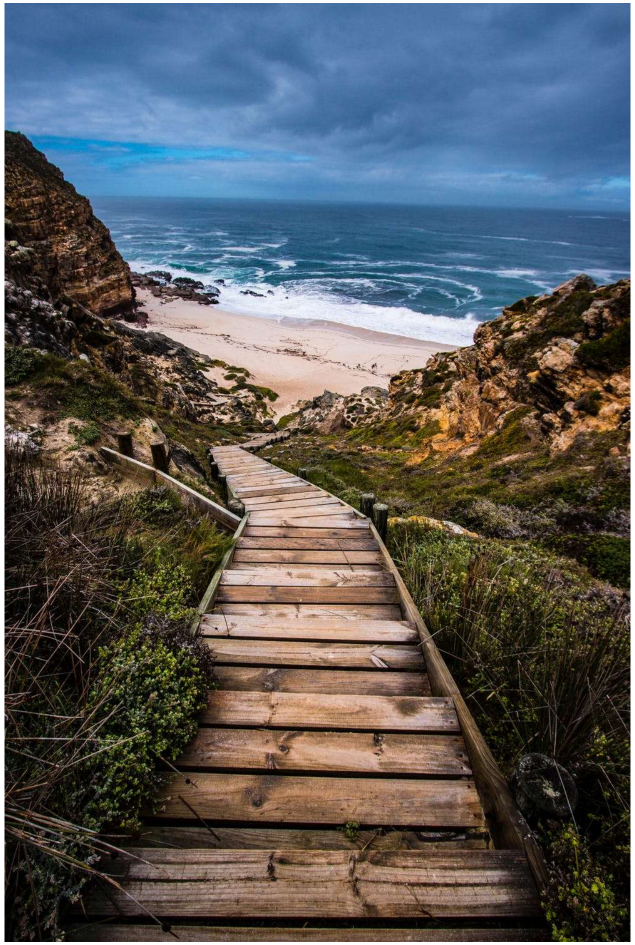
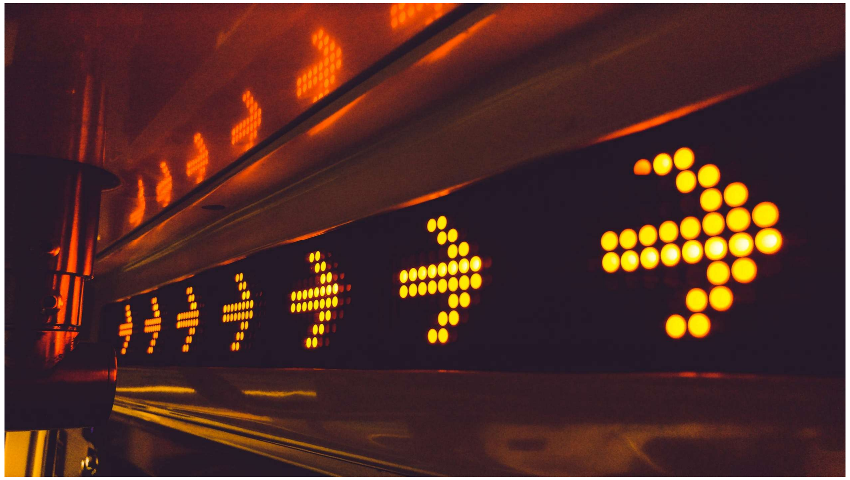


Kilowatt Hour (kWh)

One kilowatt hour is the amount of energy that would be converted by a one thousand watt appliance when used for one hour.



Example:

A consumer uses a 6 kW immersion heater, a 4 kW electric stove and three 100 watt lamps for 10 hours. How many units (kWh) of electrical energy have been converted?

- **Total power in kW:** $\frac{6+4+300}{1000} = \mathbf{10,3}\ \mathrm{kW}$
- **Energy in kWh:** $\text{Power in watts} \times \text{time in hours} = 10{,}3 \times 10 = \mathbf{103\ kWh}$

Question: Calculate the corresponding average monthly energy use for your installation, considering:

- The average monthly electric bill are: **15 000 €/year;**
- Costs of electric power: **0,11€/kWh.**

- **Result:** $\frac{\text{Average monthly electric bill}}{\text{Costs of electric power}} = \frac{\mathbf{15000}}{0{,}11} = \mathbf{136364}\ \frac{\text{kWh}}{\text{year}}$

- **Answer:** $\frac{\text{Average year electric bill}}{\text{Number of months}} = \frac{136363{,}6}{12} = \mathbf{11364}\ \text{kWh/month}$

Question:

A) If a wind turbine operates at its rated power (1500 kW) 100% of the time for a full year, how much energy would it produce in a year?

Answer: $\text{Rated power x total hours } per\ year = 1\,500 \text{ x } 8\,760 = \mathbf{13\,140\,000}\ \text{kWh/year}.$

B) This wind turbine has a capacity factor equal to 0,38 (this means that over a year, it will produce only 38% of its theoretical maximum energy production). How much energy does this turbine actually produce in a year?

Answer: $\text{Total energy production (at rated power) x efficiency} = 13\,140\,000 * 0{,}38 = \mathbf{4\,993\,200}\ \text{kWh/year}.$

Energy efficiency measures study

EXERCISE

03

Question:

A) The PV system is operating in a location where the annual average daily incident solar energy (the insolation) incident on the array equals 5 $kWh/m^2/day$. Calculate the average amount of solar energy incident on the PV array each day for a area of 50 m^2?

Answer: $\text{Area } \times \text{total incident solar energy by day} = 50 \times 5 = \mathbf{250}\ \text{kWh/day}$

B) The efficiency of the PV system equals 18% (i.e. 18% of the solar energy incident on the array is transformed into useful electric power). Calculate the daily average electric energy produced by this system?

Answer: $\text{Average amout of solar energy incident } \times \text{efficiency} = 250 \times 0{,}18 = \mathbf{45}\ \text{kWh/day}$

C) Calculate the average amount of electric energy produced by this system each year?

Answer: $\text{Daily energy produced } \times \text{n.º of days} = 45 \times 365 = \mathbf{16\,425}\ \text{kWh/year}$

Energy efficiency measures study

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Lighting Systems

Question:

In a building that has 60 light bulbs (each 150 watts) on each floor, for 8 hours per day throughout the year in a building with 8 floors and a daily population of 800 people.

Answer:

$$\frac{\left[\frac{\text{Average Watts per bulb}}{1000} \times \frac{\text{number of bulbs}}{\text{Floor}} \times \text{Floors} \times \frac{\text{Light hours}}{\text{day}}\right]}{\frac{\text{Number of occupants}}{\text{day}}} =$$

$$\frac{\left[\frac{150}{1000} \times 60 \times 8 \times 8\right]}{800} = \mathbf{0,72}\,\frac{kWh}{person}/day$$

Cooling Systems

EXERCISE

06

Question:

Calculating the energy cost of cooling your space (installation) on an annualized daily basis, this formula calculates the total kWh per year and divides this by 365 and the number of users (that often share a cooling device/system).

Answer: $(\text{number of devices}) \times \frac{\text{Watts}}{1000} \times \frac{\text{hours}}{\text{day}} \times \frac{\text{days}}{\text{year}} = \frac{\left[\frac{150}{1000}\times 60\times 8\times 8\right]}{800} = \mathbf{0,72}\,\frac{kWh}{person}/day$

Rated power x total $hours\ per\ year$ = 1 500 x 8 760 = **13 140 000** kWh/year.

Module 2

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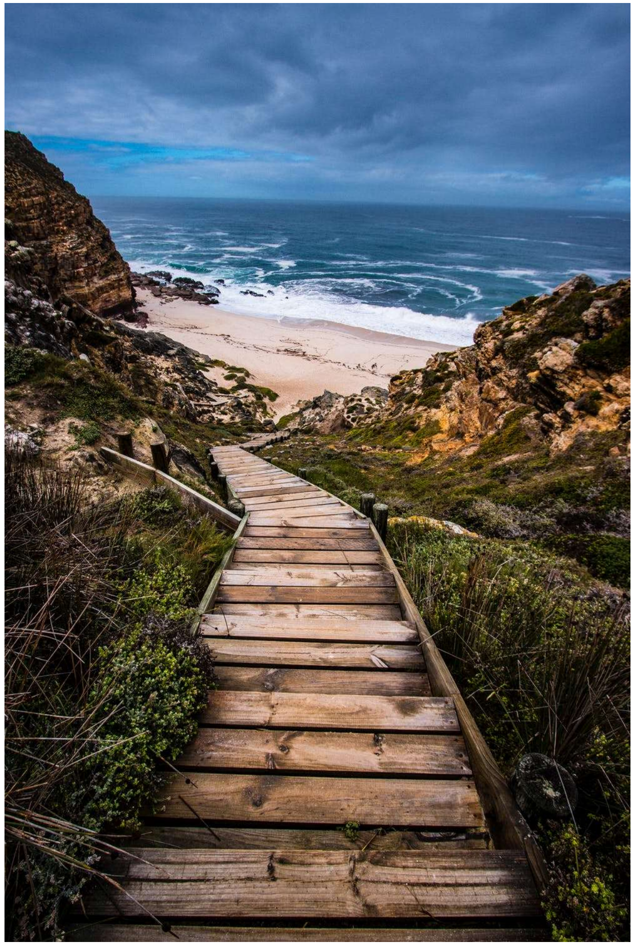

Table of contents

Description of the School

Year constructed	1968
Surface area	24 577 m^2
Energy sources and uses	Electricity • Lighting • Ventilation • Air conditioning • Compressors • Welding equipment • Computer hardware • Other Natural gas • Boilers and direct-fired air heaters
Type of heating	Hot water and direct-fired air heaters
Energy consumption at reporting period	50 114 GJ
Energy intensity at reporting period	1,76 GJ/m^2

Energy Conservation Measures

	ECM	Description	Annual Savings
1	Optimization of auditorium ventilation system controls	The addition of variable frequency drives will enable air flow into the auditorium to be controlled. To reduce the energy the fans consume, air flow will be adjusted according to auditorium occupancy. A CO_2 sensor will ensure a minimum fresh air flow. It will also enable zone damper controls to be adjusted, which will reduce fresh air intake into the CA-1 system.	2 236€
2	Optimization of garage ventilation system controls	The addition of variable frequency drives will enable air flow into the garage to be controlled. For the safety of the garage users, air volume will be adjusted based on carbon monoxide (CO) and nitrogen dioxide (NO_2) levels. The system will also adjust flow depending on whether the exhaust collector is on and the room's motion detector is activated.	53 112€
3	Optimization of cafeteria ventilation system controls	Variable frequency drives will be added to reduce air flow into this room. Flow will be controlled based on cafeteria occupancy and vent hood use. To optimize the system, motion detectors, CO_2 sensors and zone dampers will be installed.	925€
4	Optimization of body shop ventilation system controls	Existing equipment will be replaced with a variable frequency drive system. Heating will be provided by a glycol coil connected to the low-temperature system. The system can be used to pressurize the hall to avoid spreading contaminants to other sectors. A motion detector in the room will determine when the system operates.	29 982€
5	Optimization of gym ventilation system controls	Motion detector, CO_2 sensor and zone damper systems will be added to optimize fresh air input.	6 231€
6	Heat recovery and air preheating in the A-15, A-16 and A-17 systems	The recovery system will be connected to the low-temperature system, which will enable the building's domestic water to be preheated.	14 780€
7	Temperature reduction with night setback	Temperature set points will be lowered at night by 2 °C—a very conservative value. If this reduction does not cause building users any discomfort or inconvenience, the building manager will further lower temperature set points.	4 512€
8	Hot water supply system temperature adjustment	The existing hot water system will be converted into a variable flow system in each zone.	62 232€
9	Variable displacement pump in the peripheral heating system	The entire high-temperature hot water system will be controlled through the building's energy management system. Water temperature will be tightly controlled through temperature sensors to reduce system loss. Differential pressure sensors will lower the pumping system flow rate by about 40%.	
10	Heating of the high-temperature hot water system with an electric boiler	This measure proposes adding an electric boiler for off-peak heating. Using an instant power reading, a 300 kW or so electric boiler will be able to feed hot water into the system during off-peak hours.	
11	Heating of the low-temperature system with a heat pump	An air-to-water heat pump system will be installed. To maximize the system's operating range and capacity, outside air will be mixed with air from the building's exhaust systems. The installation of a solar wall is planned, which will preheat the outside air used by the heat pumps.	33 708€
12	Mechanical pool dehumidifier and heat recovery	This measure proposes replacing the DA-1 system with an energy-recovering mechanical dehumidifier as well as replacing the existing ventilation system. The dehumidifier will recover energy that can be used to heat the space in winter and mid-season. It will also heat the pool water and one of the heating systems if needed.	23 267€

Estimate of Total Project Savings

	Annual Consumption Before	Annual Consumption After	Savings	Savings	Savings
Electricity	4 715 280 kWh	6 318 475 kWh	-1 603 195 kWh	-124 404€	-34%
Natural gas	874 601 m^3	116 453 m^3	760 903 m^3	353 153€	87%
Total	50 114 GJ	27 055 GJ	23 059 GJ	228 749€	46%

Measurement option and boundary

Measurement Boundary
Option C: Whole Facility

IPMVP Option Used to Determine Savings
Option C According to the IPMVP, Volume I

Justification of the Selected Option, Gain/Reporting Period Ratio
The measurement option for the whole facility was chosen because the energy providers’ meters are used to assess the energy performance of the whole facility. This option determines collective savings for all energy conservation measures (ECMs) implemented.

Baseline: PeRIOD, Energy and Conditions

Facility's Baseline Electricity Consumption

Billing Period		Electricity Consumption
From	To	kWh
2017-07-01	2017-07-31	321 120
2017-08-01	2017-08-31	335 520
2017-09-01	2017-09-30	412 560
2017-10-01	2017-10-31	394 560
2017-11-01	2017-11-30	424 080
2017-12-01	2017-12-31	409 680
2018-01-01	2018-01-31	431 280
2018-02-01	2018-02-28	418 320
2018-03-01	2018-03-31	433 440
2018-04-01	2018-04-30	393 120
2018-05-01	2018-05-31	401 760
2018-06-01	2018-06-30	339 840
Total		**4 715 280**

Facility's Baseline Natural Gas Consumption

Billing Period		Natural Gas Consumption
From	To	m^3
2017-07-01	2017-07-31	7 970
2017-08-01	2017-08-31	12 244
2017-09-01	2017-09-30	26 441
2017-10-01	2017-10-31	49 478
2017-11-01	2017-11-30	78 797
2017-12-01	2017-12-31	112 010
2018-01-01	2018-01-31	159 910
2018-02-01	2018-02-28	144 722
2018-03-01	2018-03-31	119 151
2018-04-01	2018-04-30	87 995
2018-05-01	2018-05-31	50 595
2018-06-01	2018-06-30	25 288
Total		**874 601**

Independent Variables

Independent Variables for Electricity Consumption

Period		Heating Degree-Days (°C)	Number of class days
From	To		
2017-07-01	2017-07-31	12,7	0
2017-08-01	2017-08-31	19,4	6
2017-09-01	2017-09-30	147,6	20
2017-10-01	2017-10-31	353,4	20
2017-11-01	2017-11-30	526,7	20
2017-12-01	2017-12-31	767,5	15,5
2018-01-01	2018-01-31	876,0	14
2018-02-01	2018-02-28	773,7	18
2018-03-01	2018-03-31	696,8	17
2018-04-01	2018-04-30	436,3	15
2018-05-01	2018-05-31	220,9	17,5
2018-06-01	2018-06-30	54,2	0
Total		**4 885**	**163**

Independent Variables for Natural Gas Consumption

Period		Heating Degree-Days
From	To	°C
2017-07-01	2017-07-31	19,4
2017-08-01	2017-08-31	22,1
2017-09-01	2017-09-30	109,6
2017-10-01	2017-10-31	321,8
2017-11-01	2017-11-30	447,2
2017-12-01	2017-12-31	670,2
2018-01-01	2018-01-31	982,8
2018-02-01	2018-02-28	778,2
2018-03-01	2018-03-31	690,1
2018-04-01	2018-04-30	530,1
2018-05-01	2018-05-31	248,0
2018-06-01	2018-06-30	78,1
Total		**4 898**

Static Factors

Static factors	Source of Data
Building or area utilization	Detailed feasibility study of the energy efficiency project and floor drawings
Building occupancy rate	Detailed feasibility study of the energy efficiency project
Building floor area	Floor drawings
Number and capacity of heating, ventilation, and air conditioning systems (HVAC)	Appendices 1 and 2 of the present M&V plan
Building standards and legislation governing ambient conditions	Client's conditions
Building utilization schedule	Appendix 2 of the present M&V plan and detailed feasibility study of the energy efficiency project
Hours of operation of HVAC systems	Appendix 2 of the present M&V plan
Lighting hours of operations	Detailed feasibility study of the energy efficiency project
Outdoor air supply rate	Detailed feasibility study of the energy efficiency project
Temperature setpoints	Detailed feasibility study of the energy efficiency project
Hot and chilled water temperature	Detailed feasibility study of the energy efficiency project

Basis for Adjustment

Retained Option	Equation
Avoided energy use (or energy savings)	Avoided energy use = Baseline energy (±) Routine adjustments to reporting period conditions (±) Non-routine adjustments to reporting period conditions (-) Reporting period energy
Avoided demand	Avoided Demand = Baseline demand (±) Routine adjustments to reporting period conditions (±) Non-routine adjustments to reporting period conditions (-) Reporting period demand

But, there is more………..**like the energy costs**

Format of the M&V Report

M&V report for the Installation XXX

- **Facility consumption and demand data (utility bills):**
    - Electricity consumption and demand data;
    - Natural gas consumption data;
    - Summary chart of facility consumptions and demands.
- **Baseline period adjustment data:**
    - Independent variables;
    - Static factors.
- **Readjusted baseline period calculation;**
- **Energy savings calculations (kWh, m_3 and €);**
- **Evaluation of cumulative savings from the start of the project, on a yearly basis.**

Amádis Cláudio Santos

Energy Expert

amadis.santos@adene.pt

adene
Agência para a Energia

Av. 5 de Outubro, 208 - 2º Piso

1050-065 Lisboa – Portugal

(+351) 214 722 800 / 925 495 311

Amádis Cláudio Santos

Energy Expert

amadis.santos@adene.pt

adene
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Av. 5 de Outubro, 208 - 2º Piso

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