1 Decision Support Tool (SDT) for: school rehabilitation planning, based on most suitable REEE solutions tested in the project for building type & use and climatic zone; estimation of potential impact.

ESMES Project

“Energy Smart Mediterranean Schools Network”

A_B.4.3_0123

ENI CBC MED PROGRAM

OUTPUT 3.4

INTRODUCTION

In order to simplify the writing of a tool for choosing the best energy efficiency measures, the steps to be developed are described:

Step 1

- Carrying out a simplified energy audit for the building under consideration to determine a number of parameters (Pi) typically:
o types of winter and summer air-conditioning systems;
o use of renewable energy; (yes/no)
o level of thermal insulation of the dwelling
o energy requirements of the building (other than lighting)
o materials used for fixtures (possibly with the support of thermo-scanners)
o type of indoor lighting
o climatic positioning of the school
o positioning of the school in the urban context
o Size of the building (m^2) and evaluation of the % glazed area
o Type and efficiency of fixtures

- For each of the above parameters a **reference value** should be assigned to allow the choice of the best intervention afterwards.
An example: *if the school already has LED indoor lighting for that parameter a nominal value will be given that is minimal compared to the value given to the energy/cost improvement ratio.*
If possible, taking average literature data for public buildings (schools) as a reference, an algorithm will be produced to obtain a value for the building under consideration.

Step 2

Based on the findings of the audit, it is determined "ex-ante" what the starting energy class is and based on Pi's notional reference values what are the most reasonable and impactful energy improvements.

What is the expected RESULT?

To achieve with the suggested improvements and the available budget an energy efficiency value energy efficiency value that deviates less from the average value in the literature and that in any case has a lower delta % than the starting figure:

Energy class	Consumption kWh/year
A+	<15
A	<30
B	between 31 and 50
C	between 51 and 70
D	between 71 and 90
E	between 91 and 120
F	between 121 and 160
G	> 160

Step 3

- At the same time, a tool, any tool, is created that reports a series of energy improvement 'actions' such as:

o Action to be taken

o Energy efficiency improvement (savings? How to quantify it? in terms of KWh/year of savings?)

o Available budget

o Cost of the action in the various ESMES countries (in Euros):

The currency column is filled in case the PP has sent the inputusing the local currency

#	PP	PP1			PP2	PP3	PP4		PP5	
No.	Energy improvement action	Currency	PP1_Cost in Jordan All prices may vary for several reasons such as: - Services provided - Installation costs - Warranty period Also, prices may vary from day to day	Note	PP2_Cost in Italy	PP3_Cost in Spain (obtained from the Valencian Building Institute)	Currency	PP4_Cost in Tunis	PP5_Cost in Lebanon	Note
1	Replacing incandescent bulbs with energy-saving bulbs	Jod	**0.5JDs - 1.5JDs per item**	Currently, this is **not used in Jordan** since LEDs are used for efficient lighting. Also, the prices for energy-saving bulbs and LEDs are almost the same, which increase the usage of LEDs.	Prezzo in media di 5€	8,40 €	Not available		2.7 €/Bulb	Based on input from local suppliers in Lebanon
		Euro	0.63 Euro - 1.91 Euro per item							
2	Replacing energy-saving light bulbs with LED bulbs	Jod	**1JDs - 6.5JDs per item** **Most Common (Avg.): 1.5JDs**	Prices may vary depending on LEDs characteristics such as: Wattage, Lifetime, Size, Lumin, and Continuous Operating Time	Lampade LED: prezzi compresi tra 15€ e 50€	16,10 €	TND	**634,967.440 TND**	5.81 €/Bulb	Based on input from local suppliers in Lebanon, (Bulb price included)
		Euro	1.27 Euro - 8.30 Euro per item Most common (Avg): 1.91 Euro				Euro	190,930.3264 EUR		
3	Replacement of window frames	Jod	**15 JDs - 85 JDs per squared meter** **Most Common (Avg.): 30JDs**	Prices may vary depending on brand, the space in inner champer, and insulation type (which might include powders to absorb heat and humidity)	Infissi prezzi in PVC ha un costo compreso tra 100 € e 200 € al metro quadro. Il legno si aggira tra i 150 € e i 250 € al metro quadro, a seconda della varietà della materia e dei trattamenti. Prezzi finestre in alluminio invece possono avere un costo tra i 200 € e i 300 € al	626,82 € (ventana aluminio con RPT de 1,2x1,2)	Not available		47 €/m2	Calculated based on the below two entries
		Euro	19.16 Euro - 108.57 Euro per squared meter Most Common (Avg.): 38.32 Euro							
4	Replacement and/or improvement of glazing (double glazing, with inner chamber)	Jod	**15 JDs - 85 JDs per squared meter** **Most Common (Avg.): 30JDs**		Prezzi medi al mq : da 120 a 180€	104,70 € (ventana de 1,2x1,2 - cristal 6/9/6)	TND	**484,076.000 TND**	75.2 €/m2	Based on input from local installers in Lebanon
		Euro	19.16 Euro - 108.57 Euro per squared meter Most Common (Avg.): 38.32 Euro				Euro	145,558.31191 EUR		
5	Complete window replacement	Jod	**65JDs - 170 JDs per squared meter** **Most Common (Avg.): 80JDs**		Serramenti completi prezzi in PVC ha un costo compreso tra 150 € e 300 € al metro quadro. Il legno si aggira tra i 200 € e i 350 € al metro quadro, a seconda della varietà della materia e dei trattamenti. Prezzi finestre in alluminio invece possono avere un costo tra i	787,95 € (ventana 1,2x1,2)	Not available		122.2 €/m2	Based on input from local installers in Lebanon
		Euro	83.02Euro - 217.14 Euro per squared meter Most Common (Avg.): 102.18 Euro							
6	Efficiency upgrading of heating systems by replacement with condensing boiler	Jod	**400JDs - 850JDs per 24kW boiler** **Most Common (Avg.): 550JDs**	Prices vary each day and highly depends on installation costs. Also, the boiler size plays an important role, where larger sizes may	Il costo di una caldaia a condensazione parte da circa 500-600€ per potenze basse sui 24 kW fino a 1.500-2.000€ per potenze sui 32kW. Il prezzo	3.063,12€ (Caldera gas 30 kW)	TND	**128,793.770 TND**	Gas condensing boiler: €1458 Oil condensing boiler: €3952	For small family houses with cumulative area 150 m²

		Euro	510.93 Euro - 1085.73 Euro per 24kW boiler Most Common (Avg.): 702.53 Euro	reach 3650JDs	dei modelli di caldaie più sofisticati possono anche superare 4 o 5 migliaia di euro.		Euro	38,727.39765 EUR		
7	Efficiency upgrading of heating systems by replacement with heat pump	Jod	**2000JDs - 6000JDs**	Rarely used in Jordan and hard to find. This type is not recommended in Jordan, and can be implemented by one company, which recommends the availability of PV systems before installation	In linea di massima, il prezzo di un sistema di questo tipo si aggira sui € 15.000. La pompa di calore ha un costo che può andare dagli 800 ai 1.700 €/kW, a seconda del tipo di impianto.	8.223,76 (Bomba de calor 15 kW)	TND	**1214908.284 TND**	Air-water heat pump: €13689	For small family houses with cumulative area 150 m²
		Euro	2554.66 Euro - 7664 Euro				Euro	365,314.5352 EUR		
8	Insulation of heating system distribution network	Jod	**0.5JDs - 5JDs/m**	Depends on insulation type, tube type, tube size, installation method, and materials used (such as gypsum, cement, fabric, tape, plastic, nylon)	Not available	15 €/m	TND	**27,293.280 TND**	9.4€/m	Per meter of pipework
		Euro	0.63 Euro - 6.38 Euro/m				Euro	8,206.90091 EUR		
9	Replacement of emission terminal units	Jod	**55JDs - 68JDs**	Prices do not include installation. Prices depends on the material used: **Iron sheet** is being sold by meter, and requires a set of wrenches, where the **Aluminum pipes** are being sold by pipe, and requires a set of plugs	Not available	212,19 € (emisor de 570x80x80mm, 20 bar, 105 kcal/h)	Not available		11.1€/m² of building floor area	Price of installing a new heat radiator into an existing system
		Euro	70.25 Euro - 86.85 Euro							
10	Climatic thermoregulation systems	Jod	Not Available	This type of thermoregulation system cannot be found alone and only installed with a complete system, and not available in Jordan. However, it can be fixed using the warranty.	Not available	is not possible to calculate it due to the variability	Not available		VRF (Variable Refrigerant Flow): 24400€	For 5 apartments with cumulative area 600m2 (COP approx. 4.2) - one outdoor unit supplying several indoor units
		Euro								
11	Zone thermoregulation systems	Jod	**40JDs/peace**	Thermoregulation systems are rarely found in Jordan. However, this price is found in Jordan for the digital type	Not available	is not possible to calculate it due to the variability	Not available		VRF (Variable Refrigerant Flow): 8580€	For 4 rooms with cumulative area 100m2 (COP approx. 4.2) - one outdoor unit supplying several indoor units
		Euro	51.09 Euro/peace							
12	Room thermoregulation systems	Jod	**30JDs - 300JDs/peace** **Most Common (Avg.): 50JDs/peace**	Prices may vary depending on the system's features such as Wifi monitoring and controlling, in addition to other customer's requirements. Also, there are several types such as electric underfloor, and basic room thermoregulator	Not available	is not possible to calculate it due to the variability	Not available		Single split AC: 728€	For 2 rooms with cumulative area 50m2 (COP approx. 4.2)
		Euro	38.32 Euro - 383.20 Euro/peace Most Common (Avg.): 63.86 Euro/peace							

13	Efficiency systems for domestic hot water production	Jod	**150JDs - 550JDs** **Most Common (Avg.): 400JDs**	Prices may vary depending on the solar heating technology used, such as pipes or plates. Also, prices depend on pumps and insulations	Not available	is not possible to calculate it due to the variability	TND	**11,102.500 TND**	1.363€	Price for a 200L flat plate solar water heater system
		Euro	191.60 Euro - 702.53 Euro Most Common (Avg.): 510.93 Euro				Euro	3,338.44512 EUR		
14	Efficient cooling and ventilation systems	Jod	**290JDs - 515JDs**	Prices may vary depending on the brand, refregirant type, and technologies such as Wifi control, and auto-settings	Not available	is not possible to calculate it due to the variability	TND	**1,502,344.318 TND**	Ventilation system with 60% heat recovery: 1154€ VRF (Variable Refrigerant Flow): 8580€	For small family houses with cumulative area 150 m² For 4 rooms with cumulative area 100m2 (COP approx. 4.2)
		Euro	370.42 Euro - 657.82 Euro				Euro	451,744.56663 EUR		

Step 4: FINAL RESULT and recommendations

1) Match between the various actions in order to find the best compromise that for the available budget gives the best percentage of energy efficiency and thus financial savings and payback.
2) Difficulties: define this requires very extensive literature research to:
   - Define the energy efficiency improvement of the various actions in terms of KWh/year
   - Define the cost of the various actions in the various ESMES countries
3) Once the **table** has been somewhat defined:
   Define the methodology for which, based on the "building" audit, one chooses which/what type of actions should be carried out. For example, one may choose to intervene on a single item (e.g. replacement of incandescent lighting vs LED) or on a mix of several items (fixtures + thermal insulation) etc. etc.

ESMES

Educational approach for calculation and optimization energy consumption in school buildings

Educational software tool to be used for calculatimg the energy consumtion of school buildins and the financial consequences of the implementation of energy saving measures.

The tool complies with international standard, including: ISO/DIS 13790 "Termal performance of buildings - Calculation of energy use for space heating and cooling" for the calculation of energy consumption and EN15316-4-3 for calculating the output of a solar plant.

The energy trends in the Mediterranean region are characterized by the growing demand for energy, fossil fuels dependence, high CO2 emissions, etc., with negative consequences on the environment. Buildings are responsible for a significant part of the total energy consumption, causing 36% of CO2 emissions. In this context, increasing the energy performance of the building stock has a key role to play in the transition to a smarter, renewable-intensive and decarbonised energy system and, in the longer term, to a climate-neutral economy. ESMES project will specifically focus on the optimization of energy consumption in public schools through innovative, monitoring-based renewable energy and energy efficiency (REEE) pilot actions. At the same time, the project will improve the capacity of 5 public institutions in order to implement innovative energy rehabilitations.

The use of the tool is a process using the 4 steps described below, starting with step 1:

1) BUILDING Data INPUT
2) USE of Building and Lighting Data INPUT
3) Optimization
4) Final REPORT

ASCOT Light embedded

ESMES

Building Data INPUT

I.T.S. di prova

WEATHER DATA — Terni TR

CONSTRUCTION DATA

Construction Year	1990	
N° of students	380	
Total area of the school	4.800	m² [10m² per student]
Teaching Area	2.400	m²
Area of corridor/staircases	1.400	m²
Number of floor levels	1	
Desired temperature into the room	21	°C
Heated basement	No	
Window area/heated floor area	Medium – 20%	

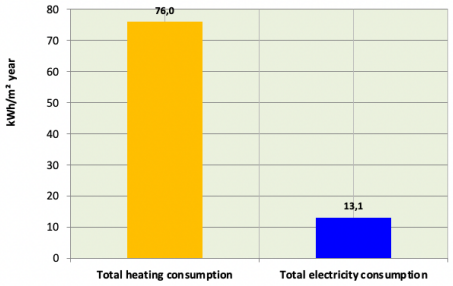
BUILDING TYPE

- (●) *School - Compact plan*
- ( ) *School - Side Corridor*
- ( ) *School - Open plan*
- ( ) *School - Central Corridor*

PLANT TECHNOLOGIES

TYPE OF VENTILATION	Mechanical ventilation withouth hea
HEAT SUPPLY	Natural gas Boiler
HEATING SYSTEM	Floor heating
THERMOSTAT	Unavailable
HOT WATER CONSUMPTION	School without gym

Delivered yearly energy consumption of Reference Building



ESMES

Use of Building and Lighting Data INPUT

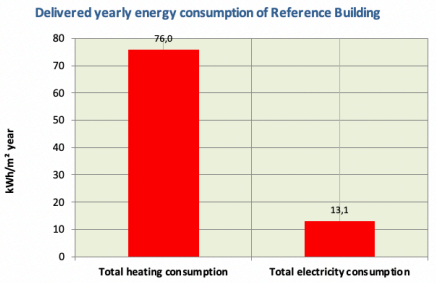
USE OF THE BUILDING

DAYS OF USE (excluiding weekend and vacation)

Month	Number of days	Suggested values	
January	123	21	Days
February	15	15	Days
March	16	16	Days
April	21	21	Days
May	20	20	Days
June	19	19	Days
July	0	0	Days
August	14	14	Days
September	20	20	Days
October	18	18	Days
November	20	22	Days
December	15	15	Days
Total	301	201	

TIME OF USE

Start time (hh:mm)	08:00	08:00
Finish time (hh:mm)	13:00	17:00



TOTAL ENERGY CONSUMPTION

Total heating consumption	76,0
Total electricity consumption	13,1

LIGHTING in Classroom. Choose from the pull down menu

Requirements for light level	Medium high – 250 lux
Number of zones in clasroom	1
Lighting control in clasroom	Always on
Type of lighting- Power level max	Compact fluorencent light (CFL) –

LIGHTING in corridor / stairs. Choose from the pull down menu

Requirements for light level	Standard – 100 lux
Lighting control in corridor/ staircases	Always on
Type of lighting- Power level max	Fluorescent tubes – 14 W/m²

ESMES

OPTIMIZATION

1 SELECT DIFFERENT ENERGY IMPROVEMENTS FROM THE PULL DOWN MENUS

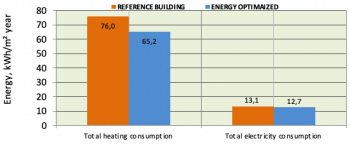
SOLAR HOT WATER HEATING	Yes	0	€
PHOTOVOLTAIC	Yes	0	€
EXTERNAL WALL INSULATION	+6 cm insulation	-11	€
ROOF INSULATION	+9 cm insulation	116.160	€
FLOOR INSULATION	Reference Building	0	€
BASEMENT INSULATION	Reference Building	0	€
WINDOWS	Reference Building	0	€
VENTILATION	Reference building	0	€
HEAT SUPPLY	Reference building	0	€
TYPE OF LIGHTING IN CLASSROOM	Reference Building	0	€
LIGHTING CONTROL IN CLASSROOM	Reference Building	0	€
LIGHTING ZONES IN CLASSROOM	Reference Building	0	€
TYPE OF LIGHTING IN CORRIDOR/STAIRCASE	Reference Building	0	€
LIGHTING CONTROL CORRIDOR/STAIRCASE	Reference Building	0	€
THERMOSTAT	Reference Building	0	€
Investment: eg. fee to advisor. Deduction: eg. subsidy scheem (indicated by minus)		0	€
TOTAL INVESTMENT PR. SCHOOL		188.149	€

2 SOLAR PANELS DATA

Collector area per school	0 m²	PV cells area per school	0 m²
Slope	30 °	Slope	30 °
Orientation	South	Orientation	South

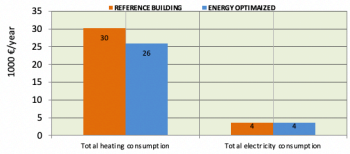
Delivered yearly energy consumption

The energy optimization is compared with Reference building



Yearly cost of delivered energy consumption

The cost of the optimization is compared with Reference building



ESMES

Final REPORT

Reference Building:	***I.T.S. di prova***
Referring Weather Data	*Tipo Temi TR*

Construction Year	1990	
N° of students	380	
Total area of the school	**4.800**	m^2
Teaching Area	2.400	m^2
Area of corridor/staircases	1.400	m^2
Number of floor levels	**1**	
Desired temperature into the room	21	°C
Heated basement	No	
Window area/heated floor area	Medium - 20%	

PLANT TECHNOLOGIES:

TYPE OF VENTILATION	*Mechanical Ventilation without heat recovery*
HEAT SUPPLY	*Natural gas Boiler*
HEATING SYSTEM	*Floor heating*
THERMOSTAT	*Unavailable*
HOT WATER CONSUMPTION	*School without gym*

USE OF THE BUILDING
DAYS OF USE (excluiding weekend and vacation)

Month	Number of days	Suggested values	
January	**123**	21	Days
February	**15**	15	Days
March	**16**	16	Days
April	**21**	21	Days
May	**20**	20	Days
June	**19**	19	Days
July	**0**	0	Days
August	**14**	14	Days
September	**20**	20	Days
October	**18**	18	Days
November	**20**	22	Days
December	**15**	15	Days
Total	**301**	201	

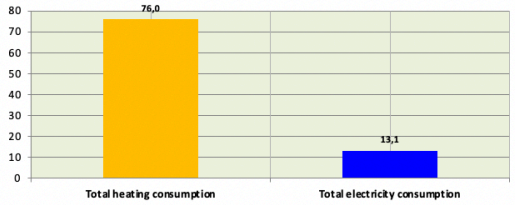
TIME OF USE

Start time (hh:mm)	**08:00**	08:00

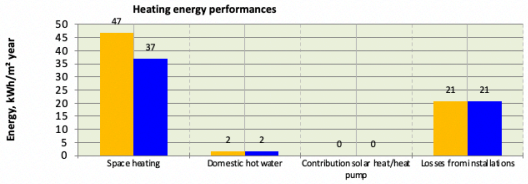
Before the optimization investment:

Total Heating Consumption:	**76,0**	kWh m^2/y
Total Elettricity Consumption:	**13,1**	kWh m^2/y
TOTAL Energy "state of fact":	**89,0**	kWh m^2/y
Current Total Operation Cost Estim.:	**44.447 €**	Euro/year

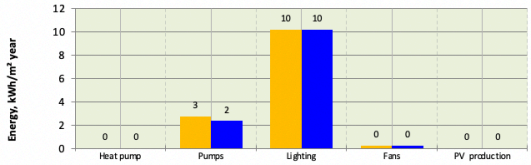
Delivered yearly energy consumption of Reference Building



Heating energy performances



Electrical energy performances



Total Cost of Energy consumption