

**Energy efficient and lighting project  
at King Faisal Hospital (KFH) located  
in Kigali  
RWANDA**

**Financed by UNIDO  
Executed by ERE Ltd  
30 /March/2023**



# KFH between 1991 and 2019



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## KFH plot (7.9 hectares)



## **KFH Overview**

King Faisal Hospital (KFH) is a hospital in the Kacyiru area of the Rwandan capital, Kigali. It was established between 1987 and 1991 with the help of the Saudi Fund for Development (SFD). Being the largest referral hospital in Rwanda, KFH spreads on 7.9 Hectares. It is located in an upscale area and has 18,000 square meters of floor space distributed over 4 floors, and an extension building of 2,285 square meters of floor space. The hospital provides a range of highly specialized medical care, including diagnosis of diseases and specialized treatment.

KFH has a 160-bed capacity. That includes :

- 7 Intensive Care Unit (ICU) beds;
- 7 high-dependence unit beds;
- 5 operation theatres: 7;
- Neonatal Intensive Care Unit (NICU) beds;
- 13 beds in the emergency observation rooms and
- 2 fully equipped resuscitation rooms;
- A private wing with 8 high-en rooms, 2 of which are ICU rooms;

KFH has an average annual number of consultations of 72,201 patients, and an average annual number of admissions of 8,346 patients. The hospital has the region's lowest average length of stay of 5 days.

## **KFH Specialties**

The hospital has in key medical specialties including cardiology, cardio-thoracic, neurosurgery, digestive surgery and orthopedics. Other specialties include nephrology, emergency medicine, pediatrics, oncology, gynecology and obstetrics, ENT, urology, pulmonology, dental and maxillofacial services, ophthalmology, dermatology, hematology, and pathology services.

With the arrival of a specialized adult nephrologist and one of the pioneers of kidney transplant in Sub-Saharan Africa, the hospital foresees starting a kidney transplant center, the very first in Rwanda.

# KFH under renovation and extension since 2020



In September 2020, the hospital started a renovation and expansion project. An outpatient block, comprising of 45 new consultation rooms and an outpatient clinic, was added offering premium services. The revamping of the hospital's lobby and its private inpatient wing has been completed.

The Obstetrics and Gynecology unit acquired a high-resolution ultrasound machine that will significantly improve the diagnostic accuracy for fetal anomalies in the first and second trimester of pregnancy. The new ultrasound machine delivers 3D and 4D imaging format, allowing KFH to stay at the forefront of women's health imaging from routine women's health exams to complex imaging including fetal echocardiography.



## Electricity consumption at KFH

KFH spends about 45,000\$ monthly for electricity bills. This cost goes mainly to lighting, water heating and cooling. In addition, the hospital releases a significant amount of carbon dioxide emissions to the environment. Therefore, KFH is permanently looking at measures that help to reduce the cost of electricity and the impact on the environment. KFHK has undertaken energy efficient lighting and appliances policy as measures and the use of solar as source of energy as measures to reduce the cost of electricity bill.

## EEALA measures

- ***Under the Energy Efficient Lighting and Appliances by UNIDO:***
  - Replacement of old incandescent and florescent bulbs (**40 Watts**) with new LED lights (**18 Watts**)
  - Replacement of old electrical water boilers by solar water heaters
  - Replacement aged split units are going to be replaced by inverter split units
- ***Installation of a solar PV system as source of energy: 50 kWhp (as soon as possible and 1 MW when the law allows)***

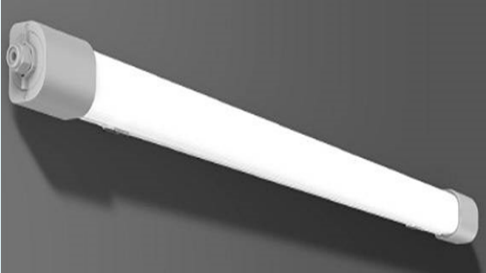
## Space for the solar water heating system



## Installation of LED lights



**40 watts old fluorescents tubes to be replaced**



**18 watts new LED lights to be installed**

## RZB Planox Eco Lights

In 2021, KFH replaced 770 old florescent bulbs (**40 Watts**) with new LED lights (**18 Watts**). This was executed before the launch of UNIDO's 1<sup>st</sup> call for the energy efficiency and lighting project, but KFH couldn't execute further measured due to budget constraints.

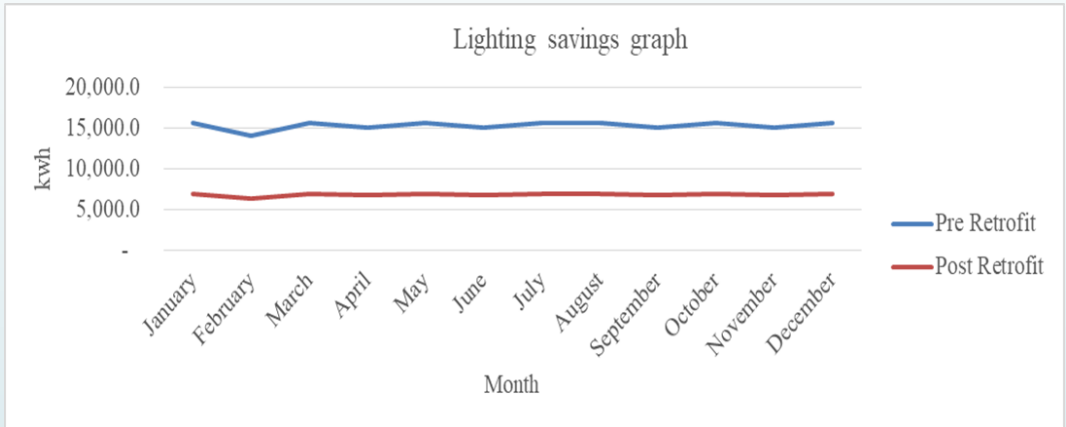
We have agreed with the KFH management to use the same type and brand of lights as the previously installed, hence this RZB Planox Eco lights are 18 Watts, switchable to 6 Watts.

The use of LED lights reduce the consumption of energy without compromising much on the lumens emitted. In addition, LED lights have much longer life than ordinary bulbs (Sperber et al., 2012).

## Lighting Calculations (supported by EELA project)

| Month        | # of Days | Pre-Retrofit consumption | Post-Retrofit consumption | Cons. Savings    | Cost Savings   |
|--------------|-----------|--------------------------|---------------------------|------------------|----------------|
|              |           | <i>kWh</i>               | <i>kWh</i>                | <i>kWh</i>       | <i>EUR</i>     |
| January      | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| February     | 28        | 14,152.3                 | 6,368.5                   | 7,783.8          | 680.0          |
| March        | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| April        | 30        | 15,163.2                 | 6,823.4                   | 8,339.8          | 728.6          |
| May          | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| June         | 30        | 15,163.2                 | 6,823.4                   | 8,339.8          | 728.6          |
| July         | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| August       | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| September    | 30        | 15,163.2                 | 6,823.4                   | 8,339.8          | 728.6          |
| October      | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| November     | 30        | 15,163.2                 | 6,823.4                   | 8,339.8          | 728.6          |
| December     | 31        | 15,668.6                 | 7,050.9                   | 8,617.8          | 752.8          |
| <b>TOTAL</b> |           | <b>184,485.6</b>         | <b>83,018.5</b>           | <b>101,467.1</b> | <b>8,864.2</b> |

# Lighting Calculations



The calculations above show that the lighting replacement with LED lights save up to 55% of the electric consumption

## **Solar water heating**

KFHK use 2 nos. fuel boilers (of 4,000L each) as a water heating system, consuming 250L of fuel per day giving around 13,000 USD per year.

To decrease the electric energy consumption for heating water, we will install solar collectors to generate hot water using free renewable energy.

The need of hot water at the hospital is estimated at 10,000L per day. According to our calculations, we will use 9 nos. kits of solar collectors, where each kit consists of 5 nos. 200L collectors, water pumps and a hybrid hot water tank, which provides assistance in heating in case the hot water demand wasn't met.

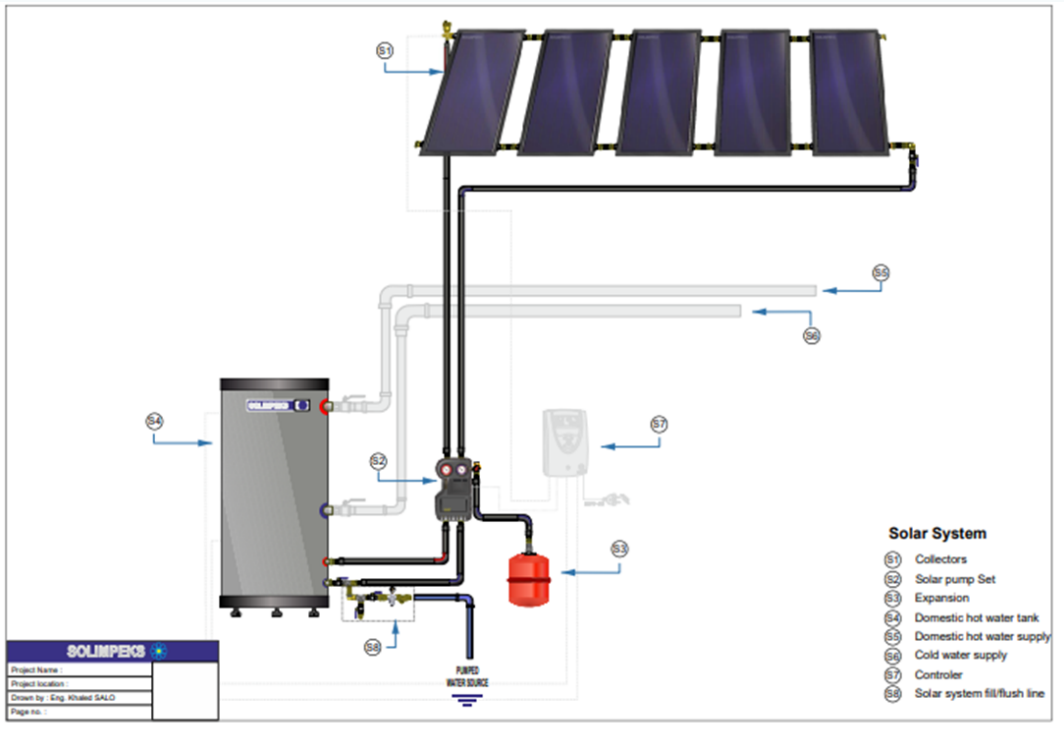


## EISENWERK water boilers



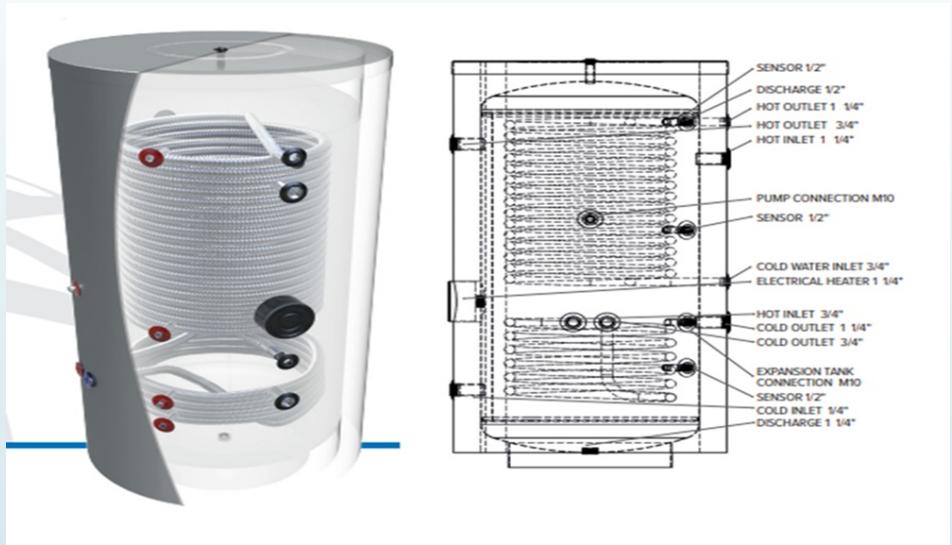
2 nos. EISENWERK water boilers of 4000L each will be replaced

# Solimpeks 1000 liters solar water heater



9 nos. Solimpeks solar water od 1000L each will be installed

# Typical Solimpeks SWH section



# Solimpeks 1000 liters SWH specifications

## TECHNICAL SPECIFICATIONS

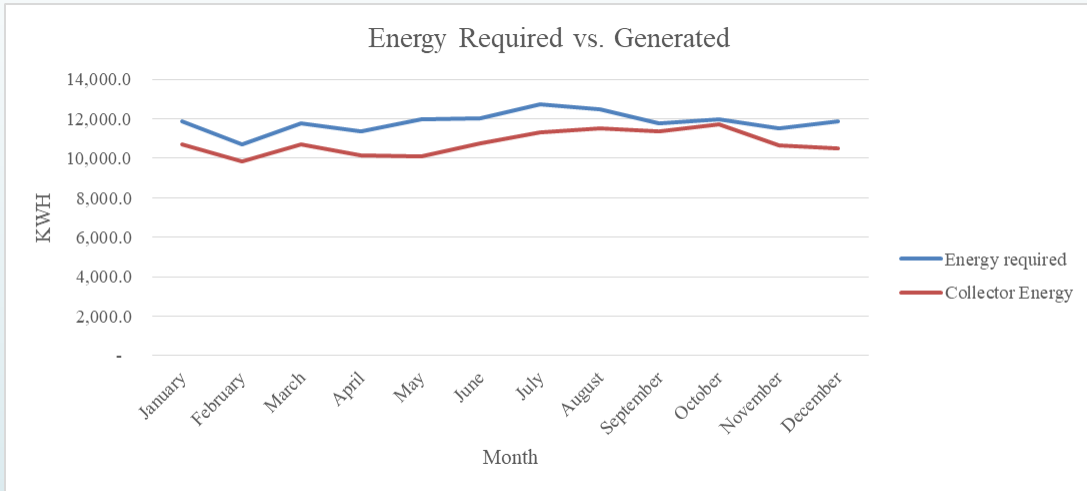
|                                | SOLIKOMBI 300                            | SOLIKOMBI 500   | SOLIKOMBI 800               | SOLIKOMBI 1000              |
|--------------------------------|--|---|-----------------------------|-----------------------------|
| Product Code                   | MA- 0367                                 | MA- 0494  | MA- 0608                    | MA- 0495                    |
| Height (mm)                    | 1770                                     | 1653  | 1733                        | 2033                        |
| Diameter (mm)                  | 542                                      | 750/807   | 1017                        | 1017                        |
| Net Weight (kg)                | 85                                       | 100   | 175                         | 190                         |
| Volume (lt)                    | 245                                      | 454   | 800                         | 970                         |
| Insulation                     | 50 mm /40 kg/m <sup>3</sup>              | 50 mm /40 kg/m <sup>3</sup> - 80 mm /18 kg/m <sup>3</sup>     | 80 mm /14 kg/m <sup>3</sup> | 80 mm /14 kg/m <sup>3</sup> |
| Insulating Material            | Polyurethane (CFC Free)                  | 18 Density Foam Rubber / Polyurethane (CFC Free)              | 18 Density Foam Rubber      | 18 Density Foam Rubber      |
| Outer Cylinder Materials       | Electrostatic Powder Painted ST 37 Steel | Electrostatic Powder Painted ST 37 Steel / Leatherette Jacket | Leatherette Jacket          | Leatherette Jacket          |
| Materials of Coil              | AISI 316 L Stainless Steel               | AISI 316 L Stainless Steel                                    | AISI 316 L Stainless Steel  | AISI 316 L Stainless Steel  |
| Number of Coils                | 2  | 2   | 2                           | 2                           |
| 1. Coil Area (m <sup>2</sup> ) | 3,83                                     | 4,81  | 7,23                        | 8,76                        |
| 2. Coil Area (m <sup>2</sup> ) | 1,75                                     | 1,75  | 2,19                        | 2,62                        |

## Solar Water Heater Calculations (supported by EALA project)

| Month     | Before Retrofit |         | After Retrofit |       | Savings  |         |
|-----------|-----------------|---------|----------------|-------|----------|---------|
|           | kWh             | EUR     | kWh            | EUR   | kWh      | EUR     |
| January   | 11,873.6        | 1,037.3 | 1,158.1        | 101.2 | 10,715.5 | 936.1   |
| February  | 10,729.0        | 937.3   | 867.9          | 75.8  | 9,861.1  | 861.5   |
| March     | 11,769.9        | 1,028.2 | 1,054.5        | 92.1  | 10,715.5 | 936.1   |
| April     | 11,370.3        | 993.3   | 1,196.1        | 104.5 | 10,174.2 | 888.8   |
| May       | 11,996.6        | 1,048.0 | 1,887.7        | 164.9 | 10,108.9 | 883.1   |
| June      | 12,032.2        | 1,051.1 | 1,271.0        | 111.0 | 10,761.1 | 940.1   |
| July      | 12,752.5        | 1,114.1 | 1,430.5        | 125.0 | 11,322.0 | 989.1   |
| August    | 12,507.4        | 1,092.6 | 983.2          | 85.9  | 11,524.2 | 1,006.8 |
| September | 11,768.8        | 1,028.1 | 420.7          | 36.7  | 11,348.1 | 991.4   |
| October   | 11,986.8        | 1,047.2 | 260.4          | 22.8  | 11,726.4 | 1,024.4 |
| November  | 11,523.5        | 1,006.7 | 860.2          | 75.1  | 10,663.3 | 931.5   |
| December  | 11,894.8        | 1,039.1 | 1,381.5        | 120.7 | 10,513.3 | 918.4   |

|                       |          |          |
|-----------------------|----------|----------|
| <b>Total CapEx</b>    | 78,903.7 | EUR      |
| <b>Annual Savings</b> | 11,307.3 | EUR/YEAR |
| <b>Simple Payback</b> | 7.0      | YEARS    |

## Solar Water Heater Calculations (supported by Ark Energy)



**Plot showing Energy Required vs. Solar Energy Generated by Collectors**

## Ventilation and air conditioning

The existing aged split units are going to be replaced by inverter split units. These split units will decrease the consumption by at least 30%; however, at this stage we cannot estimate the HVAC equipment consumption since it depends on many variables and requires excessive energy modeling with high level of uncertainty.

The table below shows the Existing Split Units to be Replaced :

| S. N. | Equipment name / Type          | Wattage | Capacity (Btu/h) | Model           | Location                        | Refrigerant type /Kgs | Prop. installed date |
|-------|--------------------------------|---------|------------------|-----------------|---------------------------------|-----------------------|----------------------|
| 1     | Daikin - Split unit (2016)     | 3,520   | 18,500           | RYNV35AV1       | Transport office                | R410a/1.20kgs         | >5 yrs back          |
| 2     | LG- Split unit                 | 2,450   | 18,500           | S186GH s50      | HRO                             | R22 /1.2Kgs           | >5 yrs back          |
| 3     | Tadiran- Split unit            | 2,040   | 18,000           | GTM-18C         | Medical filing office           | R22/1.11              | >5 yrs back          |
| 4     | Samsung - Split unit           | 7,030   | 24,000           | AR24JVFSWW AX   | Lab-Chemistry 2                 | R410A/1.050kgs        | >5 yrs back          |
| 5     | Samsung-Split unit (2016)      | 1,880   | 18,000           | AR18JRF38AU RXF | Tea room                        | R410a(900g)31.7oz     | >5 yrs back          |
| 6     | Samsung-Split unit (2016)      | 7,030   | 24,000           | AR24JVFSWW KXAF | Lab- Immunology 2/1             | R410a(900g)31.7oz     | >5 yrs back          |
| 7     | Samsung-Split unit (2016)      | 1,880   | 18,000           | AR18JRFSAX      | Lab- Main store refrigeration   | R410(900g)(31.70oz)   | >5 yrs back          |
| 8     | Samsung-Split unit (2016)      | 7,030   | 24,000           | AR24JVSWWK X    | Lab- General testing area/1     | R410a(1050g/37.oz)    | >5 yrs back          |
| 9     | Samsung-Split unit (2016)      | 7,030   | 24,000           | AR24JVSWWK X    | Lab- General testing area/2     | R410a(1050g/37.oz)    | >5 yrs back          |
| 10    | Samsung-Split unit (2016)      | 7,030   | 24,000           | AR24JVSWWK X    | Lab- General testing area/3     | R410a(1050g/37.oz)    | >5 yrs back          |
| 11    | Samsung-Split unit (2016)      | 5,270   | 18,000           | AR18JVFSWW KX   | Lab- Microbiology               | R410a/850g (30.0oz)   | >5 yrs back          |
| 12    | Samsung-Split unit             | 5,270   | 18,000           | AR18JVFSWW KX   | Lab Microbiology                | R22a/1.2Kgs           | >5 yrs back          |
| 13    | LG- Split unit                 | 1,990   | 18,500           | S186GH s50      | Lab-Histopathology              | R22a/1.2kgs           | >5 yrs back          |
| 14    | Daikin- Slt unit               | 6,000   | 18,500           | P60TV16U        | Radiology -CT scan              | R31a/1.0kgs           | >5 yrs back          |
| 15    | Samsung -Split unit (2016)     | 7,030   | 24,000           | AR24JVFSWW KX   | Radiology -CT scan              | R410A/1050g           | >5 yrs back          |
| 16    | Samsung - Split unit (2016)    | 3,520   | 18,500           | AR12JVFSWW KX   | Radiology- CT scan testing area | R410a/730g            | >5 yrs back          |
| 17    | Samsung - Split unit (2016)    | 7,030   | 24,000           | AR24JVFSWW KX   | Radiology -CT scan Ups room     | R410a/1050            | >5 yrs back          |
| 18    | Samsung- Ceiling cassette type | 1,740   | 9,034            | RC052SHEC       | Radiology- MRI Chamber          | R410a/1.3KG           | >5 yrs back          |
| 19    | Samsung- Split unit            | 5,280   | 18,000           | AR18MQFRB WKXFA | Lab Microbiology                | R410a/1310gs          | >5 yrs back          |
| 20    | Samsung- Split unit            | 5,280   | 18,000           | AR18MQFRB WKXFA | Lab Microbiology                | R410a/1310gs          | >5 yrs back          |
| 21    | Lg- Split unit                 | 2,700   | 24,000           | S346SC          | Cythistopathology               | R22/1.30kgs           | >5 yrs back          |



## Planned actions for the EELA at KFH Kigali

| Nº                           | Description  | Unit | Quantity |
|------------------------------|--|------|----------|
| <b>A LED's lights</b>        |  |      |          |
| 1                            | RZB Planox Eco LED lights  | pc   | 1,053    |
| 2                            | Installation cost(Engineering cost,accessories,transport, etc..)                   | item | 1        |
| 3                            | Recycling cost   | item | 1        |
|                              |  |      |          |
| <b>B Air conditioners</b>    |  |      |          |
| 1                            | Air conditioners   | Pc   | 21       |
| 2                            | Installation   | item | 1        |
| 3                            | Recycling cost   | item | 1        |
|                              |  |      |          |
| <b>C Solar water heaters</b> |  |      |          |
| 1                            | Suply of Solimpeks solar water heaters ( 1000 liters)                              | pc   | 9        |
| 2                            | Installation cost(Engineering cost,accessories,transport,electrical back up etc..) | item | 9        |
|                              |  |      |          |

## Initial Project Cashflow (10-years /supported by EELA project)

### Summary of Project Costs and Annual Cost Savings (supported by EEALA)

| ECM                 | Material Cost | Installation Cost | Recycling Cost | OpEx (O&M, labor, M&V, etc.) | Savings    | Simple Payback |
|---------------------|---------------|-------------------|----------------|------------------------------|------------|----------------|
|                     | EUR           | EUR               | EUR            | EUR/yr.                      | EUR/yr.    | Yrs.           |
| Lighting (ERE)      | EUR 70,615    | EUR 28,246        | EUR 3,538      |                              | EUR 11,819 | 8.7            |
| Solar Water Heaters | EUR 67,410    | EUR 26,964        |                |                              | EUR 11,307 | 8.3            |
| Split Units         | EUR 22,337    | EUR 5,477         | EUR 4,290      |                              | EUR 6,423  | 5.0            |

### Initial Project Cashflow (10-years/supported by EELA project)

|                     | 0        | 1        | 2        | 3        | 4        | 5       | 6       | 7       | 8      | 9      | 10     |
|---------------------|----------|----------|----------|----------|----------|---------|---------|---------|--------|--------|--------|
| Savings (EUR/yr.)   |          | 29,549   | 29,549   | 29,549   | 29,549   | 29,549  | 29,549  | 29,549  | 29,549 | 29,549 | 29,549 |
| Total CapEx (EUR)   | -228,878 |          |          |          |          |         |         |         |        |        |        |
| Total OpEx (EUR)    |          | 0        | 0        | 0        | 0        | 0       | 0       | 0       | 0      | 0      | 0      |
| Net Cashflow        | -228,878 | 29,549   | 29,549   | 29,549   | 29,549   | 29,549  | 29,549  | 29,549  | 29,549 | 29,549 | 29,549 |
| Cumulative Cashflow | -228,878 | -199,329 | -169,780 | -140,231 | -110,682 | -81,132 | -51,583 | -22,034 | 7,515  | 37,064 | 66,613 |

# Energy Savings Performance Contracting (ESPC)

*An agreement to guarantee energy cost savings to the Client for Energy Efficiency Retrofit projects*

## Concept

- Under an ESPC arrangement, an external organization (Energy Service Company - ESCO) identifies and implements energy efficiency or renewable energy solutions at a Client's facility
- The ESCO uses the stream of income from the cost savings or the renewable energy produced to repay the costs of the project
- Investment in energy efficiency measures are recovered by the savings expected by the level of energy efficiency improvement agreed by contract

## Benefits

- Guaranteed energy and economic savings
- No investment risks
- Energy operational and management performance improved

# Energy Savings Performance Contracting (ESPC)

*The Client can consider one of the following options*

## Guaranteed Savings ESPC Model

### Overview

- 100% Investment by Client through equity (or debt)
- ESCO guarantees a certain savings on the client's energy bill

### Cons

- 100% financed by the Client
- Client pays for performance guarantee (savings) insurance on annual basis
- Client takes credit risk

### Pros

- ESCO assumes performance risk
- If savings are not achieved, ESCO needs to pay the difference

## Shared Savings ESPC Model

• ESCO can provide financing, project development and implementation, with energy savings shared between the ESCO and the client over the contract period

- Client avoids the need for upfront CapEx
- Pays the ESCO on the savings obtained (project is off-balance sheets)
- Aligned-interest partnership

- Project financed by the ESCO through the existing funds or debt
- High upfront investment (capex)
- ESCO is assuming technical (performance) and the credit risk (of the client)
- If savings not achieved ESCO loses money as being only paid out of the savings
- Long-term agreement

## Non-ESPC Model (DBO)

- Client provides financing
- ESCO implements the project and gets directly paid for the services (no difference than other SLAs)

- No Performance Guarantees
- No strings attached

- Business ends after installation is done, hence no continuous business
- Lack of differentiation in value proposition (financing, O&M, M&V etc.)

## PROJECTED RESULTS (Part 1)

- ❑ The main goal of this project is to reduce the energy consumption of the hospital buildings by targeting its major components.
- ❑ As a start, LED lights consume less energy than fluorescent and incandescent lights while providing the same illumination levels. The use of LED lights in the hospital buildings will reduce the lighting energy demand by about 45%, in which the proposed lighting have been selected with an average lifetime of over 50,000 hours.
- ❑ In addition, the replacement of 2 nos. waters boilers (8,000L each) by 9 nos. kits of solar water heaters (1,000L each) will remove completely the energy cost related to water heating and deliver the demanded hot water to the facility, which will enable up to 10% reduction on energy consumption.

# Opportunity and barriers to implementing EELA projects in Rwanda

## Opportunities :

The Government put in place an initiatives for high intensity energy users and households.

- This includes Municipality energy efficiency, Building Energy Efficiency, Industrial Energy Efficiency, Residential Energy Efficiency

Example: 1. Solar water heater for house hold is subsided  
2. Municipality energy efficiency : LED Street Lighting, EE in public building

- The Rwanda Cooling program introduce by the government with a Development partner is a program targeting salaried employees of public and private institutions interested in a new refrigerator or air conditioner and other home appliances;
- Many companies operate in the energy sector and can offer energy efficient program support to various segment of the society like hospitality, agriculture, healthy ect...

## **Barriers:**

Lack of qualified human resources (expertise) and lack of appropriate tools to perform energy audit

Lack of operating and maintenance expertise

EE appliances are expensive

Unavailability of cheap funding for upgrading appliance

Limitation in policy in place: limitation on system capacity when one chooses PV system as source of electricity

## Gaz emission reduction expected from the current project.

### Annual GHG reductions

| Emission per year | Emission Before kg/kWh per year | Emission After kg/kWh per year | Saved emission kg/kWh per year |
|-------------------|---------------------------------|--------------------------------|--------------------------------|
| CO2               | 292,812                         | 75,318                         | 217,494                        |
| N2O               | 5                               | 1                              | 3                              |
| CH4               | 63                              | 16                             | 47                             |

### Cost of consumed energy

| Emission per year | Energy(kWh) consumed by FL | Energy(kWh) consumed by LED | Cost of kWh/month Before [USD] | Cost of kWh/month After [USD] | Saved Cost of kWh/month [USD] |
|-------------------|----------------------------|-----------------------------|--------------------------------|-------------------------------|-------------------------------|
| CO2               | 473,040                    | 121,676                     | 248.4                          | 153.3456                      | 950,544                       |

After combining all of the benefits and impacts of this proposal, we can confidently say that this is a very rewarding project.



## **Other benefits:**

- 15 new jobs will be created for the duration of this project. At least 2 or 3 people will end by having a permanent job in the company;
- 7000 employee whom 75 % are women will benefit from this projects;
- 11000 patients whom 7000 are hospitalized will benefit from this EELA project at KFH Kigali.

**Thank you**