

ASSESSMENT OF THE EFFECTIVENESS OF THE CEDRO,
GLOBAL SOLAR WATER HEATING MARKET
TRANSFORMATION AND STRENGTHENING INITIATIVE (GSWH),
AND THE NATIONAL ACTION PROGRAMME
TO MAINSTREAM CLIMATE CHANGE
INTO LEBANON'S DEVELOPMENT AGENDA (CCCU)
PROJECT ACTIVITIES IN REDUCING GHG EMISSIONS

FINAL REPORT

Presented to

United Nations Development Programme – UNDP

BEIRUT, LEBANON

Prepared by



October 11, 2013

CONTENTS

<i>EXECUTIVE SUMMARY</i>	4
<i>INTRODUCTION</i>	6
<i>1. Background: Projects and Programmes Overview</i>	7
<i>Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon (CEDRO project):</i>	7
<i>The Lebanese Center for Energy Conservation (LCECP) and National Energy Efficiency and Renewable Energy Action (LCEC):</i>	7
<i>Climate Change Mitigation - Renewable Energy (Italian Corporation) (CCM)</i>	7
<i>Technology Brief</i>	7
<i>Solar Water Heater systems (SWH)</i>	7
<i>Photovoltaic (PV)</i>	8
<i>Efficient Lighting Devices</i>	8
<i>2. Methodology of Calculation Adopted to Compute the GHG Reductions</i>	9
<i>GHG emission reductions from Solar Water Heaters</i>	9
<i>GHG emission from boilers</i>	9
<i>GHG emission from active SWH systems</i>	10
<i>GHG emission from 1 degree increase in the inlet / outlet temperature</i>	10
<i>GHG emission from electricity consumption</i>	10
<i>GHG emission from street lighting</i>	11
<i>GHG emission from PV</i>	12
<i>GHG reduction attained per annum</i>	12
<i>GHG reduction per project and per installed unit</i>	12
<i>3. Assumptions</i>	13
<i>4. Limitations</i>	15
<i>5. GHG Emission Reduction Calculation - CEDRO</i>	16
<i>5.1. General description of CEDRO</i>	16
<i>5.2. Solar Water Heaters (SWH)</i>	16
<i>5.3. Photovoltaic Cells (PV)</i>	17
<i>5.4. Street Lighting</i>	18
<i>5.5. Total GHG Emission Reduction from the Cedro Project</i>	18
<i>6. GHG Emission Reduction Calculation - LCEC</i>	19
<i>6.1. Solar Water Heaters (SWH)</i>	19
<i>6.2. Street Light projects</i>	19
<i>7. GHG Emission Reduction Calculation - CCM</i>	20
<i>7.1. Calculation of the Carbon reduction</i>	20
<i>8. Total Carbon reduction from the three UNDP sponsored projects</i>	21
<i>9. Recommendations for improving the calculation of GHG reduction</i>	21

ACRONYMS

ASDC:	Atmospheric Science Data Center
BDL:	Bank Du Liban
CDR:	Council for Development and Reconstruction
CEDRO:	Country Energy Efficiency and Renewable Energy Demonstration
CFL:	Compact Fluorescent Lamps
CO ₂ :	Carbon Dioxide
EDL:	Electricite Du Liban
EF CO _{2e} :	Emission Factor in Carbon dioxide equivalent
EF:	Emission Factor
EF _e :	Emission Factor from production of Electricity
EU:	European Union
Gg:	Gegagrams
GHG:	Greenhouse Gas
GHG-P:	Greenhouse Gas Protocol
HPS:	High Pressure Sodium
IL:	Incandescent Lamp
IPCC:	Inter governmental Panel for Climate Change
ISC:	Integral Storage Collectors
kg:	Kilogram
kW:	Kilowatt
Kg CO _{2e} :	Kilogram of Carbon dioxide equivalent
kWh:	Kilowatt Hour
LCECP:	Lebanese Center for Energy Conservation
LED:	Light Emitting Diode
MoE:	Ministry of Environment
MoEW:	Ministry of Energy and Water
MoF:	Ministry of Finance
MW:	Mega Watt
NCV:	Net Calorific Value
NEEREA:	National Energy Efficiency and Renewable Energy Action
O&M:	Operations and Maintenance
PV:	Photovoltaic
RE:	Renewable Energy
SNC:	Second National Communication
Sq.m:	Square Meters
SWH:	Solar Water Heater
TCO _{2e} :	Tonnes of CO ₂ equivalent
TJ:	Tonnes of Joules
UNDP:	United Nations Development Programme

To overcome power shortages, generate clean energy and promote the renewable energy sector in Lebanon, three UNDP managed projects were launched. The Lebanese Center for Energy Conservation (LCECP) includes the National Energy Efficiency and Renewable Energy Action (NEEREA), Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon (CEDRO) and Global Solar Water Heating Market Transformation and Strengthening Initiative Project (GSWH). These programmes are designed to implement renewable energy (RE) projects utilizing solar water heater and photovoltaic systems, as well as energy efficiency systems that aim to reduce power demand in the country.

This report calculates the Greenhouse Gas (GHG) emission reduction from the above programmes according to the GHG Project Protocol recommendations, which are developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). The total GHG emission reduction attained from the above noted programmes is 104,070 TCO_{2e} since the projects' respective commissioning date. The CEDRO programme portion of the GHG emission reduction is 884.3 TCO_{2e}; the LCEC programmes contributed to GHG reduction of 103,636 TCO_{2e}; while the GSWH programme contributed to 127.0 TCO_{2e}. LCEC's project contributed to 99% of the total GHG emission reduction while the GHG reduction from the installation of Solar Water Heaters doubled from 2011 till 2013 (87 tons and 161 tons, respectively).

To achieve a better understanding of the GHG emission reductions from the implemented projects as well as comply with the recommendations of GHG Project Protocol, V4 Advisors took the liberty to make recommendations to be incorporated for future projects.

Lebanon ratified the United Framework Convention on Climate Change (UNFCCC) on the 15th of December 1994 and submitted its Initial National Communication in 1999. The Country's total GHG emissions in year 2000 were 18.5 MtCO_{2e}, recorded to be increasing from the 1994 baseline. Lebanon's Second National Communication (SNC) to the UNFCCC submitted in March 2011 presented information on Lebanon's GHG emissions for each sector totaling 20.299 MtCO_{2e}. Lebanon's GHG inventory breakdown revealed that the energy production is the main source of GHG emissions, accounting for 53.45% of the total national emission. The country's demand for power is continuously increasing, thus putting additional pressure on Electricite Du Liban's (EDL) installed capacity that already can't meet Lebanon's power needs. The shortages have and will continue to be met by high polluting and low efficient diesel-powered generators. On the other hand Lebanon enjoys a total of 4,435 hours of sunlight (NASA 2013), which could be utilized for power generation and water heating, resulting in reducing the country's GHG emission and meeting its target of 12% renewable energy by 2020.

Consequently, several national programmes addressing renewable energy and energy efficiency installations / projects were implemented in Lebanon; projects that aimed to prepare the Lebanese clean energy market to accelerate and promote sustainable market transformation. The Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon (CEDRO project), The Lebanese Center for Energy Conservation (LCECP) and Global Solar Water Heating Market Transformation and Strengthening Initiative (GSWH) are some of these programmes that were done in partnership with the relevant Lebanese ministries and other local development agencies; managed by the United Nations Development Programmes (UNDP).

V4 Advisors have been appointed to quantify the GHG emission reduction of the UNDP programmes according to the GHG Project Protocol. The GHG Project Protocol is internationally adopted standard as a policy-neutral accounting tool for quantifying the GHG benefits of climate change mitigation projects. It is the result of a four-year dialogue among business, environmental, and government experts led by World Resources Institute and the World Business Council for Sustainable Development.

The data and information for the GHG emission reduction auditing were provided by the respective project leaders, which covered periods from 2009 till Sept of 2013.

COUNTRY ENERGY EFFICIENCY AND RENEWABLE ENERGY DEMONSTRATION PROJECT FOR THE RECOVERY OF LEBANON (CEDRO PROJECT):

CEDRO is a United Nations Development Project (UNDP) managed project with a five-year mandate ending in October 2013. CEDRO is a partnership between the Ministry of Energy and Water (MoEW), the Ministry of Finance (MoF) and the Council for Development and Reconstruction (CDR). CEDRO project has a total budget of 9.3 Million USD and funded by the Lebanon Recovery Fund (LRF) through international donations. CEDRO aims to: 1) install 120 energy efficiency and Renewable Energy (RE) projects in public facilities throughout the country, 2) ensure technology transfer as well as encouraging the private sector to invest in various RE sources and 3) create an enabling environment to adopt a national sustainable energy policy¹.

THE LEBANESE CENTER FOR ENERGY CONSERVATION (LCECP) AND NATIONAL ENERGY EFFICIENCY AND RENEWABLE ENERGY ACTION (LCEC):

LCEC was established in 2002 in partnership between the UNDP and the Ministry of Energy and Water with funding from the Global Environmental Facility (GEF). LCEC was initially managed by the UNDP with the aim to address the end-use of energy conservation and renewable energy at the national level; LCEC gradually became an independent national center, but continues to be supported by the UNDP.

LCEC is a setup to support the financing of energy efficiency and renewable energy projects in Lebanon, through Lebanese commercial banks.

The 11.9 million Euro funding of the LCEC initiative is provided by the EU as a grant to Banque Du Liban to subsidize interest rates and increase repayment period of the loan given to projects. The targeted segment for the LCEC facilities are Small and Medium Enterprises (SME) in Lebanon¹.

CLIMATE CHANGE MITIGATION - RENEWABLE ENERGY (ITALIAN CORPORATION) (CCM):

The Ministry of Environment has embarked with the Italian Embassy in the installation of over 900 Solar Water Heaters under the framework of the project "Climate Change Mitigation - Renewable Energy". This initiative culminated by the installation of the solar water heaters on 66 public utility buildings, including Red Cross centers, prisons, orphanages, family shelters, retirement homes and hospitals contributing to the strengthening of the overall national resilience in the field of energy management.

SOLAR WATER HEATER SYSTEMS (SWH)

SWH systems use solar energy to heat water for domestic and industrial uses. The collected heat is transferred to a storage tank through a fluid system, where it will heat the water.

SWH systems have two main units: a solar collector and a storage tank. Depending on the circulation of the fluid between these two units, SWH systems can be classified into passive and active systems:

- Passive SWH systems, also known as thermo-siphon, are designed whereby the fluid circulates by heat convection to the tank that is located above the collectors. Passive SWH systems are inexpensive and easy to install.
- Active SWH systems use a pump to circulate hot water from the collector to the storage tank; this type of system has higher efficiency, but is more expensive and difficult to install.

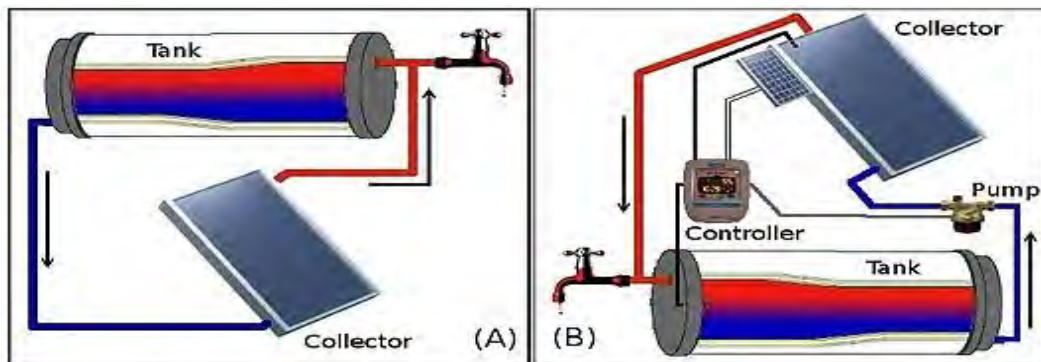


Figure 1: Types of Solar Water Heater (SWH) systems. A) Passive SWH system. B) Active SWH system

There are several types of SWH systems:

- Glazed non-selective surface flat plate
- Glazed selective surfaced flat plate
- Evacuated tubes
- Unglazed plastic collectors

SWHs were installed in Lebanon to provide hot water to hospitals, jails and other public buildings / facilities. The SWH systems are placed in parallel to existing conventional heating units or in series to reduce

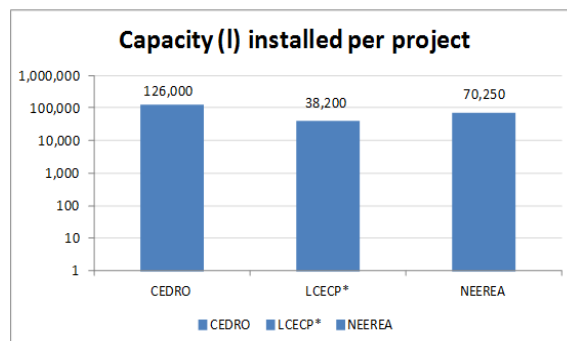


Figure 2: Total capacity of installed SWH per project. *Due to data limitation, 800 units of 300 l each were excluded in this report

diesel consumption in the existing conventional boilers systems. The total installed capacity by CEDRO, LCEC projects and LCEC was 234,450 liters (Figure 2). 800 units having a total capacity of 240,000 liters were distributed by LCEC, but were not included in this report due to lack of data.

PHOTOVOLTAIC (PV)

Photovoltaic (PV) converts solar radiation into direct current electricity (Figure 3). PV systems are made from the following materials monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride and copper indium gallium selenide / sulfide.

This report has quantified the GHG emissions from the 304.2 MWh produced by CEDRO and the 467.2 MWh generated from LCEC projects till the 1st of September 2013.



Figure 3: two PV projects installed by CEDRO

EFFICIENT LIGHTING DEVICES:

Efficient lighting devices include Light Emitting Diodes (LEDs), Compact Fluorescent Lamps (CFL), Ceramic Metal Halide (CMH), electronic ballasts, and retrofitting of lighting systems. The high efficiency of the above noted bulbs in comparison with the conventional incandescent lamp (IL), results in giving the same amount of light (lumens) for less kWh.

Electrical power equivalents for differing lamps (EnergyStars) ²

Minimum light output (lumens)	Electrical power consumption (Watts)		
	Incandescent	Compact fluorescent	LED
450	40	9–13	4–9
800	60	13–15	10–15
1,100	75	18–25	17
1,600	100	23–30	22
2,600	150	30–52	Not available

Table 1 summarizes the lumens production from the 3 types of light bulbs.

² Energystar.gov. http://www.energystar.gov/index.cfm?c=cfls.pr_cfls_lumens

METHODOLOGY OF CALCULATION ADOPTED

V4 Advisors used the guidelines of the GHG protocol as well as adopted the IPCC calculation methodologies to quantify the GHG emission reductions attained from the installation of SWH, PV and efficient bulbs. The emission reductions were primarily achieved from the difference of fossil fuel used pre and post the installation of the RE and energy efficient systems.

GHG EMISSION REDUCTIONS FROM SOLAR WATER HEATERS

To reiterate the SWH systems that were installed in Lebanon by the CEDRO, LCEC and MOE programs are the passive and active types.

As the passive SWH systems do not require electricity or any other source of energy, their GHG emissions is zero. The active SWH systems, on the other hand, require the installation of a pump that is powered by electricity; and as a result emits GHG emissions equal to the amount of power used by the pump.

GHG emission reduction is calculated from the difference of using conventional fuel source to produce hot water from producing it using RE sources.

$$\text{GHG saving} = \text{GHG}_{\text{boilers}} - \text{GHG}_{\text{SWH}}$$

GHG EMISSION FROM BOILERS:

The GHG emissions emitted by boilers using conventional fuel source is computed using the following formula that is in accordance to the IPCC guidelines⁵:

$$\text{GHG}_{\text{boiler (tCO}_2\text{eq)}} = \text{Diesel (l)} \times D_{\text{CO}_2 \text{ (tCO}_2\text{/TJ)}} \times \text{NCV (TJ/Gg)} \times D_{\text{diesel (kg/l)}} \times 10^{-6} \text{ (Gg/kg)}$$

Where:

D_{CO_2} (tCO₂/TJ) is the emission factor of diesel which is equal to 74.1 tCO₂/TJ

Diesel (l) is the amount of diesel used in liter

NCV: Net Calorific Value of Diesel which is equal to 43.3 TJ/Gg

D diesel x 10⁻⁶ is the density of Diesel equal to 0.85 Gg/l

To compute the GHG emissions from boilers which are emitted by the production from the energy produced due to the heating process of water, the formula below was used:

$$\text{GHG}_{\text{boilers}} = Q_{\text{heating kWh}} \times \text{GHG}_{1\text{kWh}}$$

Where:

Q_{heating} is energy (W) produced in warm a certain amount of water from initial temperature (t_i) to final temperature (t_f),

Consequently,
$$Q_{\text{heating}} = Kg_{\text{water}} \times SHC_w \times (t_f - t_i) / T_s$$

Where

K_g water is the amount of heated water in Kg,
 SHC_w is the Specific Heat Capacity of water = $4180 \text{ J Kg}^{-1} \text{ K}^{-1}$,
 T_s is the required time of heating in second

The GHG emitted from the production of 1kWh was computed using the IPCC methodology and found to be: 1 kWh produces 2.93 Kg of CO_{2e} .

GHG EMISSION FROM ACTIVE SWH SYSTEMS

In the case of a forced circulation (Active SWH), the GHG_{pump} is equal to the emission emitted from the electricity used to drive the pump. The GHG emitted is computed based on the IPCC methodology:

$$GHG_{\text{pump}} = CE_{\text{(kWh)}} \times 10^{-3} \times EF_{\text{Elec (tCO}_2\text{e/MWh)}}$$

Where:

CE is the amount of Consumed Electricity in kWh_{consumed}
 EF_{Elec} is the Emission factor of Electricity in Lebanon expressed in TCO_{2e} per MWh it is equal to 0.65

GHG EMISSION FROM 1°C INCREASE IN THE INLET / OUTLET TEMPERATURE

To compute the effect of 1°C change in the inlet / outlet per year, the following formula is used:

$$GHG_{\text{(1°C)}} = \frac{GHG_{\text{(year)}}}{D} * \delta t$$

Where:

$GHG_{\text{1°C}}$ is the emission from an increase of 1°C in inlet / outlet
 $GHG_{\text{(year)}}$ is the cumulative GHG emission emitted from commissioning till end of the fiscal year considered in this report
 D is the total number of days till from commissioning till end of the fiscal year considered in this report
 δt is the temperature between inlet and outlet in °C

GHG EMISSION FROM ELECTRICITY CONSUMPTION

The total GHG emission from electricity consumption in TCO_{2e} is computed as per the following formula:

$$GHG_{\text{electricity (tCO}_2\text{e)}} = CE_{\text{(kWh)}} \times 10^{-3} \times EF_{\text{Elec (tCO}_2\text{e/MWh)}}$$

Where:

⁴ Revised 1996 IPCC Guidelines for National Greenhouse Gas

⁵ Project 7214 : The Lebanese CFL Replacement CDM Project – South Lebanon

GHG electricity in TCO_{2e} is the amount of GHG emitted due to electricity consumption
 CE in kWh is the consumption of electricity
 10⁻³ to convert from kWh to MWh
 EF_{Elec} is the Emission factor of Electricity in Lebanon expressed in TCO_{2e} per MWh it is equal to 0.65

GHG EMISSION FROM STREET LIGHTING

While in CEDRO project the street lighting projects were based on replacing conventional bulbs with LED, LCEC installed diodes, switches or photocells. Therefore, the calculation of GHG reduction from both programmes differed.

GHG emission reduction from CEDRO's implementations in street lighting:

The total GHG emission from light bulbs is computed as per the following formula:

$$GHG_{lightbulbs} = W_{(Watt)} \times H_{(h)} \times D_{(day)} \times 10^{-3} \times EF_{Elec} (tCO_{2eq}/MWh)$$

Where:

GHG_{lightbulb} is the amount of GHG emitted from the electricity consumed by light bulbs

W in Watt is the wattage of the light bulb

H in hours number of hours of use per day

D in number of day of usage per year

10⁻³ to convert from kWh to MWh

EF_{Elec} in TCO_{2e} per MWh is the Emission factor of Electricity in Lebanon, is equal to 0.65 TCO_{2e} / MWh

The GHG emission reductions were computed from the difference of electricity used to produce the same lumens from incandescent as opposed to other energy efficient bulbs.

Reduction of GHG

$$= \text{Production of GHG}_{\text{Conventional bulbs}} - \text{Production of GHG}_{\text{Energy efficient bulbs}}$$

GHG emission reduction from LCEC's implementations in street lighting:

As the reduction was on time of electricity availability, from 24 to 13 hours, the total GHG emission from light bulbs is computed as per the following formula:

$$GHG_{lightbulbs} = W_{(Watt)} \times \delta H_{(h)} \times D_{(day)} \times 10^{-3} \times EF_{Elec} (tCO_{2eq}/MWh)$$

Where:

GHG_{lightbulb} is the amount of GHG emitted from the electricity consumed by light bulbs

W in Watt is the wattage of the light bulb

ΔH is the difference between the number of hours used before the implementation and after the implementation and per day

D in number of day of usage per year

10⁻³ to convert from kWh to MWh

EF_{Elec} in TCO_{2e} per MWh is the Emission factor of Electricity in Lebanon, is equal to 0.65 TCO_{2e}/MWh

GHG EMISSION FROM PV

The total GHG emission reductions attained from the installation of PV systems in TCO_{2e} were computed from the amount of power produced from the PV systems as opposed to EDL or diesel power generators

Saving of GHG = Amount of GHG_{to produce the same amount of electrical power}

Where:

Amount of GHG to produce the same amount of electrical power produced from PV is computed using the following formula:

Amount of GHG_{produced} = Electricity used_{kWh} × Emission Factor Electricity_{TCO_{2e}/kWh}

GHG REDUCTION ATTAINED PER ANNUM

V4 Advisors adopted a fiscal year (1st January till 31st of December) as basis for its GHG reductions; consequently the calculations for emission reductions were calculated from commissioning dates till the end of the fiscal year, and on cumulative basis, with the exception of 2013 calculated on cumulative basis too till the date of this report which is 1st of September.

GHG REDUCTION PER PROJECT AND PER INSTALLED UNIT

To facilitate the comparison between projects, the GHG reduction was computed by installed unit as follow:

GHG_{unit} = GHG_{year} / T_{Cap}

Where:

GHG unit is the GHG reduced per installed unit

GHG year is the total fiscal yearly emission

T_{Cap} is the total installed capacity in liters for SWH, in W for PV and in light bulb for unit for street lighting

ASSUMPTIONS

The following assumptions were used in the calculation of GHG emissions:

- The RE equipments: actual condition, efficiency of usage
- Source of electricity: EDL, self-generators supply
- Sunlight times during summer and winter
- SWH were to replace diesel boilers

The RE equipments

For the quantification of the GHG emission reductions and taking the technical recommendations from the “Evaluation for Community energy Efficiency and Renewable Energy \ Demonstration project for the Recovery of Lebanon CEDRO II” into consideration, V4 Advisors assumed that all implemented projects with a commissioning date before December 2012 have a utilization of 80%. The utilization percentage takes into account damaged equipments and non optimal / efficient utilization of the RE systems.

For the CEDRO street lighting projects, V4 Advisors calculated the GHG emission reductions in two scenarios. The first scenario having a failure rate of 4.5%, as provided by the CEDRO team and the second scenario assumes no-failure rate.

Electrical shortage / outage

Due to Lebanon’s continuous increase in electricity demand in peak load, and the decrease in supply provided by EDL, the shortage of electricity is met by the diesel-powered generators that are owned and operated by the private sector in Lebanon. For the sake of comparison, the following two scenarios were considered:

EDL provides power on continuous basis

EDL’s electrical shortage not being met by any source or parallel or backup power

Sunlight availability during summer and winter


Using data from the Atmospheric Science Data Center (ASDC) NASA Su face meteorology and Solar Energy model (table 2), the yearly average sunlight at an altitude from 10 to 100 m was found to be 12.15 hours per day⁷.

Monthly Averaged Daylight Hours (hours) ⁷												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average	10.1	11	11.9	13	13.9	14.3	14.1	13.4	12.4	11.3	10.4	9.96

Table 2: Monthly Average Daylight Hours from Surface Meteorology and Solar Energy model, NASA

⁶Lebanon's Second National Communication to the UNFCC, MoE, 2011

⁷NASA. Surface meteorology and Solar Energy, a renewable energy resources web site, release 6, <https://eosweb.larc.nasa.gov/cgi-bin/sse/sse.cgi?+s01#s01>



SWH were to replace diesel boilers

Due to the large capacity of solar water heaters, it was assumed that the baseline scenario of the SWH is diesel consumption, in other words, the SWH were to replace the diesel boilers, but not the electrical dependent boilers.

LIMITATIONS

Some of the information provided by LCEC (11 projects) regarding the commissioning dates did not include the month but only the year. V4 Advisors made an assumption that all the systems in that specific year were commissioned on the 1st of June.

For systems that had a no commissioning dates (i.e. no month and year) V4 advisors excluded the projects from its GHG reduction calculation (800 units from LCEC).

Since EDL's power shortages have been inconsistent and unscheduled for the past couple of years in all the regions in Lebanon (with the exception of Beirut), V4 Advisors assumed an average of 12 hours per day across the board and an 8-hour shortage for the governorate of Beirut.

GHG EMISSION REDUCTION CALCULATION - CEDRO

GENERAL DESCRIPTION OF CEDRO

Since 2009, the CEDRO programme has installed a total of 67 PV cell systems, attaining power production of 104,175 Wp; 16 SWH units with a total capacity of 126,000 L of water and; 539 street lighting systems (LED bulbs, PV poles, induction floodlight). Table 3 summarizes the total number of accomplished projects per governorate.

	North	Mount Lebanon	South	Bekaa	Beirut
PV (n)	20	14	14	17	2
PV (Wp)	31500	23625	4500	25200	19350
SWH (liter of water)	17500	64500	16000	28000	-
Street Lighting	22	262	45	210	-

Table 3: Summary of the CEDRO implemented projects

SOLAR WATER HEATERS

From 2009 till 2013 CEDRO installed 16 projects of SWH with a total capacity of 126,000 liters of hot water in all governorates except for Beirut. The cumulative number of operating days till 1st of September 2013 was 13,161 days.

Table 4 and Figure 4 show the installed capacity and cumulative number of operating days since commissioning per governorate.

Around half of the total capacity was installed in 6 locations in Mount Lebanon (64,500 liters).

In all projects, it was estimated that the temperature of water will increase from 20°C to a maximum of 45°C, and that the circulation of water will be via a pump of 20 Wp.

	Number of days since commissioning				
	North	Mount Lebanon	South	Bekaa	Total
Dec-11	1369	426	2099	943	4837
Dec-12	2680	1797	3410	1522	9409
Sep-13	3656	3109	4386	2010	13161

Table 4: Number of commissioning dates per governorate

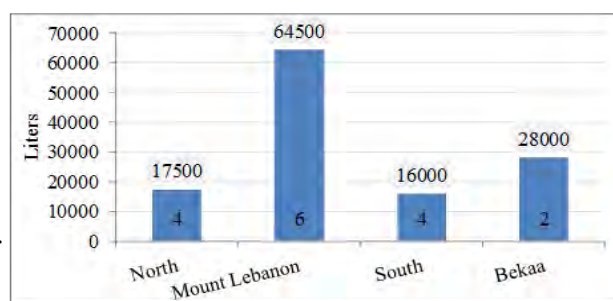


Figure 4: Installed capacity per governorate

After accounting for the power consumption of all pumps, the overall reduction of CO_{2e} till 1st of September 2013 was calculated to be 52 TCO_{2e}.

According to the “Evaluation for Community energy Efficiency and Renewable Energy \ Demonstration project for the Recovery of Lebanon CEDRO II” auditing report of CEDRO II, it was noted that some sites had installed SWH that were either damaged and / or not utilized. Therefore, the total GHG emission reductions could be 26% below the calculated number (Roumieh Prison alone accounts for 25% of

the total installed capacity).

In some sites or seasons, the base temperature of 20°C is incorrect and will require higher boiler utilization, therefore, an increase in the GHG emission of 1°C change will directly affect the total emission by an average of 0.15 kg of CO_{2e} per 1°C.

Taking the above assumptions into consideration, the daily average GHG emission reductions from all implemented SWH systems is 4 kg of CO_{2e} / day.

Figure 5 shows the cumulative total GHG emissions reduction per fiscal year from CEDRO project.

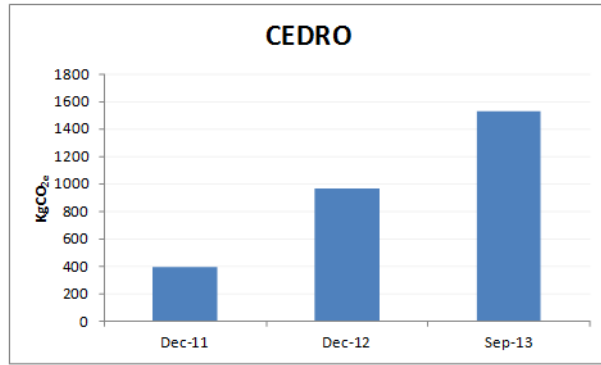


Figure 5: Total avoided GHG emissions in Kg of CO_{2e} from CEDRO per installed liter per fiscal year

PHOTOVOLTAIC CELLS (PV)

A total installed capacity of 104,175 Wp was put online since December 2009, generating a total of 1,046 MWh assuming an average of 12.15 hours of sunlight per day. Up till the 1st of September 2013, the cumulative operating number of days from commissioning is 56,021.

680 tons of CO_{2e} were reduced from the power generated from the PV systems up till 1st of September 2013.

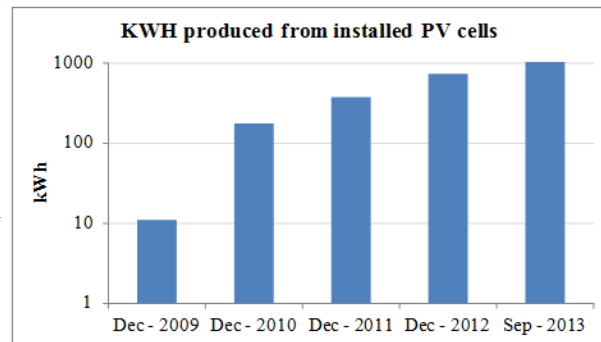


Figure 6: kWh produced from installed PV units per year

One may account for 20% lower GHG emission reductions assuming that 20% of the installed PV systems are not properly working or fully utilized.

The daily average GHG emission reduction from all PV systems installed varied from 12.1 kg of CO_{2e} to 13.1 Kg of CO_{2e} from December 2009 till 1st of September 2013 respectively.

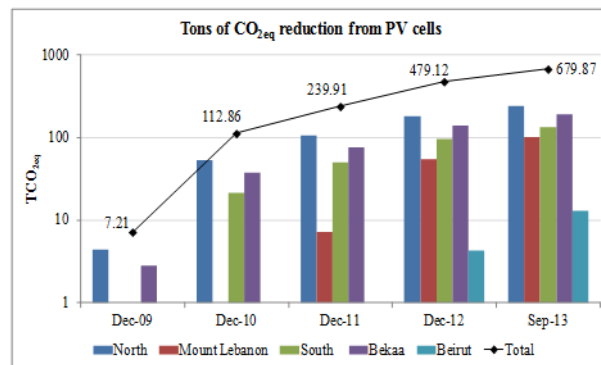


Figure 7: Tons of CO_{2e} reduction from PV Cells

STREET LIGHTING

In October 2009 CEDRO commenced implementing energy efficiency projects targeting street lights. A total of 539 street light bulbs were replaced by more efficient bulb types up till the 1st of September 2013, leading to energy reduction of 234 MWh.

From a GHG emission reduction perspective, a total of 152.4 TCO_{2e} were reduced in 9,957 days of use. Accounting for failure rates of 4.5% (according to CEDRO), the average daily amount of GHG reduction is 15.3 Kg of CO_{2e} per day.

Figure 9 shows the GHG emissions from one installed led bulb per year.

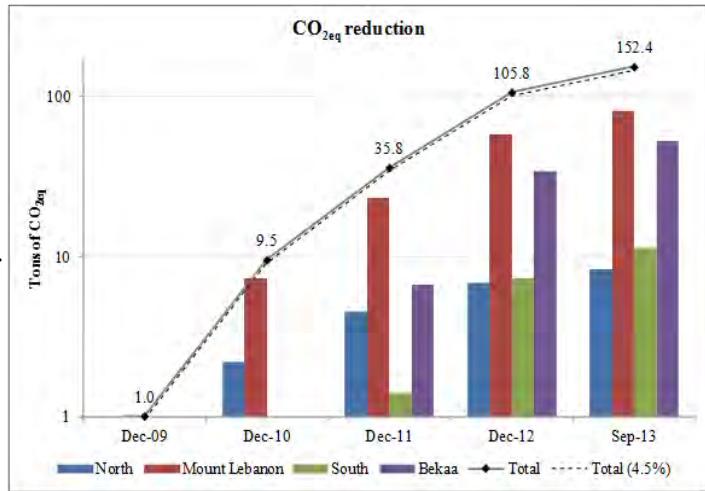


Figure 8: CO_{2e} reduction per year and per governorate from all Street lighting projects implemented by CEDRO

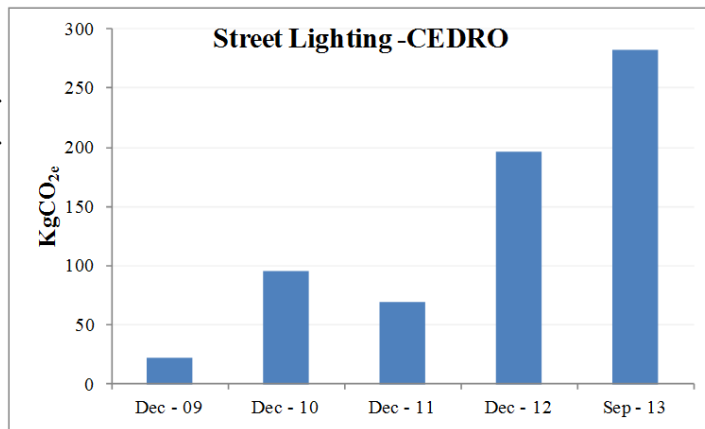


Figure 9: GHG emission reductions from installed LED bulbs per year

TOTAL GHG EMISSION REDUCTION FROM THE CEDRO PROJECT

The total reduction of GHG emissions from CEDRO's installation of RE systems is 884.3 TCO_{2e}; a daily average of 32 kg CO_{2e}.

GHG EMISSION REDUCTION CALCULATION - LCEC

SOLAR WATER HEATER

The GHG emission reductions were calculated taking into account that a total of 11 projects were commissioned having a capacity of 38,000 liters. The remaining 800 SWH systems of 300 liters per unit were not accounted for due to the lack of available information (commissioning dates, month and year).

Since the exact date of commissioning (day and month) was not provided, V4 Advisors assumed a commissioning date of 1st of June of the respective year.

These 11 projects were implemented in the two different governorates: South and Bekaa; the total cumulative number of operating days since commissioning was 21,829 days. The total GHG emission reduction was 108.3 TCO_{2e}, which is equivalent to 4.96 Kg of CO_{2e} per day.

Figure 11 summarizes the total CO_{2e} reduction from the implemented projects, per liter and per fiscal year.

STREET LIGHT PROJECTS

The LCEC programme was also mandated with improving the efficiency of street lights across the country. From November 2011 till April 2012 more than 3,200 electrical lines in Lebanon were modified to include diodes, switches or / and timers. These modifications resulted in reducing the electrical consumption by more than 50% (from 24 hours of continuous operation down to 11 hours per day). The total power reduction of a cumulative period of 1,368,513 days was estimated to be 22 MW, while the total reduction of GHG emissions from the implementation of these projects was 103,636 TCO_{2e}. The daily average reduction of GHG emissions was calculated to be 75.0 Kg of CO_{2e} per day.

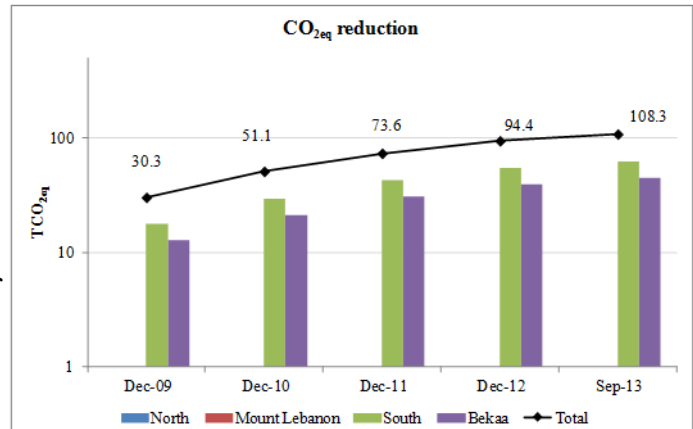


Figure 10: CO_{2e} reduction per year and per governorate from SWH projects implemented by -LCEC projects

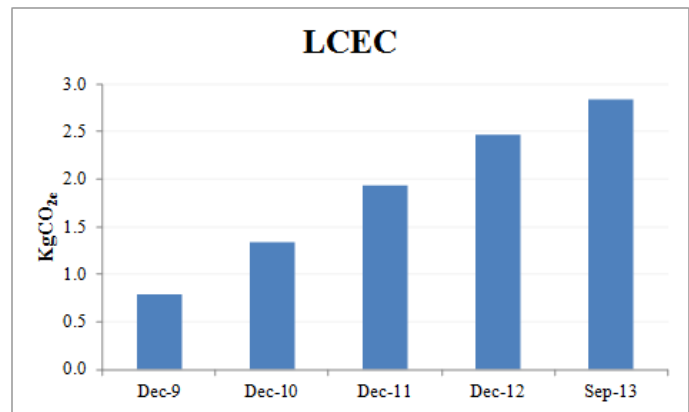


Figure 11: GHG reduction per liter intalled per year

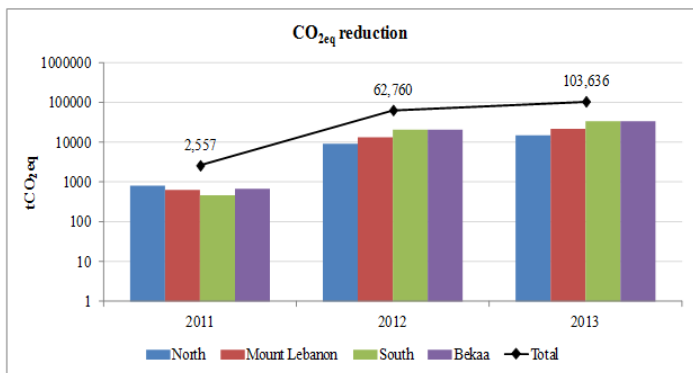


Figure 12: CO_{2e} reduction per year and per governorate from all Street Lighting projects implemented by LCEC projects

GHG EMISSION REDUCTION CALCULATION - CCM

Installed Solar Water Heaters Since 2012, 66 SWH projects were implemented under the National Action to Mainstream Climate Change into Lebanon's Development Agenda solar projects. 54 of these projects used passive circulation systems, while only 8 were forced circulations. These projects, altogether, covered the need of 70,250 liters of hot water in several regions. Their individual capacity varied from 150 liters to 8,000 liters. The cumulative number of operating days since commissioning is 17,838 days. Table 5 summaries the total capacity installed per governorate.

	North		Mount Lebanon	South		Bekaa		Nabatieh		Beirut
Forced	No yes		No	No Yes		No Yes		No Yes		No
Number of sites	11	2	14	12	3	12	2	1	1	7
Installed capacity	11,000	10,000	9,600	7,100	14,000	12,300	9,000	300	3,000	2,800
Demand	7,800	10,000	6,600	5,050	14,000	8,650	9,000	300	3,000	1,950

Table 5: Description on all SWH projects implemented by CCM per governorate

CALCULATION OF THE CARBON REDUCTION

The 66 SWH installed systems have a total capacity of 70,250 liters. As Figure 13 shows, the total GHG emission reductions up till the 1st of September 2013 are 127 TCO_{2e} or 0.82 Kg of CO_{2e} reduction per day.

Figure 13b shows the GHG emission reductions from the installation of 1 liter.

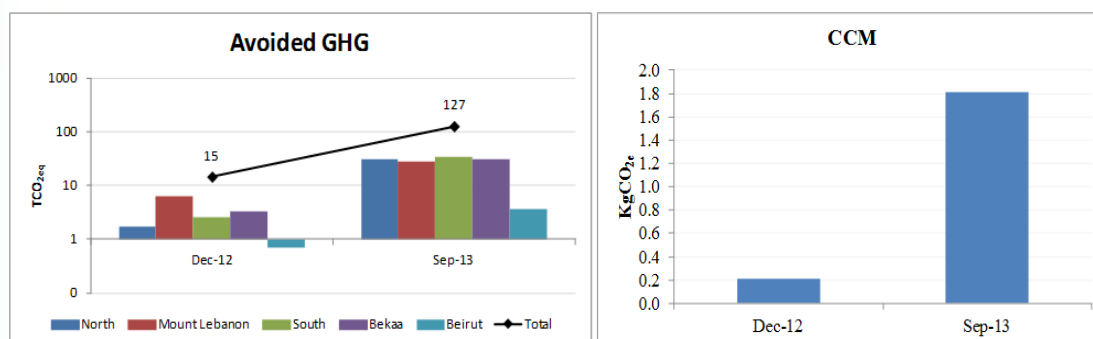


Figure 13: CO_{2e} reduction from implemented projects by GSWH from 2012 till 2013, b) GHG emissions avoided from the installed capacity per liter during the fiscal years

TOTAL CARBON REDUCTION FROM CEDRO, LCEC AND CCM

The total GHG emission reduction achieved from the projects implemented by the three programs up till the 1st of September is 104,070 TCO_{2e}. Figure 14 illustrates the GHG emission reductions obtained from these programmes per annum as well as illustrates the increase of emissions reduction from 2011 to 2013 due to the increase number of RE installations, GHG emission reduction increase of 1,950%.

Although LCEC's street lights project was the main contributor to GHG emission reduction (99%), the SWH related GHG emission reductions had doubled from 2011 till 2013 (87 tons and 161 tons, respectively).

To reiterate, the quantified GHG emission reduction noted above assumes that 100% of the total implemented projects are fully operational. By extrapolating the results of the Evaluation for Community energy Efficiency and Renewable Energy \ Demonstration project for the Recovery of Lebanon CEDRO II auditing report, evaluation to all projects commissioned before 31st of December 2012, the reduction of GHG will decrease to 91,470 TCO_{2e}.

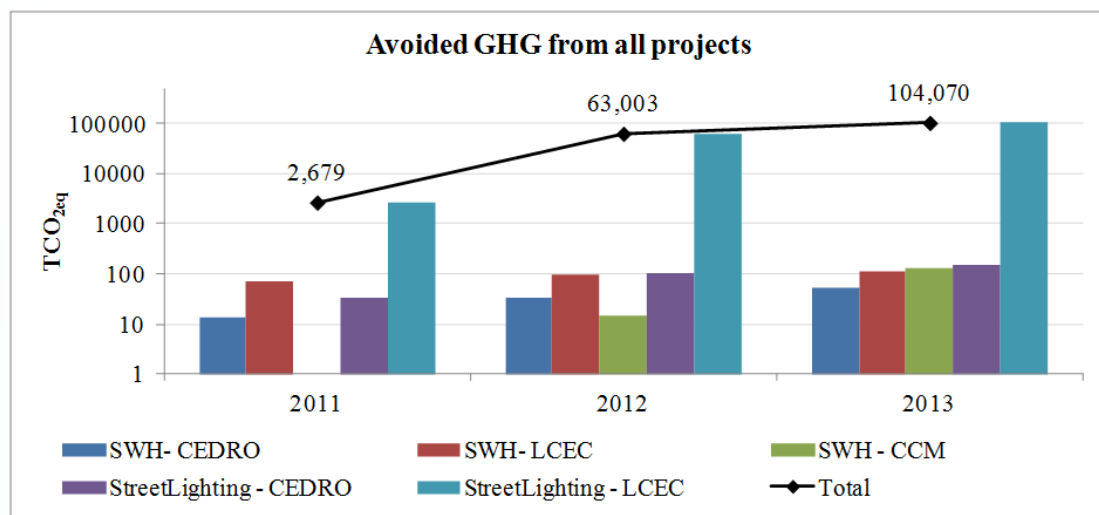


Figure 14: Cumulative GHG reduction emissions from all implemented projects

RECOMMENDATIONS

In order to achieve a better understanding of the GHG emission reductions from the implemented projects, and to comply with the recommendation of GHG Project Protocol, the following should be taken into account:

- Information related to distances travelled to install and maintain the RE systems should be provided and included in the GHG emission calculation
- The exact date for commissioning should be provided to accurately calculate the emissions of the RE installation, including the ones that were not accounted for due to complete absence of the information
- The rate of failures, capacity usage should be registered and incorporated in the GHG calculation
- Some background information on the availability of electricity and offsetting the outage should be available
- Utilization of the RE systems should be improved and accurately reported
- Regular maintenance and check-ups for the installed equipments should be provided to assure the continuity of these units