United Nations Development Program UNDP
EU-Funded CEDRO IV & Kingdom of the Netherlands
UNDP Host Community Project
RE and EE Guideline Reports

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Solar PV Hybrid Power Plants

Solar Photovoltaic (PV) Hybrid Power Plants

A Guideline Report - July 2016

Energy Efficiency in Industries

Energy Efficiency in the Lebanese Industrial Sector

A Guideline Report – July 2016

Sustainable Street Lighting

SUSTAINABLE STREET LIGHTING

A GUIDE TO EFFICIENT PUBLIC STREET LIGHTING FOR LEBANON

A UNDP-CEDRO PUBLICATION

DECEMBER 2015

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1. Solar PV Hybrid Power Plants A Guideline Report

In order to increase PV penetration and assist the GoL in achieving its 12% renewables target by 2020, the CEDRO IV project has implemented four hybrid PV-diesel power plants in collaboration with the industrial, commercial and NGO sectors.

The implemented PV hybrid pilot systems range from 120 kWp to 300 kWp and in some cases, have integrated sophisticated control.

Moreover, UNDP supported the design and implementation of four additional PV-hybrid plants in Lebanon within the MED-Solar project. However, these systems also included energy storage component for back-up of the critical loads.

The Solar Photovoltaic Hybrid Power Plants Guidelines Report was based on the experience obtained from these projects and from the feedback of the CEDRO workshops on this topic.

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212 kWp

300 kWp

130 kWp

214 kWp

135 kWp
(EU- MEDSOLAR)

120 kWp
(EU-MEDSOLAR)

120 kWp
(EU-MEDSOLAR)

145 kWp
(EU-MEDSOLAR)

Over 1.4 MW of Solar PV capacity – hybrid systems with diesel gensets

Gemayel Freres 300 kWp – Mount Lebanon


LibanJus 135 kWp – Beirut

LibanLait 214 kWp – Bekaa

Tahrir Complex 120 kWp – South Lebanon


EMKAN 120 kWp – Akkar


RMF 135 kWp – North Lebanon

AUB Campus 150 kWp – Beirut

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Outline of the Guideline Report

- Overview and General Principles
- Components and Standards of the Hybrid PV Systems
- Plant Sizing and Design
- Construction and Commissioning
- Operation and Maintenance
- Sample of a Feasibility Study

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PV-hybrid power plants are electrical generation systems consisting of centralized or distributed units of solar photovoltaic, combined with fossil fuel generators and other components.

- PV Panels
- Diesel Generator (s)
- Inverters
- PV Controller
- Distribution Line & Load
- Battery *(sometimes)*

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The interconnected units are also referred to as microgrids (or mini-grids). Their common feature is that most of the electricity is generated and consumed within the microgrid.

Furthermore, depending on their complexity, their capacity and the level of service they seek to provide, they can include a Supervisory Control and Data Acquisition System (SCADA) and advanced computing algorithms to control the energy production. In this case, they are called smart microgrids.

The PV hybrid Power Plant typically has two different grid forming power sources: the utility grid and the genset (in case energy storage is included, the plant will have a 3rd source; batteries), and the PV generator operates in parallel to both sources.

The functional description of the Operational Modes can be summarized as follows:

- Grid Parallel Mode:

When there is grid supply, the PV generator can reduce the consumption from the utility grid by parallel connection and offsetting the loads of the facility as well as potentially back-feeding surplus PV production into the grid, through the net-metering process.

- Diesel Genset Parallel Mode:

The Diesel Genset Parallel Mode is automatically triggered when there is a grid black out and the Genset is on. During the Diesel Genset Parallel Mode, the PV generator helps to reduce the fuel consumption from the genset by parallel supply to the loads of the facility.

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Figures on the Hybrid PV- Diesel System (without energy storage)

Cost
- Ranges from 1200- 1400 USD/ kWp installed

Payback
- Ranges between 5-7 years

Savings
- Savings on energy consumption
- Savings in GHG emissions

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2. Energy Efficiency in the Lebanese Industrial Sector A Guideline Report

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Typically, energy constitutes more than 30% of the annual expenses of an industrial facility.

Reducing energy costs is thus primordial in cutting production costs and enabling the company to maintain a strong market position.

In fact, reducing energy costs by 1 $c/kWh results in savings in manufacturing costs by 0.95 US Dollars.

The starting point from where a comprehensive energy management program may be developed is an energy audit, which quantifies the energy usage at a site, highlights areas for potential savings and gives the data from which performance indicators can be derived.

In short, the energy audit is designed to determine where, when, why and how energy is being used within a facility.

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The industrial energy audit is performed following the steps below:

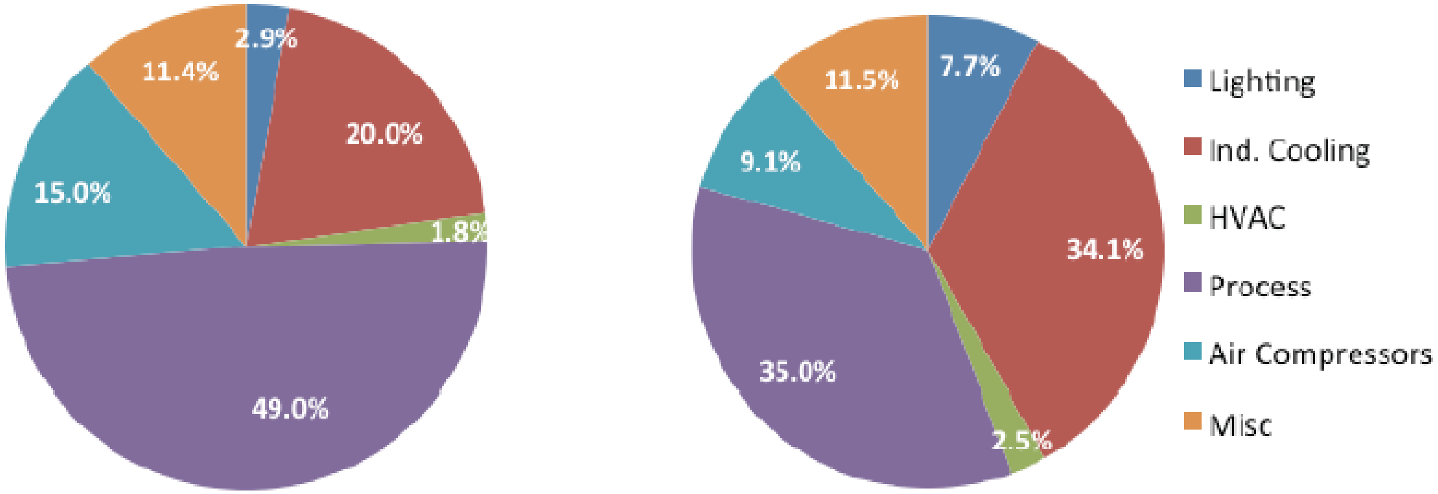
Step 1: Understanding the industrial operations
Step 2: Undertaking a Preliminary Energy Audit (PEA)
Step 3: Identifying the preliminary Energy Efficiency Measures
Step 4: Undertaking the Detailed Energy Audit (DEA) including:

I. Preparation of measurements plans
II. Detailed analysis of existing energy end uses
III. Development of all Energy Efficiency Measures with their technical background, savings calculations and financial analysis
IV. Preparation and presentation of the DEA report including the Action Plans

Key obstacles to overcome:

Lack of historical energy baseline
Unavailable information
Lack of management cooperation

Average electrical load and
energy breakdown for industrial facilities:



Average electrical load (Left) and energy (right) breakdown for the industries

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Typical Energy Efficiency Measures (EEM) in Industries:

- Monitoring and Energy Management:
  - Energy Metering and Control: analyzes tariffs, equipment operations, power quality, maintenance
  - Peak Hours Management: allowing to switch from one energy source to another depending on the spot cost of electricity

- Compressed Air System:
  - System Optimization: proper system sizing
  - Leakage Prevention: treatment of pipes and accessories
  - Temperature Optimization: implementing inlet for outdoor air
  - Pressure Reduction: reduction of set pressure to the lowest possible value

- Steam System

- Heat Recovery

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Figures on Energy Audits in Industries

Cost
- Ranges from 5,000 to 20,000 USD

Payback
- Depends on the implemented EEMs

Finance
- NEEREA Loan
- Up to 10 years payback with around 1% interest rate

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3. Sustainable Street Lighting

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Street lighting is a major electricity consumer and drastically impacts the national electricity consumption.

Investing in renewable energy and energy efficiency measures in street lighting decreases the energy consumption, the national electricity shortage and the greenhouse gas emissions.

Yet besides that, street lighting improves road safety and the overall village/city’s security.

Common lighting technologies used in street lighting:

Lamp	Lm/Watt	CRI	Lifespan (hrs)	Dimmable
Mercury vapor	40-60	✪✪✪○○	12,000	No
HPS (standard)	80-100	✪✪○○○	12,000 – 16,000	No
HPS (color improved)	40-60	✪✪✪○○	6,000 – 10,000	No
LPS	80-180	○○○○○	10,000 – 18,000	No

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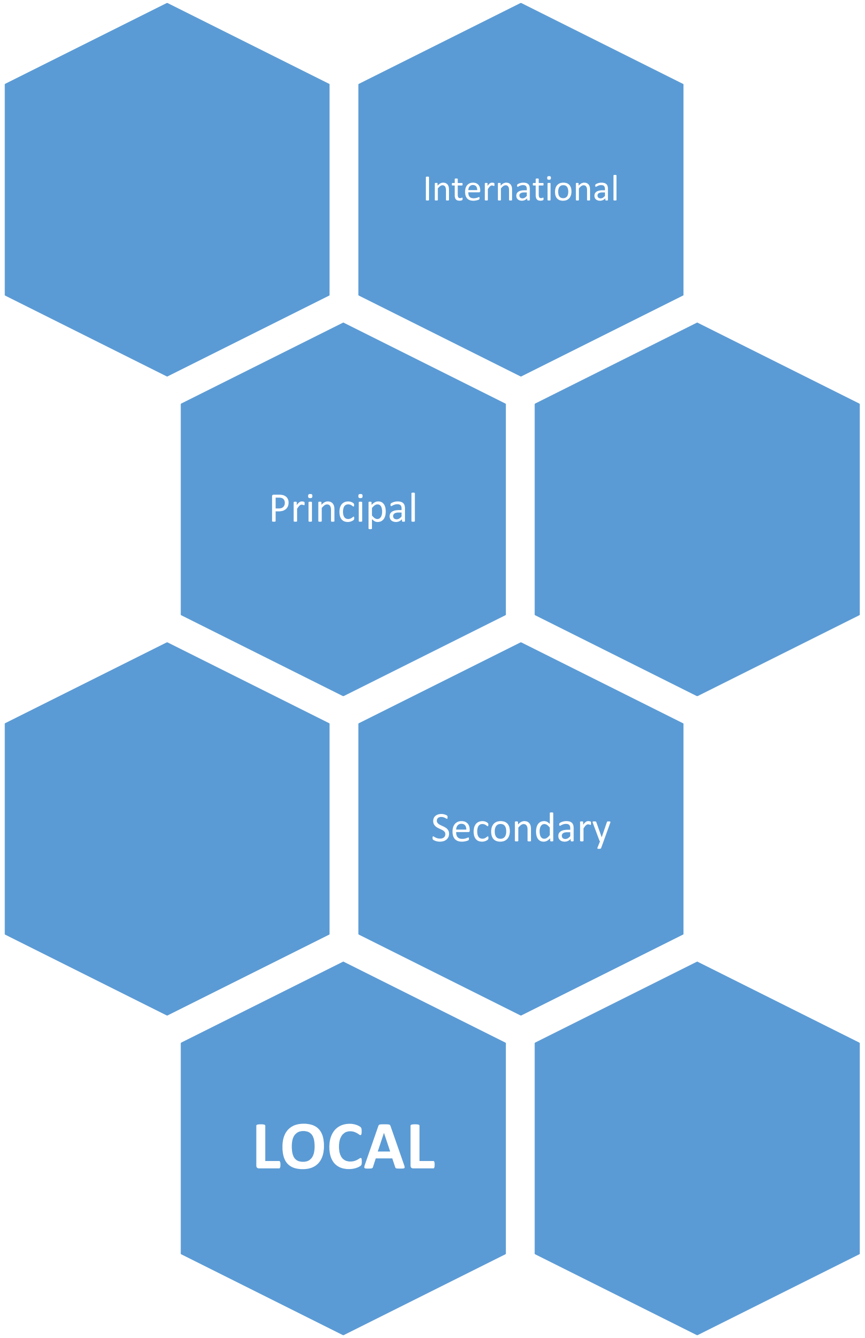
Type of Roads:



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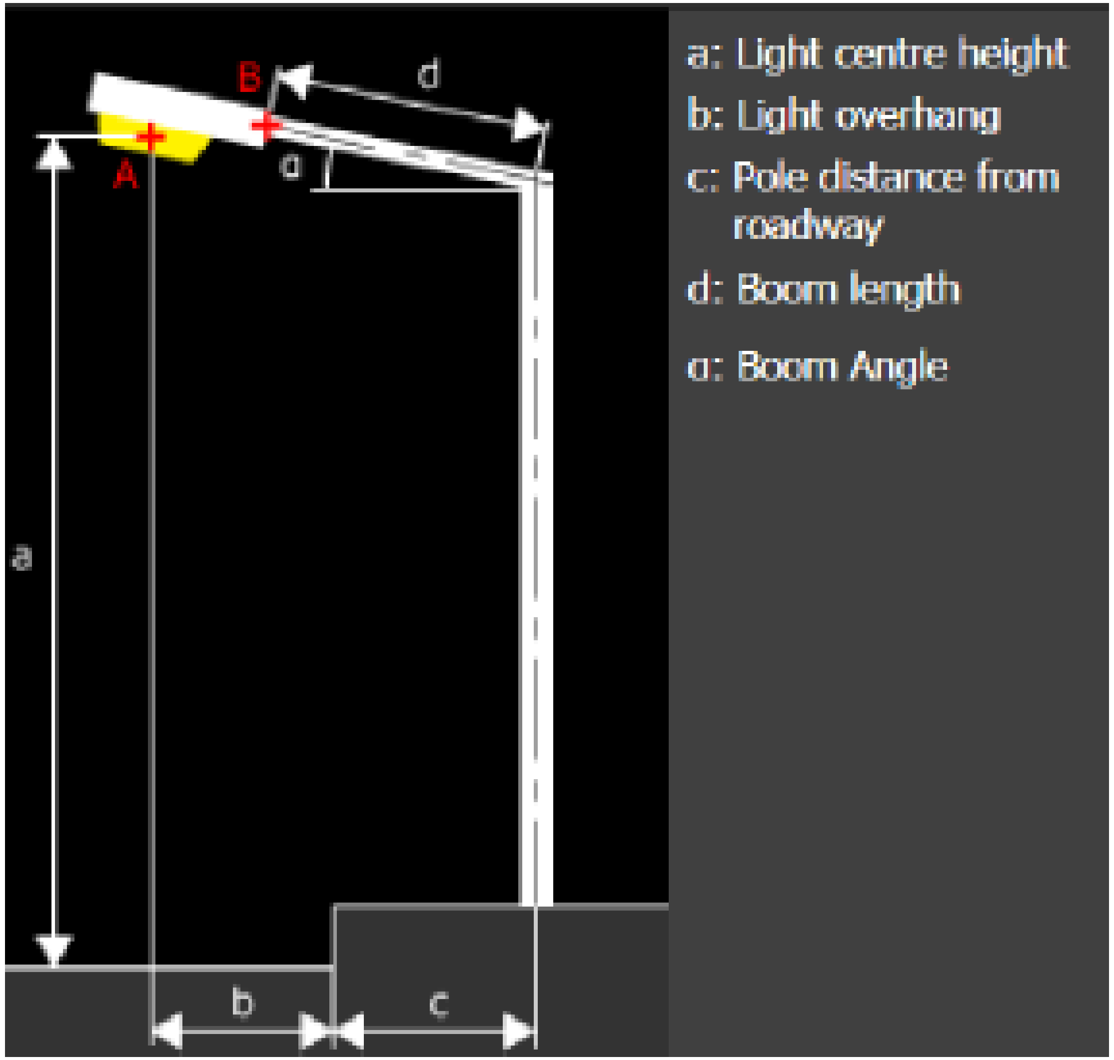
Design Considerations for Road Types:



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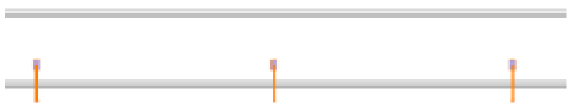
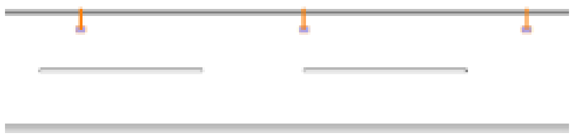
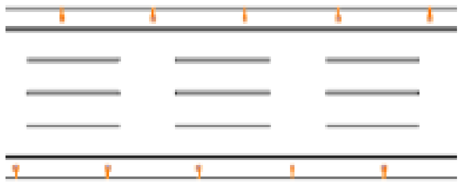
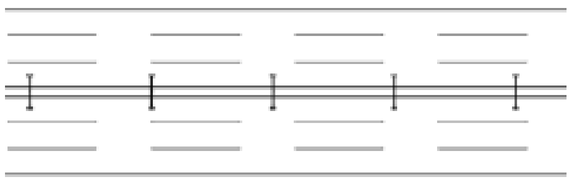
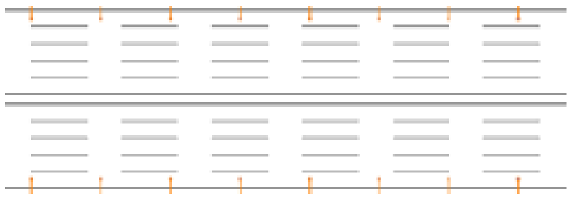
	Type of Road	Road details	Pole Details
L1		• Ways: 1 • Lanes/Way: 1 • Total Width: 3.5m • Poles type: one-side • Lamps/pole: 1	• a: 4m • b: 1m • c: 0.65m • d: 1.65m • α: 0°
L2		• Ways: 2 • Lanes/Way: 1 • Total Width: 6m • Poles type: one-side • Lamps/pole: 1	• a: 6m • b: 1m • c: 0m • d: 1m • α: 0°
L3		• Ways: 2 • Lanes/Way: 2 • Total Width: 14+4m • Poles type: Staggered • Lamps/pole: 1	• a: 7m • b: 0m • c: 2m • d: 2m • α: 0°
L4		• Ways: 2 • Lanes/Way: 3 • Total Width: 25m • Poles type: Middle • Lamps/pole: 2	• a: 12m • b: 2m • c: 0.5m • d: 2.5m • α: 15°
L5		• Ways: 2 • Lanes/Way: 5 • Total Width: 37m • Poles type: Middle • Lamps/pole: 2	• a: 10m • b: 2m • c: 0.65m • d: 2.65m • α: 15°

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Efficiency Measures in Street Lighting:

The most typical energy efficiency measures in public lighting practices are listed in the table below, in order of simplicity – recommended order for consideration:

Efficiency Measure	Description
1. Lamp replacement	• Replace lamps for highly efficient ones (LED) • Add lightning protection
2. Daylight operation prevention system	• Photocells • Astronomic Control
3. Integral Control and management system (software)	• local – decentralised (local agency or municipality) • remote – centralised (via telecommunication devices)

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Solar-Powered Street Lighting Systems for Rural Roads:

Replacing HPS 150 W

The following system is required in order to replace the street lighting fixtures of HPS type of 150W, while maintaining the same illumination and improving the quality of light.

System Description:

Stand- alone photovoltaic lighting systems with highly- efficient monocrystalline or polycrystalline silicon solar panels for power supply.

Pole height: 6-8 meters

Lamp height: 6 meters

Poles’ Spacing: 35 meters

Working Voltage: 12/24V DC

Lighting Time: 10-12 hours per day

Days of autonomy: 3 days

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System Components:

- Street lighting pole
- Solar panels
- Lamp
- Dimming system (optional)
- Charge controller
- Batteries
- Equipment storage casing
- Wire harness
- Mounting brackets (must allow variable orientation and inclination of the PV module)
- Protection circuit

Most Relevant System Specifications:

Lamp

Type of lighting: LED fixture, suitable for road lighting application, including dimmable LED driver.
Luminous Flux: meets or exceeds 6500 lm. → Power rating 56-70W
Life Span: 50,000 hours at ambient temperature of 25˚C.
Color Temperature: 2700- 3300˚K (warm white)
Color Rendering Index: greater or equal to 75.
Ingress Protection Rating: IP65.
Warranty: 3 years

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PV Panel

Type: Mono or Poly crystalline technology.
Rated power: 1 module of 240W (70W lamp).
Module conversion efficiency: greater or equal to 15%.
PV modules shall be compliant to IEC 61730 and IEC 61215 guidelines.
Warranty: minimum 10 years on material and manufacturing.
Output Warranty: 10 years with 90% power output and 20 years 80% power output warranty.

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Battery

Battery capacity: 2x 150 Ah at C10, connected in series.
Battery voltage: 12V each.
Type: deep- cycle gel battery (maintenance free)
Life cycle: minimum of 1200 cycles at 70% DoD.
Warranty: 2 years

Controller

Pulse Width Modulator 3- stage charging controller.
Voltage and Current: 24V/ 10A.
Warranty: 2 years

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Figures for PV Street Lighting

Cost

- Ranges from 1,300 to 1,500 USD per system

Impact

- Social and Economic: savings in energy and $CO2$, daily non-interrupted lighting at night, security, safety…

NOTE

- Batteries need to be replaced every 4-6 years, cost per battery approximately 200$.
  Every system comprises 2 batteries.

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Other Guideline Reports:

Sustainable Forest Management: Blueprint and Case Studies	Published on the website
Net Metering: A Guideline Report	Published on the website
Ground Source Heat Pump: : A Guideline Report	Coming Soon.....

January 10, 2017

GUIDELINES ON NET - METERING: THE CASE OF LEBANON

November 23, 2016

LEBANON'S NATIONAL BLUEPRINT FOR A SUSTAINABLE FOREST BIOMASS

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4. Where to Find the Guideline Reports?

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CEDRO WEBSITE

www.cedro-undp.org

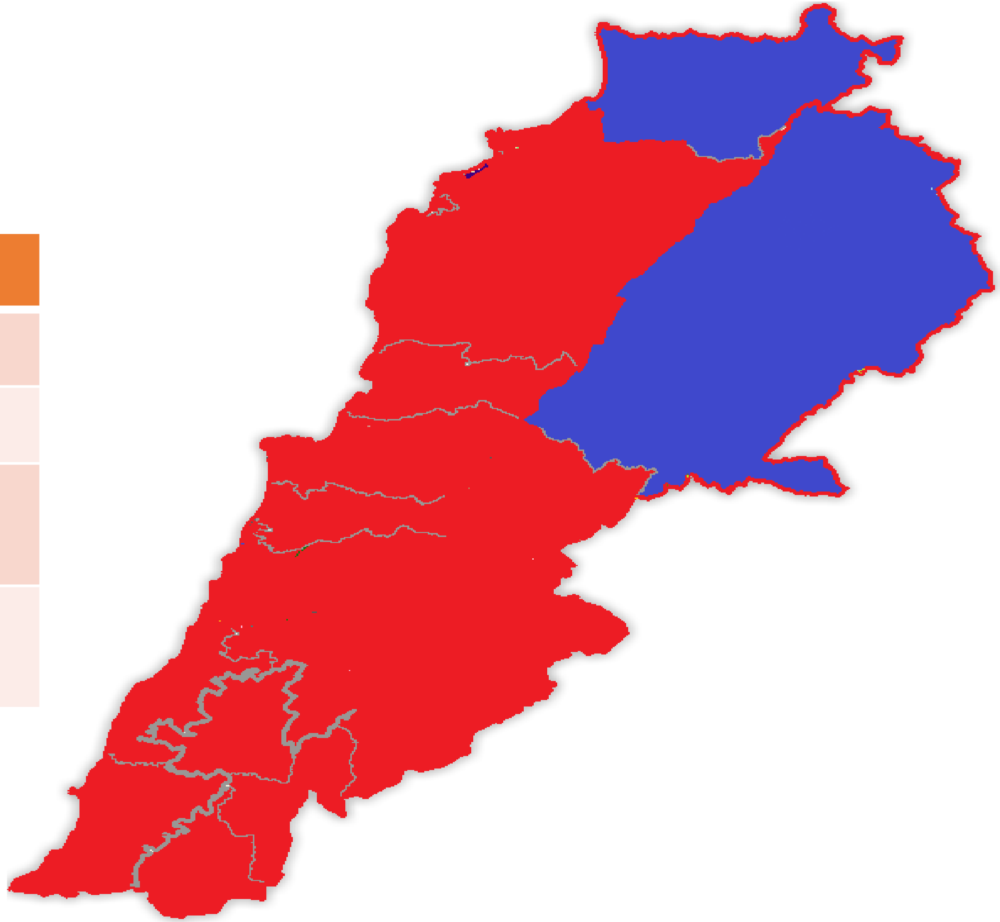
PUBLICATIONS

NATIONAL STUDIES & REPORTS

5. Host Community Projects

Host Communities

Category	Number of Units
PV lighting Kit	2,375 Units
Stoves	594 Units
Briquettes	950.4 tons Or 1.6 tons per house
Street Lighting	1,177 Systems



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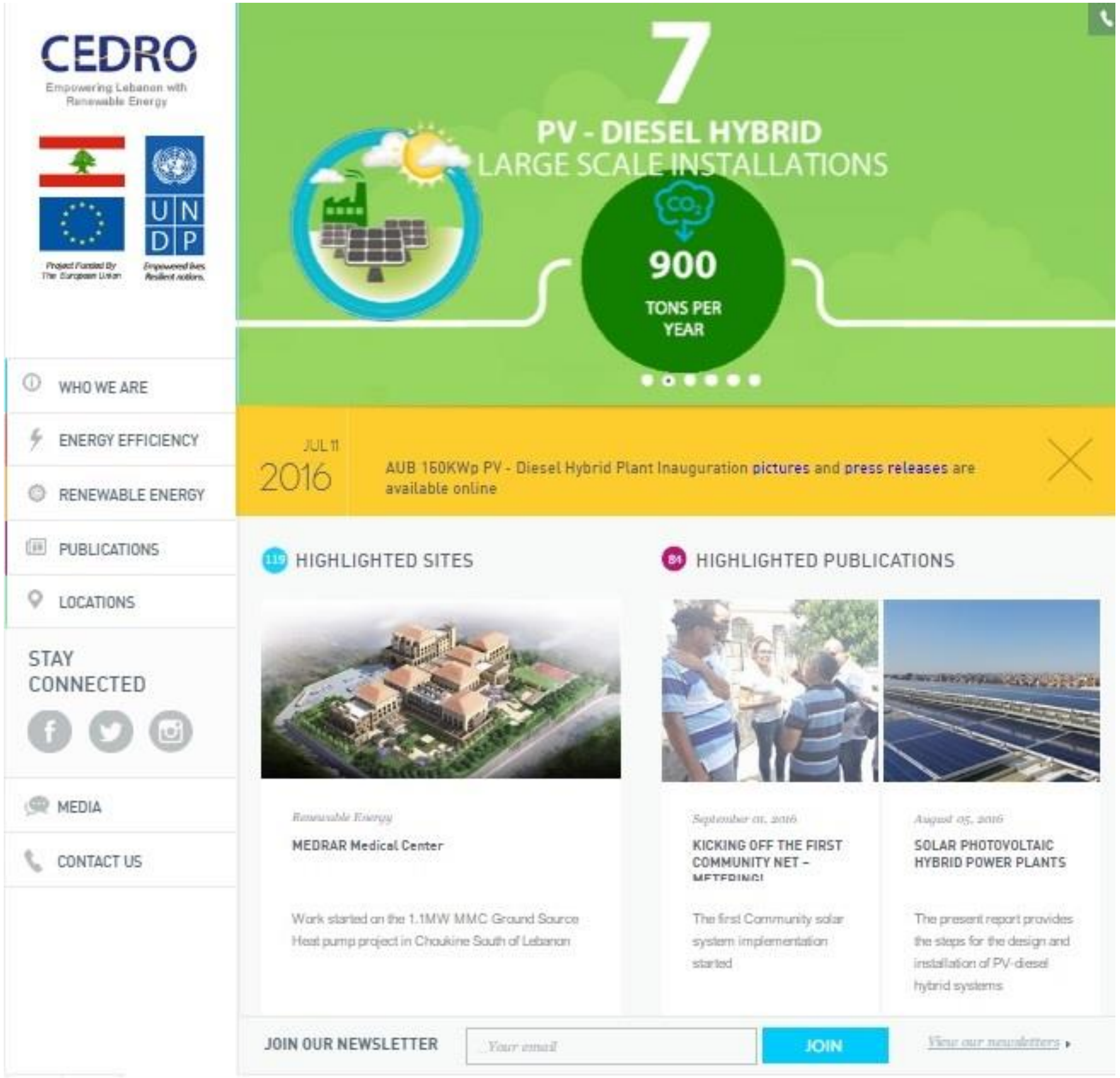

Thank you

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