AALBORG 2015 Symposium on Microgrids, REMOTE session
27 and 28 August 2015

PV HYBRID INDUSTRIAL MICROGRIDS IN UNRELIABLE NATIONAL GRIDS

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OVERVIEW OF THE FIRM - TTA

- SME Founded in Barcelona in 1986
- Independent International Engineering Consultants highly specialized in Renewable Energy (RE) distributed generation
- Reference in Micro-grids with Solar Hybrid Generation (MSG) - Since 1987: Off-grid rural electrification practitioners
- Consolidated experience in each and every phase of a rural electrification project cycle - including: Turn-key / O&M / Transversal Issues: institutional, social, regulatory
- Europe, Africa, Latin America, Middle East, Asia, Oceania …

Member of:

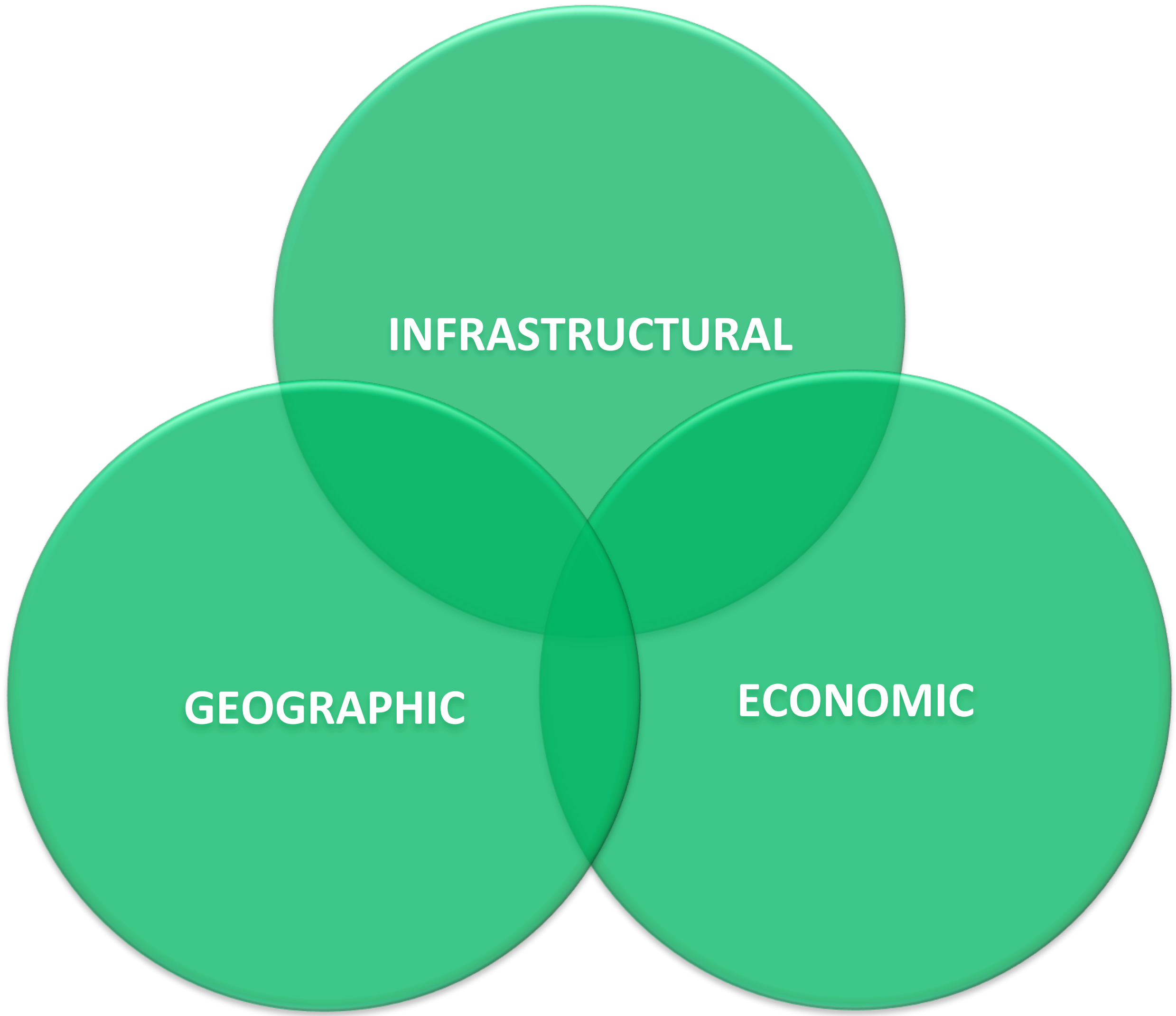
Alliance for Rural Electrification
Shining a Light for Progress

solartys
Asociación Española para la Internacionalización y la Innovación de las Empresas Solares

UNEF

WHAT IS REMOTE?

Different dimensions of Remoteness:



RETD Study, 2012
http://iea-retd.org/archives/publications/remote

GENERAL CONSIDERATIONS

Technical Considerations

Types of microgrids	Advantages	Shortcomings
Microgrid fed by RE/Hybrid power plant (small systems)	• Improved quality (surge power, load shedding, etc) • Lower investment for communities • Efficient maintenance • Genset backup • Lower LCOE	• Higher technological and organizational complexity • If there is a plant failure, everybody is cut off • Social rules required to distribute energy • Local management required • Need for storage systems
Microgrid with hybrid integration of RETs (large systems)	• Distributed generation • Lower LCOE	• Need to ensure grid stability due to intermittency of some RES • High penetration of RETs is a bigger challenge
Fossil-fueled microgrid	• Low initial investment costs • Status quo is not altered	• High O&M costs • High fuel price volatility • GHG emissions • Logistics risk when transporting diesel

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RETD Study, 2012
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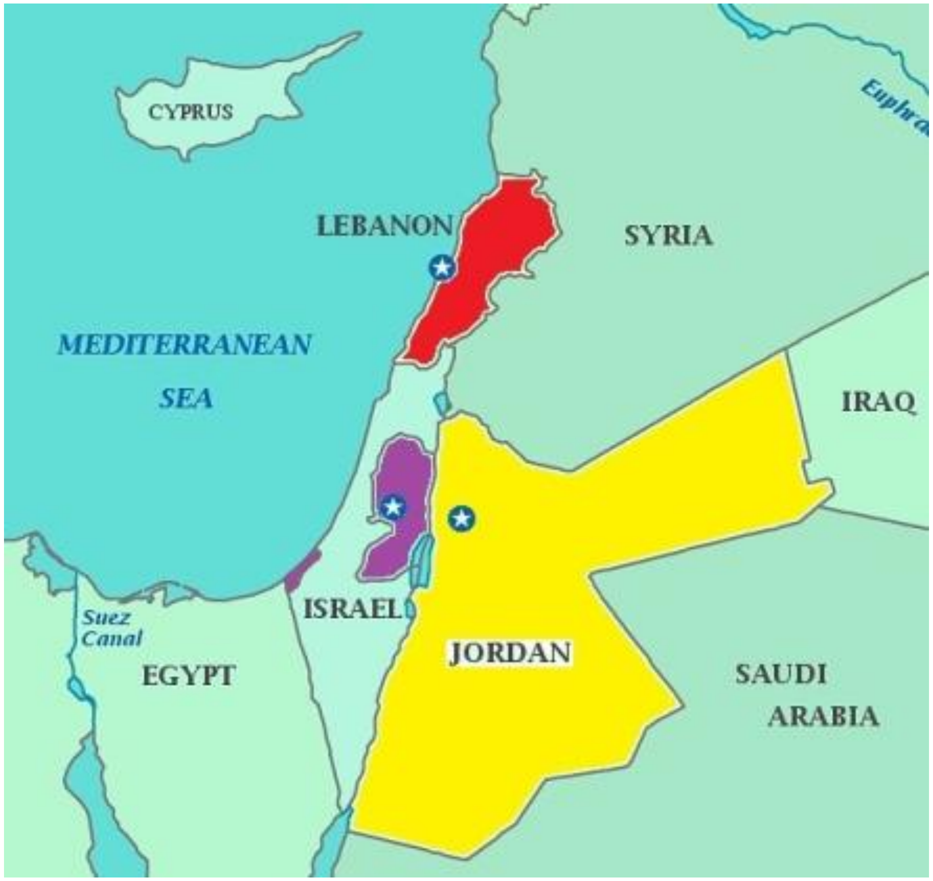
NEW PROBLEMATIC IDENTIFIED

Potential of **industrial** micro-grids in **unreliable** national grids

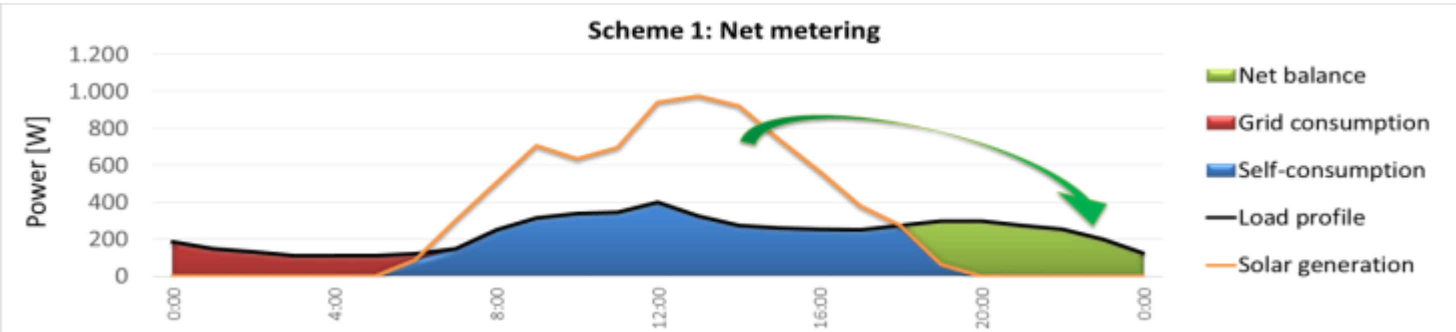
- Frequent power cuts
- Critical loads
- Necessity of backup (diesel) generator
- High dependency on foreign supply
- High cost of operation
- Low air quality

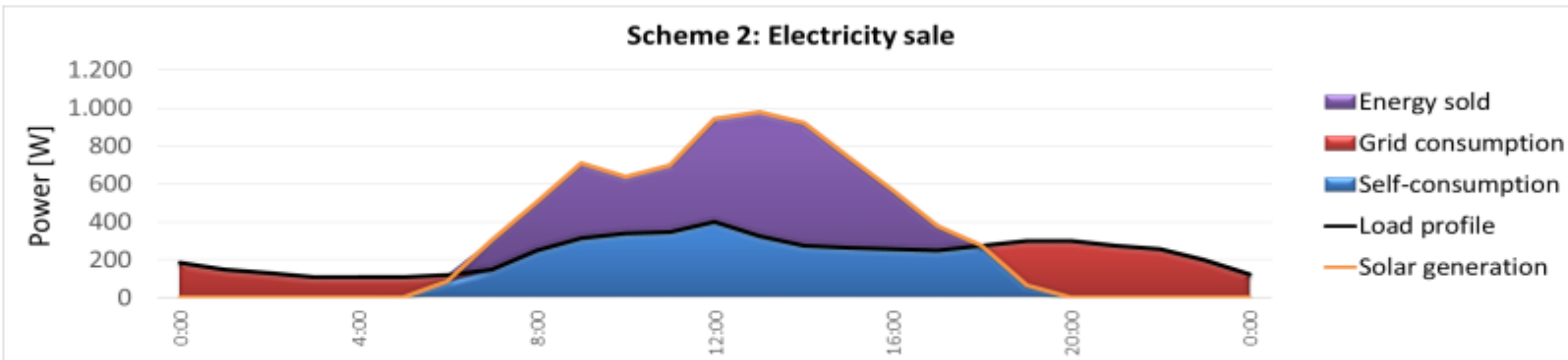


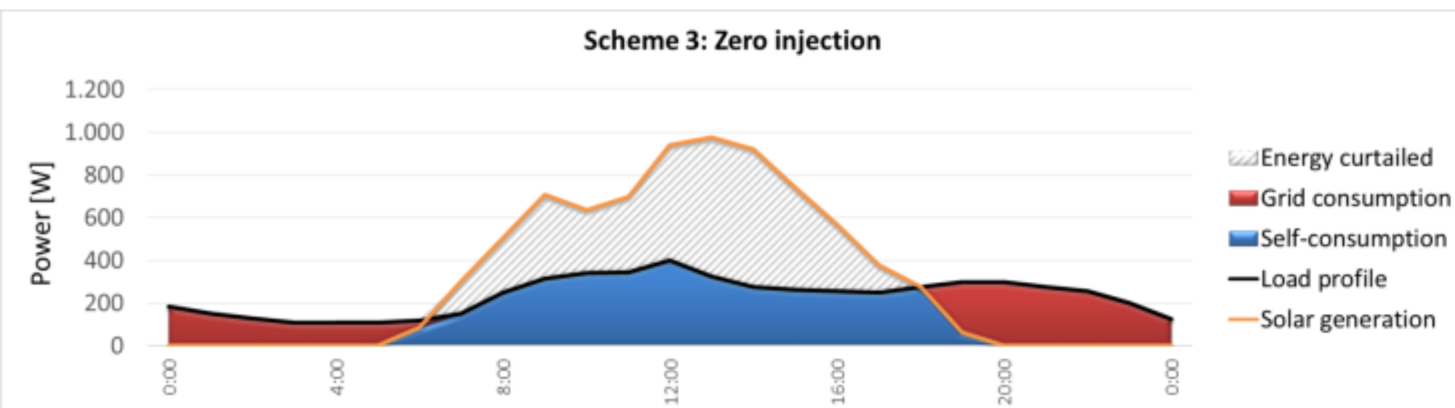
Weak grids: countries studied as part of the ENPI project MED SOLAR

ECONOMIC CHALLENGE: SUITABLE BUSINESS MODEL?

Typical schemes to integrate renewables **behind the meter** when reliable grids

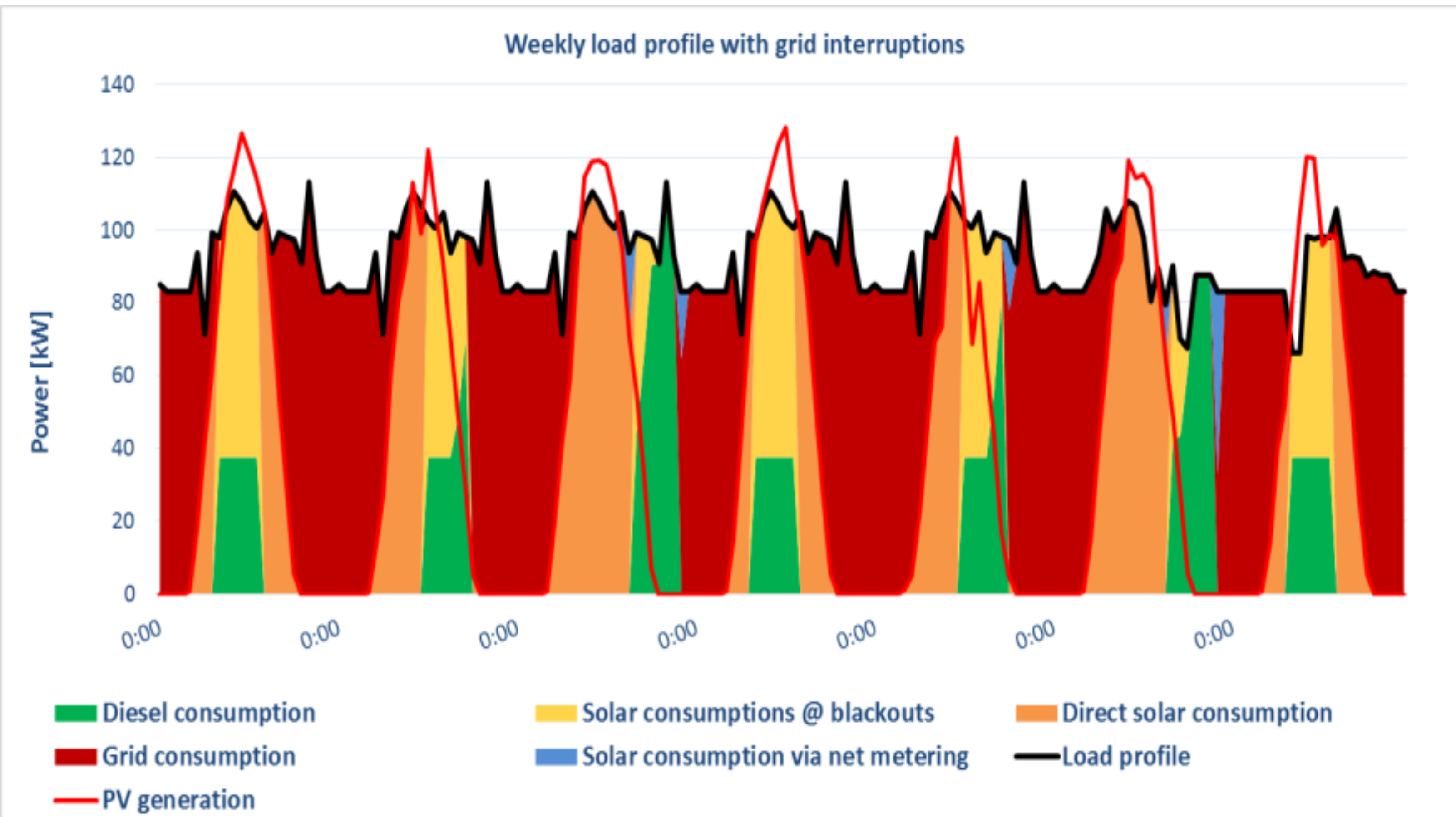


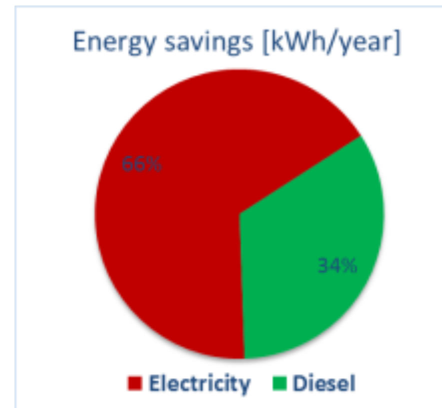


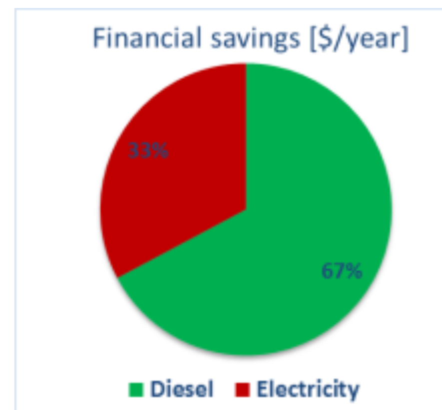


SOLUTION FOR UNRELIABLE GRIDS
CASE STUDY: LEBANON

- During **normal operation** of the national grid: self consumption and net metering
- During national grid **blackouts**: the PV plant offsets diesel consumption and curtail surplus







FINANCIAL CHALLENGE
CASE STUDY: LEBANON

Energy prices:

2014 National grid prices for industrial customers [USD/kWh]			
Summer (April 1 – September 30)		Winter (October 1 – March 31)	
00:00 – 07:00	**0,05**	00:00 – 07:00	**0,05**
07:00 – 18:30	**0,07**	07:00 – 16:30	**0,07**
18:30 – 21:30	**0,21**	16:30 – 20:30	**0,21**
21:30 – 23:00	**0,07**	20:30 – 23:00	**0,07**
23:00 – 24:00	**0,05**	23:00 – 24:00	**0,05**
Diesel price		1,2 USD/L	
Annual increase of energy price		3%	

Challenges: **Uncertainty of blackout occurrence**

Uncertainty of future prices

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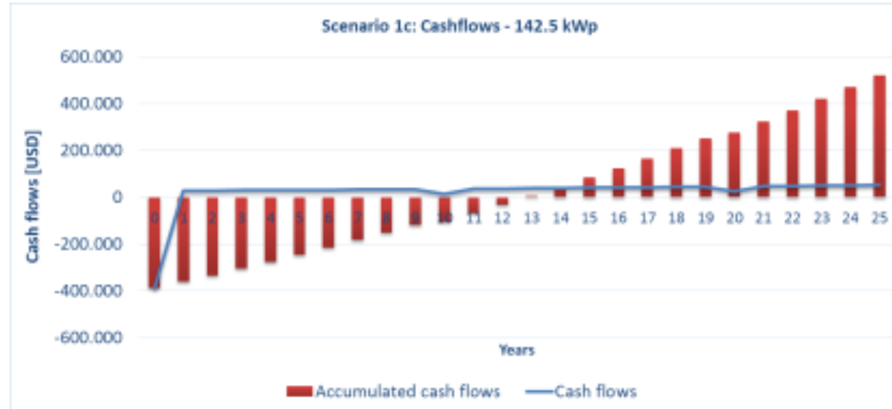
FINANCIAL CHALLENGE
CASE STUDY: LEBANON

100% equity

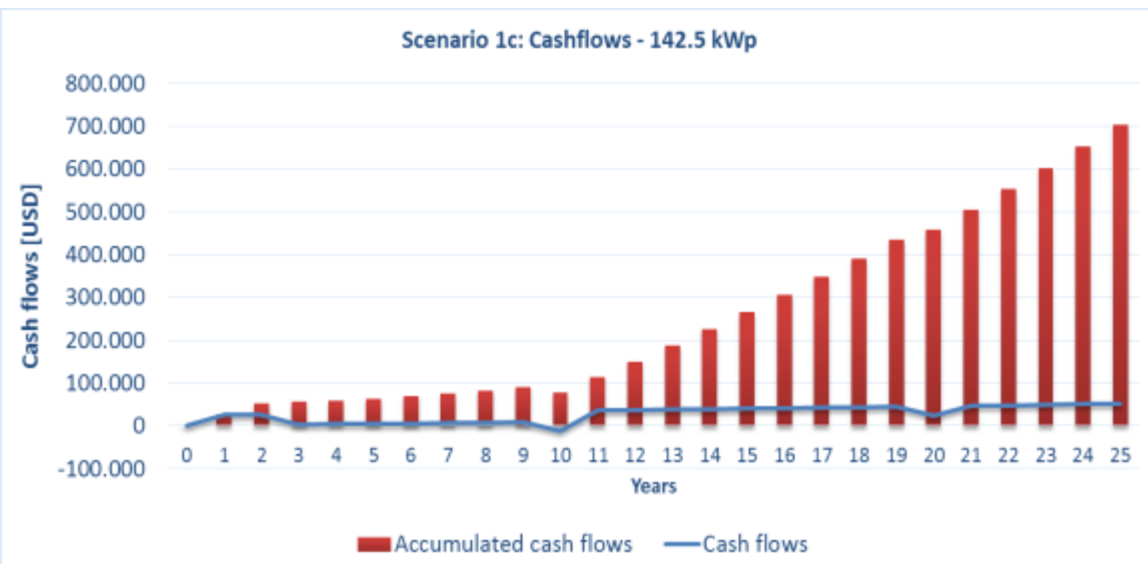
No external support

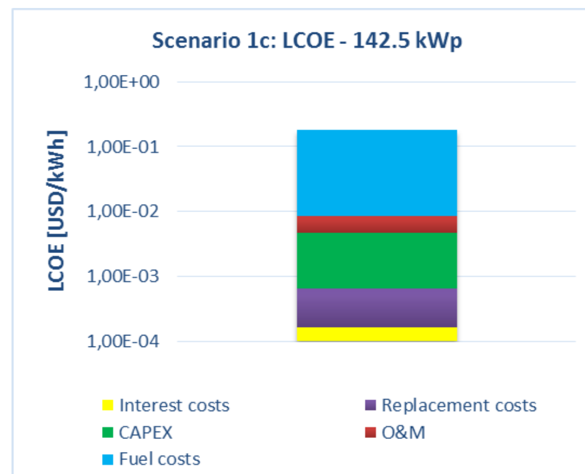
Subsidised fuel



NEEREA Loan: 0,6% interest rate, 2 years grace period, 10 year amortization.

CEDRO grant: UNDP finances up to 50% or 200k € of project





RENEWABLE ENERGY ARCHITECTURES – MAIN COMPONENTS

Distributed generation

- Utility grid
- PV distributed generators
- Loads

Rural autonomous microgrids

- Diesel generator
- PV generator
- Loads
- Storage

Interconnected microgrids

- Utility grid interface
- PV generator
- Loads
- Storage

Microgrids in unreliable grids

- Utility grid
- PV generator
- Loads
- Storage
- Diesel genset
- Power switch over/transition

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MICROGRID FOR UNRELIABLE GRIDS

Objective

Reduce the use of fuel (diesel, utility grid) using:

- PV powered micro grids
- Transient storage systems

Consequences

- Increase security of power supply
- Reduction of operation cost
- Promote SMEs development
- Improve air quality

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GRID SITUATION
CASE STUDY: LEBANON

Electric Power:

Available capacity: 1,7 GW
Peak load: 2,8 GW

→ Power gap: **1,1 GW**

Electric Energy:

Provided: 11,5 TWh
Demanded: 15,0 TWh

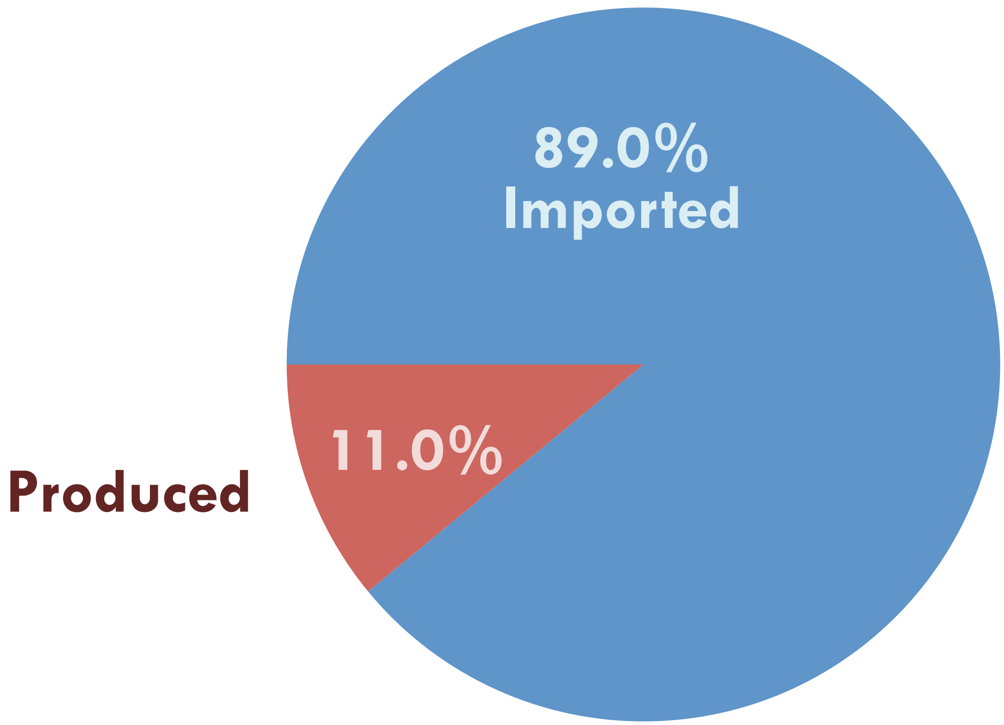
→ Energy gap: **23%**

- Power scheduled cuts across the country (between 3 and 12 hours per day)
- Extensive use of private diesel generators
  - ✓ Poor air quality (specially in summer)
  - ✓ Estimated cost: $1,3 billion

Source: **International Energy Agency (IEA).** *Lebanon Statistics 2010*

GRID SITUATION
CASE STUDY: PALESTINE

Electric energy provided: 5,2 TWh



Electricity imports:

Gaza Strip	
Israel	62,5 %
Egypt	6,7 %
Palestine	30,8%

The West Bank	
Israel	97,8 %
Jordan	2,2 %

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TECHNICAL CHALLENGE: GRID CHARACTERISATION

Main steps:

1. Standardize a grid characterization methodology
2. Selection of Measuring points
3. Data acquisition in sample site
4. Data Analysis & characterization report
5. Definition of technical need

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TECHNICAL CHALLENGE: GRID CHARACTERISATION

- **Voltage events analysis:** Lebanon has the worse grid quality among the target countries of MEDSOLAR project
- In **Lebanon,** events on voltage occurs when the grid goes down and the genset is switched ON

Voltage event	Palestine	Lebanon	Jordan
Over Voltage	No	Yes	No
Worst case		140% of Vn (350 ms)	No
Under Voltage	Yes	Yes	Yes
Worst case	Vmin: 217 V	10% of Vn (10' 340 ms)	30% of Vn (960 ms)
Interruption	No	Yes	No
Worst case		0% of Vn (6h)	

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DESIRED FUNCTIONALITIES FOR INDUSTRIAL USERS IN INTERMITTENT GRIDS

Mode 1: AC grid formed by the mains

- Grid power control
- Grid energy control
- Back feed to grid
- Load management
- Reactive power control
- Battery charge control

Mode 2: AC grid formed by the diesel genset

- Fuel reduction
- Load management
- Diesel Power Assistance
- Spinnig reserve management
- Reactive power control
- Battery charge control

Mode 3: AC grid formed by Dual Mode Inverter

- Battery charge control
- Load management

Mode 4: No source forming the AC grid

- Battery charge control
- Load management

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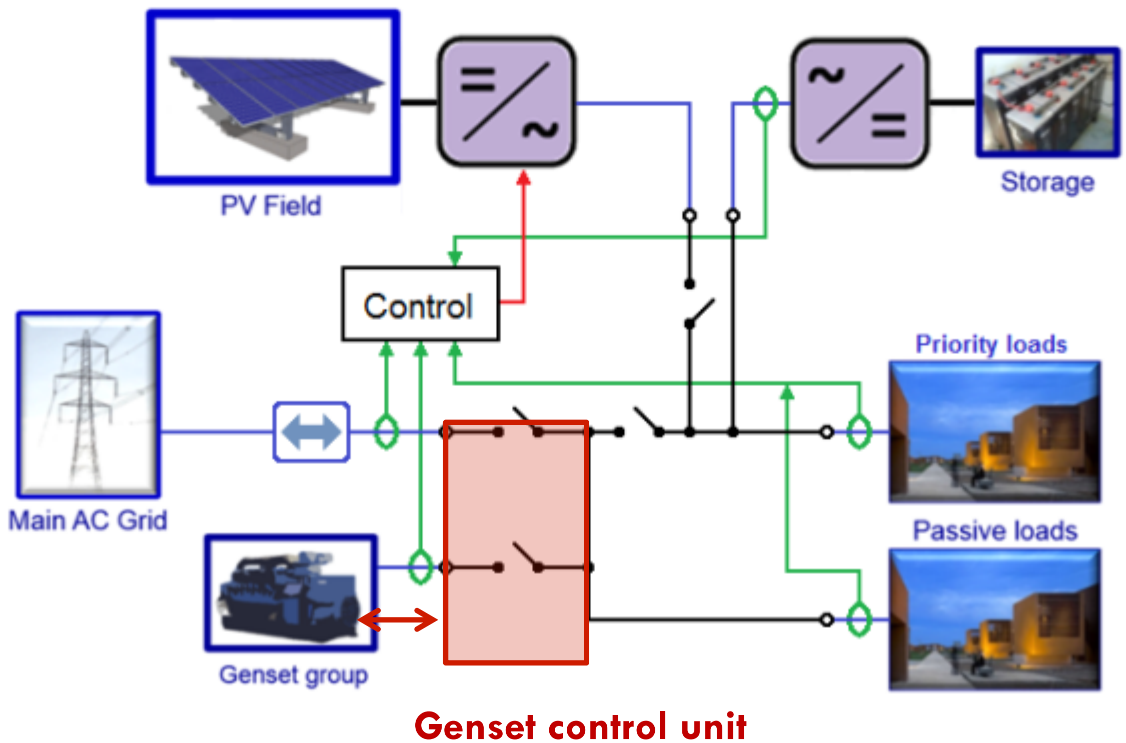
TECHNICAL SOLUTION FOR INDUSTRIAL USERS IN INTERMITTENT GRIDS: ENERGY MANAGEMENT SYSTEM



Control necessary when:

$PV \geq P_N \cdot 0{,}2$

Genset operation →

Adjustment of PV capacity:

$P_{Gen} \geq P_N \cdot 0{,}3$

Management of critical and non-critical loads

(Easy critical loads extension if required)

Challenge**:** **universal** solution for **different communications** and compatible with the **existing components** at the sites

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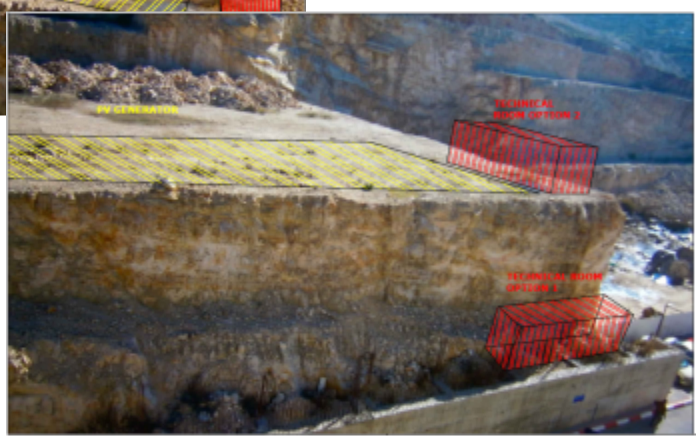
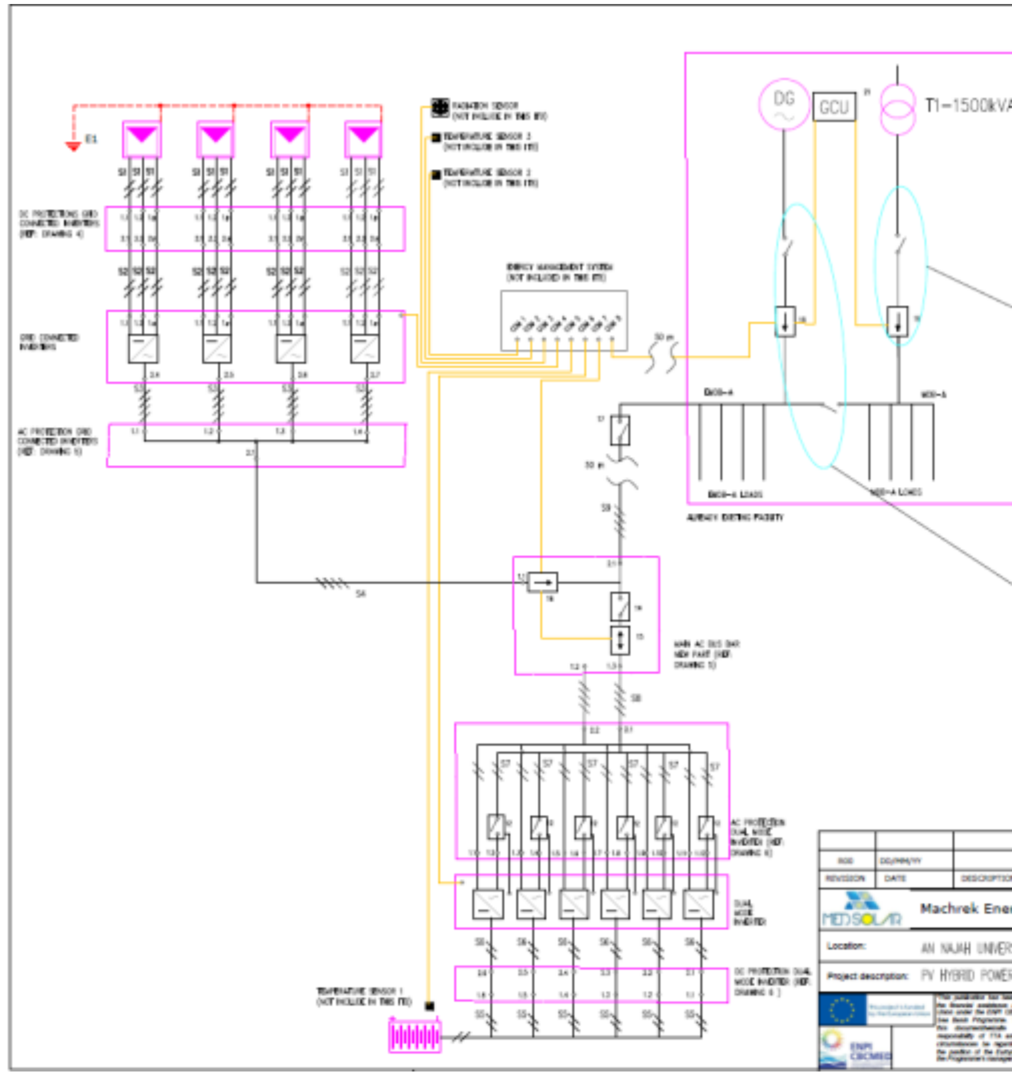
PILOT PLANTS

An-Najah National University Hospital – Palestine (MED SOLAR Project)

General specifications	
PV capacity	104 kWp
3-p Inverter	100 kW
Dual mode inverter	48 kVA
Battery capacity	150 kWh (Gel OPzV)

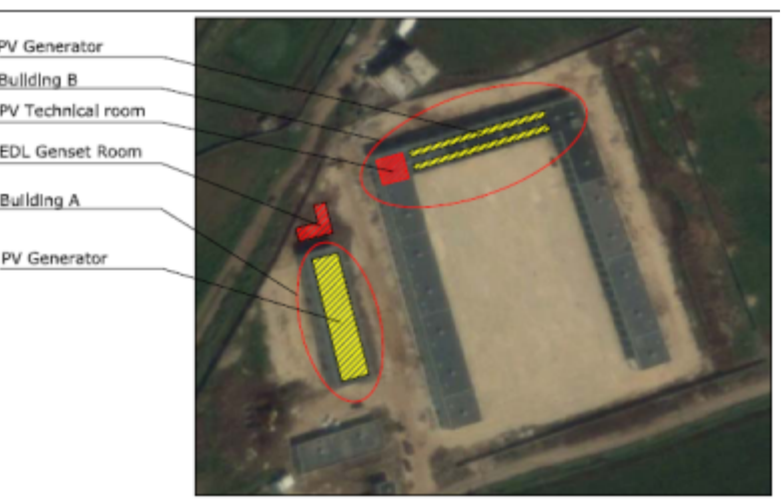




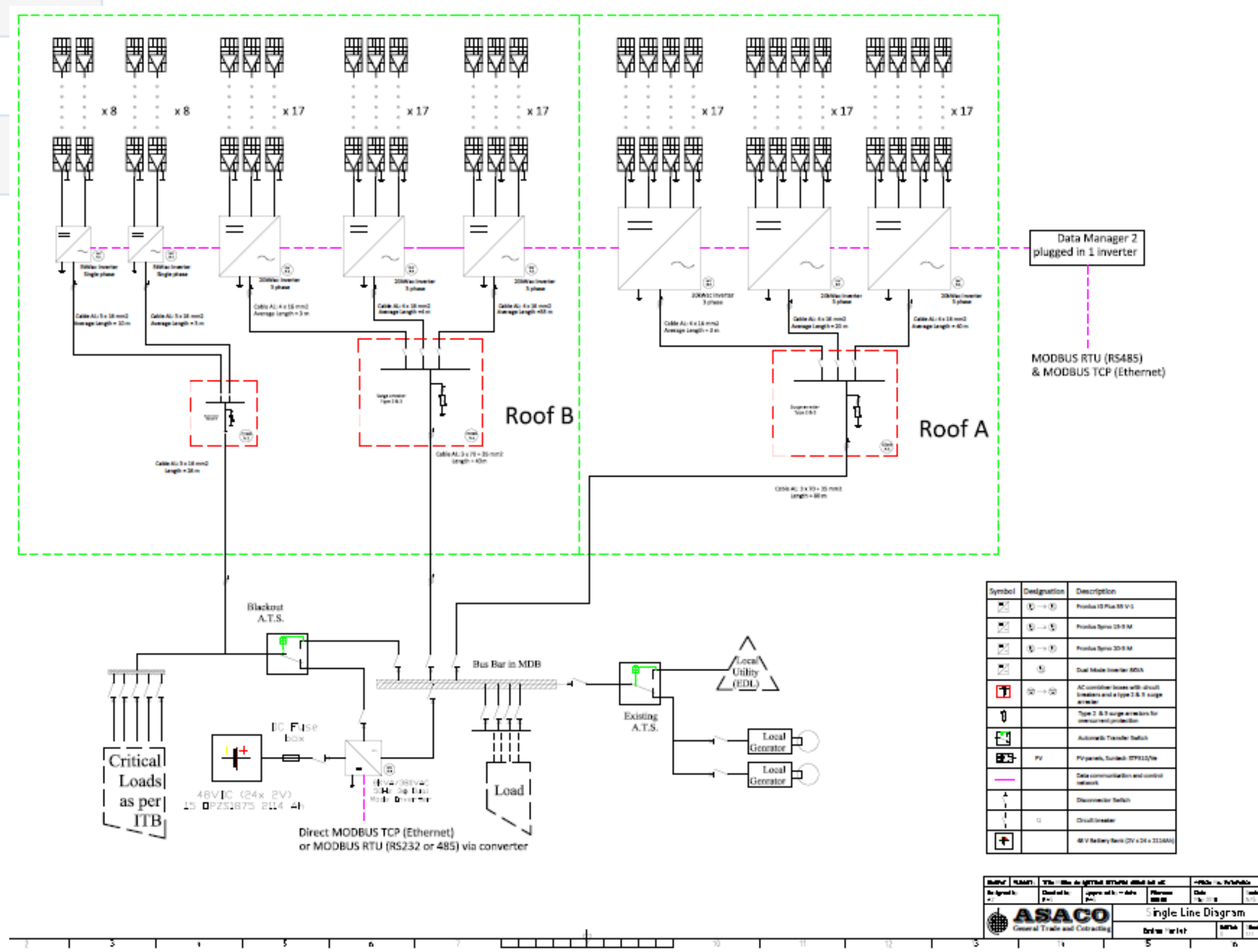
PILOT PLANTS

EMKAN Souk Akkar – Lebanon (MED SOLAR Project)

General specifications	
PV capacity	120 kWp
Solar Inverter	120 kW & 10 kW
Dual mode inverter	8 kVA
Battery capacity	101 kWh (OPzS)



PV Generator location proposed
Source: Google Earth



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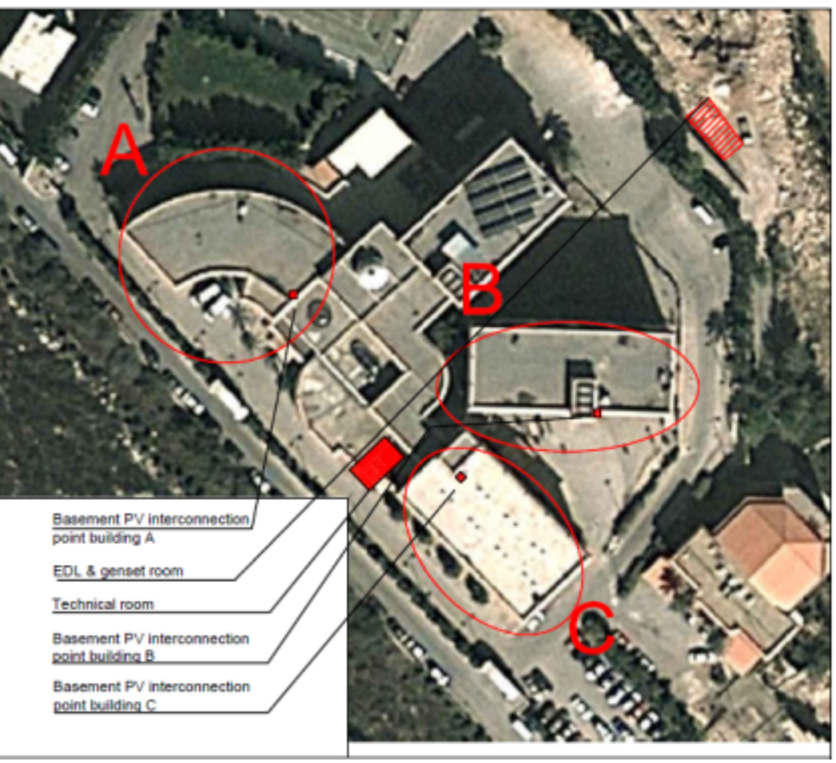
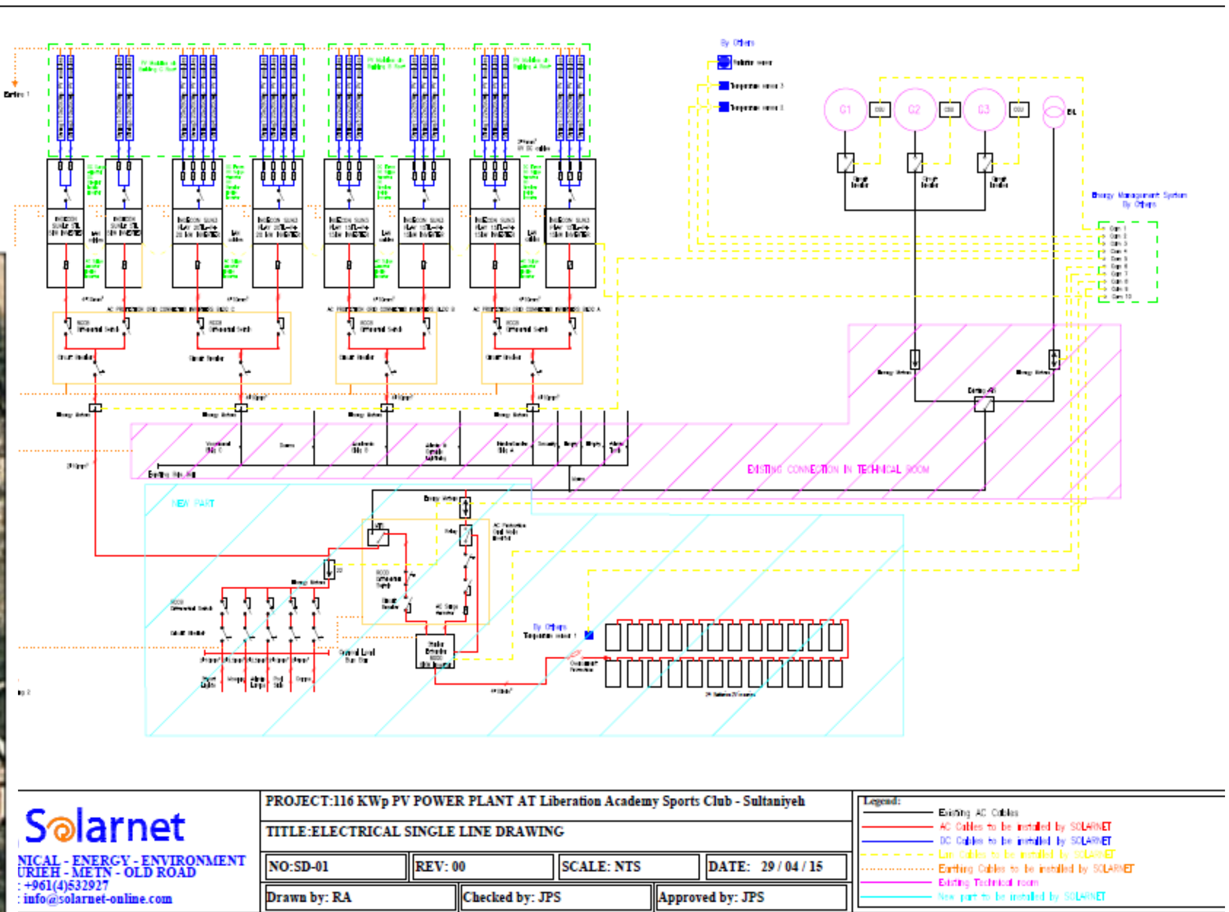
PILOT PLANTS

Tahrir square – Lebanon (MED SOLAR Project)

General specifications	
PV capacity	117 kWp
Solar Inverter	20 kW
Dual mode inverter	8 kVA
Battery capacity	50 kWh

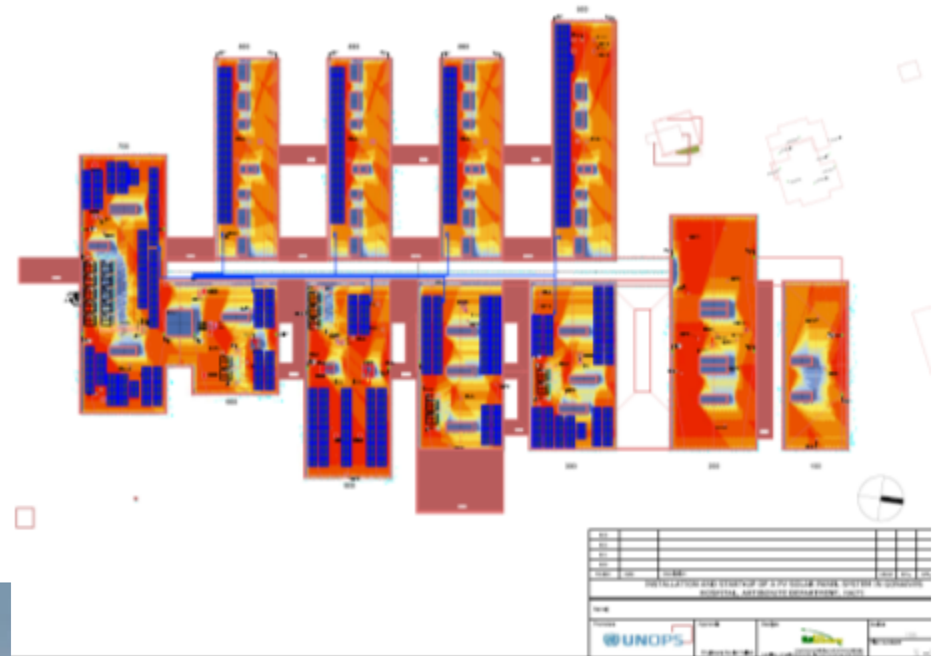




PILOT PLANTS

Gonaives Hospital – Haiti (UNOPS)

General specifications	
PV capacity	228 kWp
Solar Inverter	200 kVA



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THANK YOU FOR YOUR ATTENTION!
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