



SMALL DECENTRALIZED
RENEWABLE ENERGY
POWER GENERATION



LEBANESE CENTER FOR ENERGY CONSERVATION
المركز اللبناني لحفظ الطاقة

2017 SOLAR PV STATUS REPORT FOR LEBANON





**SMALL DECENTRALIZED
RENEWABLE ENERGY
POWER GENERATION**



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United Nations Development Programme, www.lb.undp.org

DREG, www.lb.undp.org/DREG

Note: The information contained within this document has been developed within a specific scope and might be updated in the future.

▶▶▶ ACKNOWLEDGMENTS

The United Nations Development Programme (UNDP) would like to thank both the Global Environment Facility (GEF) and the Lebanese Ministry of Energy and Water (MoEW) for their generous donation that enabled the Small Decentralized Renewable Energy Power Generation (DREG) Project to be realized. UNDP would also like to thank all its partners including the Lebanese Center for Energy Conservation (LCEC), the EU-funded UNDP CEDRO Project, Électricité du Liban (EDL), the UNDP Low Emission Capacity Building (LECB) Project at the Ministry of Environment (MoE), Banque du Liban (BDL), the Council for Development and Reconstruction (CDR), the Lebanese renewable energy companies which participated in the survey for this report, and all other institutions that work closely with this project.

FOREWORD



Lebanon continues to inch closer to its target of 12% renewable energy mix by 2020 thanks to significant advancements during 2017 in the wind energy sector, the utility-scale solar PV sector, and the decentralized solar PV sector. Lebanon's first power purchase agreements for the 200-megawatt wind farms in Akkar were signed by the Ministry of Energy and Water on the 2nd of February, 2018, 42 offers were received to implement solar PV farms totaling 180 megawatt, and the decentralized solar PV market continued its growth to 35.45 megawatt.

The decentralized solar PV sector saw an additional \$18 million invested in it during 2017 which is a promising sign that consolidates the growth of this sector year after year. In fact, by the end of 2017, this sector was worth more than \$76 million while reducing 84,000 tonnes of CO₂e in greenhouse gas emissions per year. Equally important, the number of companies working in this sector grew to 61 while employing 670 people at least.

The 2017 Solar PV Status Report for Lebanon remains the go-to source for accurate data pertaining to this sector where all key indices and metrics are presented and analyzed for easy referencing and better decision-making.

The Ministry of Energy and Water will utilize this report to continue supporting the solar PV sector in Lebanon by setting the right policies and removing any barriers standing in the way of achieving our 2020 target. We look forward to the sustainable partnership and collaboration of all the stakeholders involved to achieve this target together.

César Abi Khalil

Minister of Energy and Water

▶▶▶ ABSTRACT

The Small Decentralized Renewable Energy Power Generation (DREG) Project is funded by the Global Environment Facility (GEF) and implemented by the United Nations Development Programme (UNDP). The project is nationally executed by the Ministry of Energy and Water (MoEW) in coordination with the Lebanese Center for Energy Conservation (LCEC).

The project's objective is to reduce greenhouse gas emissions through the removal of barriers to widespread application of decentralized renewable energy power generation.

The 2017 Solar Photovoltaic (PV) Status Report for Lebanon, developed and published in its third edition in 2018, highlights the status and the growth of the solar PV market by presenting and analyzing all its available data.

Solar cells, also called photovoltaic (PV) cells, convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the PV effect.

This report is based on data collected from participating Lebanese solar PV companies with installed and operational systems all over Lebanon until the end of 2017. The analyzed data enables the understanding of the solar PV market growth in Lebanon over time through various indicators such as installed capacity, energy generation, number and type of projects, amount of investments, monetary and environmental savings, and geographical location.

The Solar PV Status Report for Lebanon has become a yearly collaborative publication reporting on the market's growth for the previous year. This in turn will enable decision makers and stakeholders to align their efforts to continue supporting the market and sustaining its healthy growth.



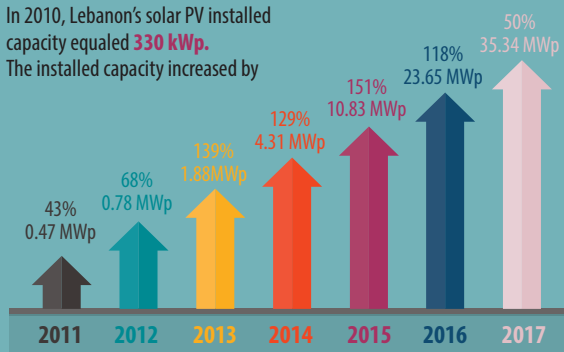
EXECUTIVE SUMMARY

Lebanon's energy generation by EDL reached **15 TWh in 2017¹**.

¹Source: EDL

In 2010, Lebanon's solar PV installed capacity equaled **330 kWp**.

The installed capacity increased by



From 2010 until the end of 2017, the cumulative installed solar PV capacity grew by an average rate of

100% per year.



Total investment in the solar PV sector up to the end of 2017 reached **\$76.34m**

The number of new solar PV projects per year increased



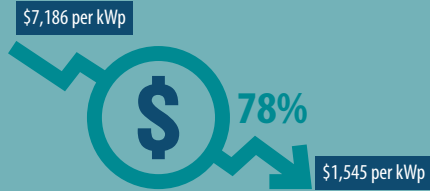
Solar PV electricity in 2017 represented **0.35%** of the total annual electricity generation by EDL (up from **0.26%** in 2016)

The year-over-year growth rate for the solar PV capacity reached 50% in 2017

Lebanon's growth rate of 50% in 2017 remains above the global growth rate of 33%

The year-over-year growth rate for the number of new solar PV projects reached at 33% in 2017

The turnkey price for solar PV has been falling steadily year after year:



-42%

The average turnkey price for Solar PV Pumping projects fell by **42%** in a single year from 2016 to 2017.

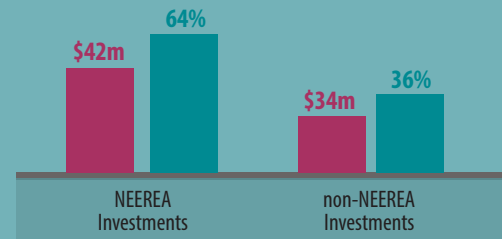
The total cumulative investment in the solar PV sector increased



NEEREA investments
\$13.19m
in 2017

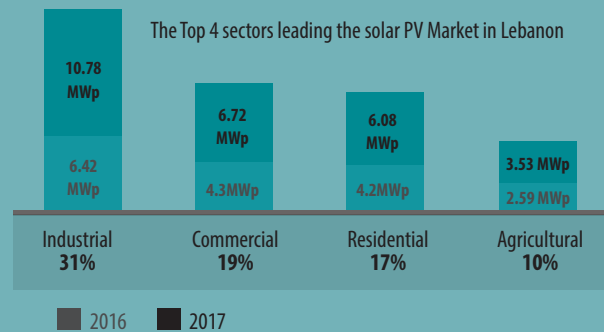
non-NEEREA investments
\$5.04m
in 2017

Total \$18.23m

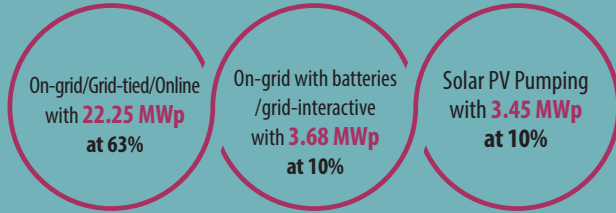


■ : of installed capacity

The Top 4 sectors leading the solar PV Market in Lebanon



The Top 3 project types prevailing in the solar PV Market in Lebanon

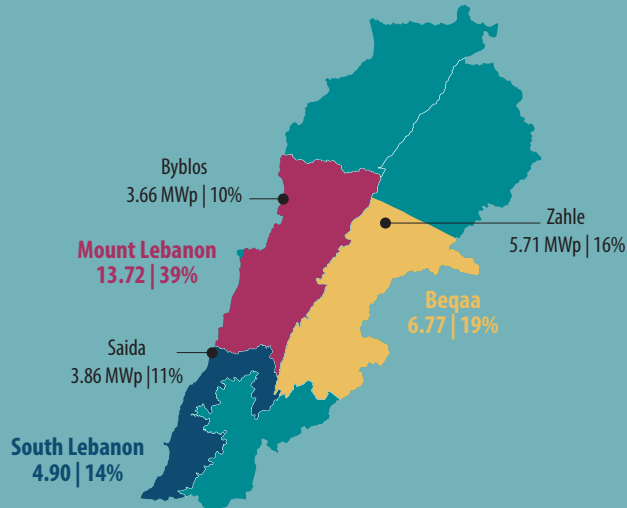


The estimated monetary savings from all the solar PV projects in Lebanon grew from **\$200k** per year in 2010 to **\$3.3m** per year in 2017.

The cumulative savings by the end of 2017 amount to **\$27.8m**.

These are the savings achieved by the operators of solar PV systems in Lebanon by deferring a portion of their electricity consumption from the grid and diesel generators to solar PV generation.

Top 3 Governorates and Districts leading the solar PV Market



The estimated emissions savings from all the solar PV projects in Lebanon

377 t CO₂e /year in 2010 → **12,500 t CO₂e /year** in 2017

The cumulative savings by the end of 2017 amount to **83,800 t CO₂e**.





TABLE OF CONTENTS

2017 Highlights	16
1. Lebanon Electricity Background Information	18
Lebanon's 2017 Electricity Generation (TWh %)	19
2. Solar PV Electricity in Lebanon	20
Solar PV Capacity and Annual Additions	21
Solar PV Capacity and Generation	22
Solar PV Annual New Projects Count	23
Solar PV Capacity and Count by Project Size Groups	24
Solar PV Capacity and Number of Projects Year-over-Year Growth Rate	25
Yearly Average Solar PV Turnkey Price	26
Yearly Average Solar PV Turnkey Price by Project Type	27
Solar PV Investment	28
Investment in Solar PV	29
Solar PV Capacity by Sector	30
Solar PV Capacity by Investment	31
Solar PV Capacity by Project Type	32
Solar PV Capacity by Governorate	33
Solar PV Capacity by District	34
Solar PV Estimated Monetary Savings	35
Solar PV Estimated Emissions Savings	36
Cumulative Solar PV Companies in Lebanon	37



TABLE OF ACRONYMS

BDL	Banque du Liban
CDR	Council for Development and Reconstruction
EDL	Electricité du Liban
GEF	Global Environment Facility
kW	Kilo-watt
kWh	Kilo-watt-hour
kWp	Kilo-watt-peak
LECB	Low Emission Capacity Building Project
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MW	Mega-watt
MWh	Mega-watt-hour
MWp	Mega-watt-peak
NEEREA	National Energy Efficiency and Renewable Energy Action
PV	Photovoltaic
TWh	Terra-watt-hour

TABLE OF TERMS

Decentralized Energy	Decentralized energy is produced close to where it will be used rather than at a large plant elsewhere and sent through the national grid.
Electricity Generation	Electricity generation is the amount of electricity a generator produces over a specific period of time.
Generation Capacity	Generation capacity is the maximum electric output an electricity generator can produce under specific conditions.
On-grid/Grid-tied/Online	These systems require connection to the grid in order to operate. For decentralized systems, in the case where PV production is greater than the local demand load, the surplus is injected into the grid via net-metering. In times of blackouts, the PV system usually operates in parallel with back-up generators (most commonly diesel gensets).
On-grid with batteries/Grid-interactive/Dual-mode	These systems combine the features of the on-grid and off-grid systems as they operate like the former whenever the grid is present and switch to the operation of the latter should the utility's availability become compromised.
Hybrid/Multisource	This refers to systems that involve the parallel operation of PV with one or more "grid-forming" sources (e.g. PV-Diesel) without any actual connection to the EDL grid.
Off-Grid/Stand-alone/Autonomous	These systems work independent of a grid. Batteries are an integral part of this configuration. PV will feed the local loads and charge the batteries thereby ensuring a fully autonomous operation.
Off-grid with generator back-up	Same as off-grid, but the battery bank can be recharged by another generator (e.g. Diesel back-up genset).
PV/Solar pumping	These systems consist of a direct connection to a DC pump or through an inverter to feed an AC pump, instantly providing all the available power collected by the PV modules directly to the load. The system can be upgraded to include batteries.

▶▶▶ 2017 HIGHLIGHTS

- ▶ Whereas 2016 saw an addition of **12.82 MWp**, 2017 witnessed the addition of **11.62 MWp** of solar PV capacity bringing the total installed capacity to **35.45 MWp**. With Lebanon's decentralized solar PV target set at **100 MWp** by 2020 as per the National Renewable Energy Action Plan (NREAP), the market needs to add **65 MWp** in three years or **21.7 MWp** per year. With **64%** of the installed capacity so far being funded by NEEREA, the NEEREA loan application, evaluation, and approval processes need to be further encouraged and expedited so that the market can add the required **21.7 MWp** per year to reach the 2020 target for decentralized solar PV .
- ▶ Decentralized solar PV electricity generation increased from **0.26%** of the total annual electricity generation by EDL in 2016 to **0.35%** in 2017. This is equivalent to **53 GWh** per year. With Lebanon's decentralized solar PV generation target set at **160 GWh** per year by 2020 as per the National Renewable Energy Action Plan (NREAP), the market needs to add **107 GWh** of decentralized solar PV electricity generation in three years.
- ▶ The Medical sector achieved the highest solar PV capacity growth rate of over **240%** with **1.5 MWp** total installed capacity by the end of 2017 compared to just **0.43 MWp** in 2016. With hospitals and other medical facilities operating around the clock, electricity demand is relatively more constant thereby justifying the use of on-grid (with or without batteries) PV systems to reduce energy costs and emissions. More importantly, many hospitals heavily depend on their diesel generators to maintain uninterrupted electricity supply which in turn can maximize the savings of PV systems by reducing diesel consumption.
- ▶ The Industrial sector achieved the highest solar PV capacity addition of **4.37 MWp** during 2017 thereby bringing the total installed capacity to **10.78 MWp** for the sector. This is partially due to the increase in the cost of oil witnessed in 2017 which created a bigger incentive for industrialists to reduce their diesel consumption by investing in and operating on-grid solar PV systems. The savings achieved by offsetting diesel with PV is creating all-year-round net positive cash flows and payback periods of six years or less. The higher the cost of oil trends, the bigger the savings are going to be.

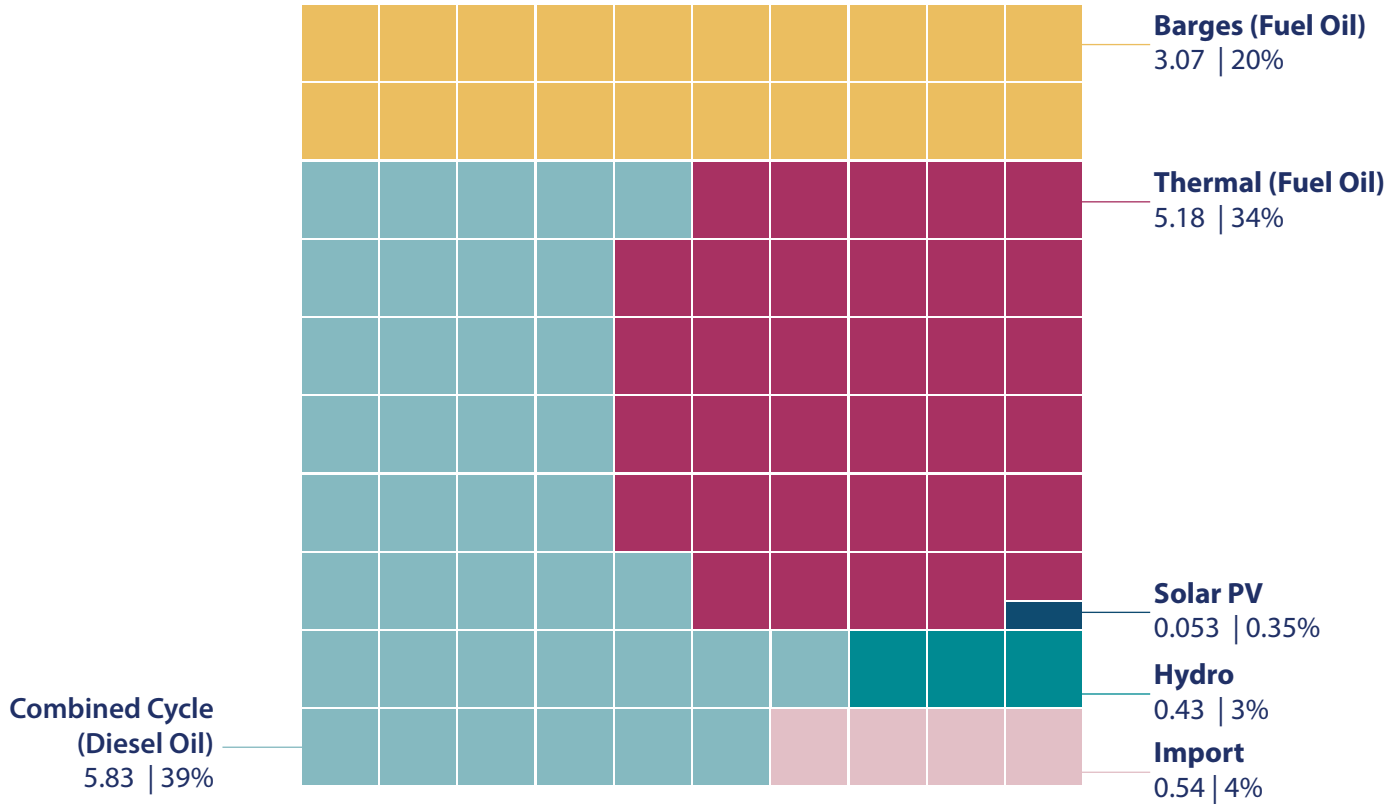
- ▶ The average turnkey price for solar PV continued its decline from **\$1,872** per kWp in 2016 to **\$1,545** in 2017; a drop of **17.4%** which exceeds the global cost drop rate of 10-15% per year. The major contributor to this drop remains the drop in the cost of equipment, but local competition during 2017 significantly increased as well due to numerous tenders by various national and international stakeholders which helped bring the prices down as well. To better grasp the positive impact these price reductions have on the market, a **\$100,000** investment in 2011 would have developed a **14 kWp** system. The same investment achieves **53 kWp** and **65 kWp** systems in 2016 and 2017, respectively.
- ▶ In 2017, total investment in the solar PV sector grew by **31%** from the previous year; totaling over **\$76 million**. This means that 2017 saw an additional **\$18 million** in new investments introduced into the market. This is largely thanks to the NEEREA loan programme which provided **\$13 million** or **72%**. This is another indicator that highlights the importance of the NEEREA facility to ensure that the market can continue to expand and grow.
- ▶ **7** Lebanese solar PV companies were working in the sector up until 2008. This number started growing steadily from **14 companies** in 2010 to **61 companies** by the end of 2017. At least **670** new jobs were created in this sector. Based on all the data presented in this report, especially the **35.45 MWp** installed capacity and **\$76m** total investment, this job creation indicator can be extrapolated to estimate the massive economic development and substantial employment opportunities that will result from building **utility-scale wind farms and solar PV farms**.



1

**LEBANON
ELECTRICITY
BACKGROUND
INFORMATION**

LEBANON'S 2017 ELECTRICITY GENERATION (TWh | %)

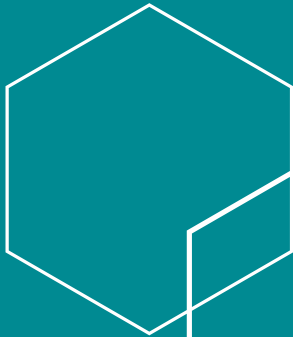


EDL's share of the total electricity generation equaled 15.05 TWh while the solar PV's share equaled 0.053 TWh or 0.35% of the total electricity generation (up from 0.26% in 2016).

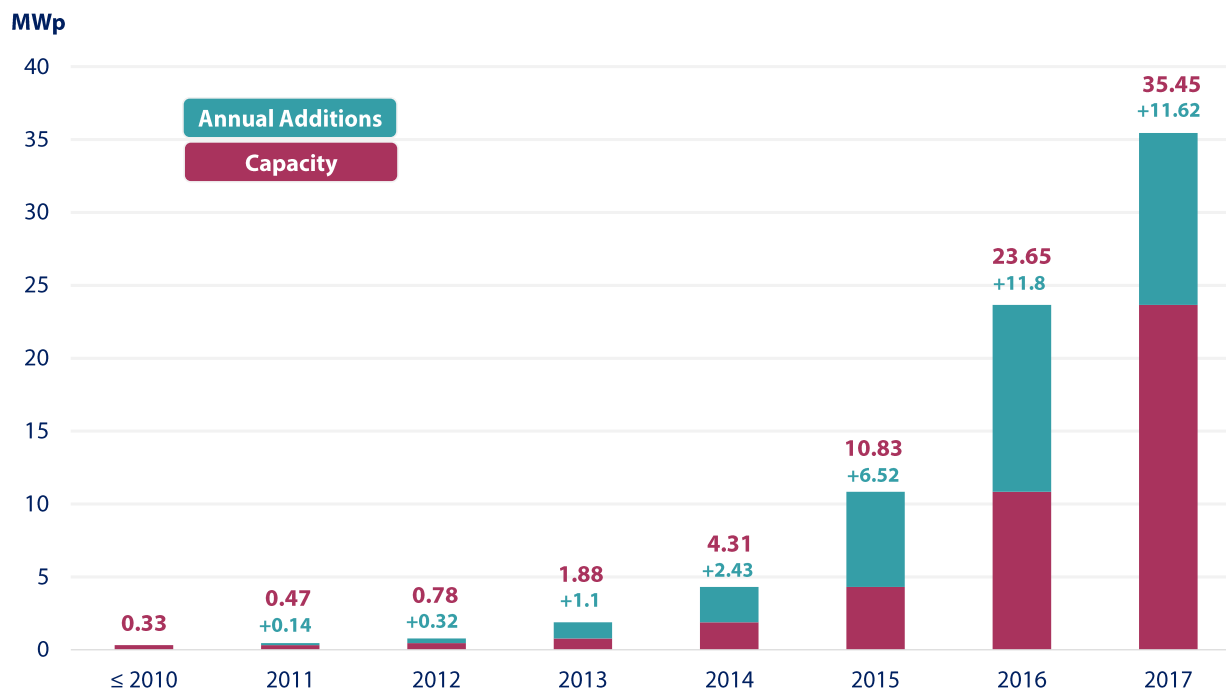
With solar PV added to Hydro, the renewables' share of the total annual electricity generation in 2017 is equal to 3.35%.

2

**SOLAR PV
ELECTRICITY
IN LEBANON**



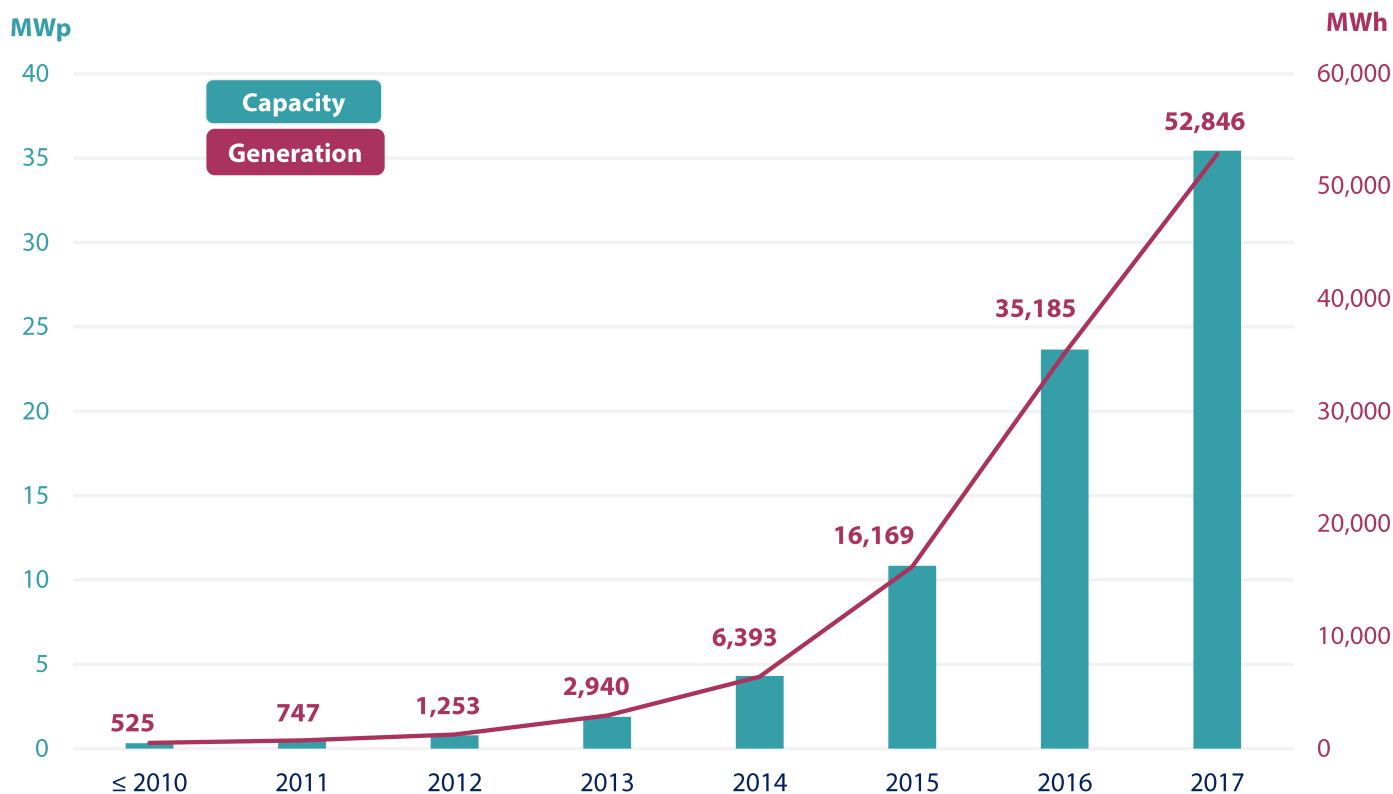
SOLAR PV CAPACITY AND ANNUAL ADDITIONS



11.62 MWp of solar PV installed capacity was added in 2017 to reach a total of 35.45 MWp.

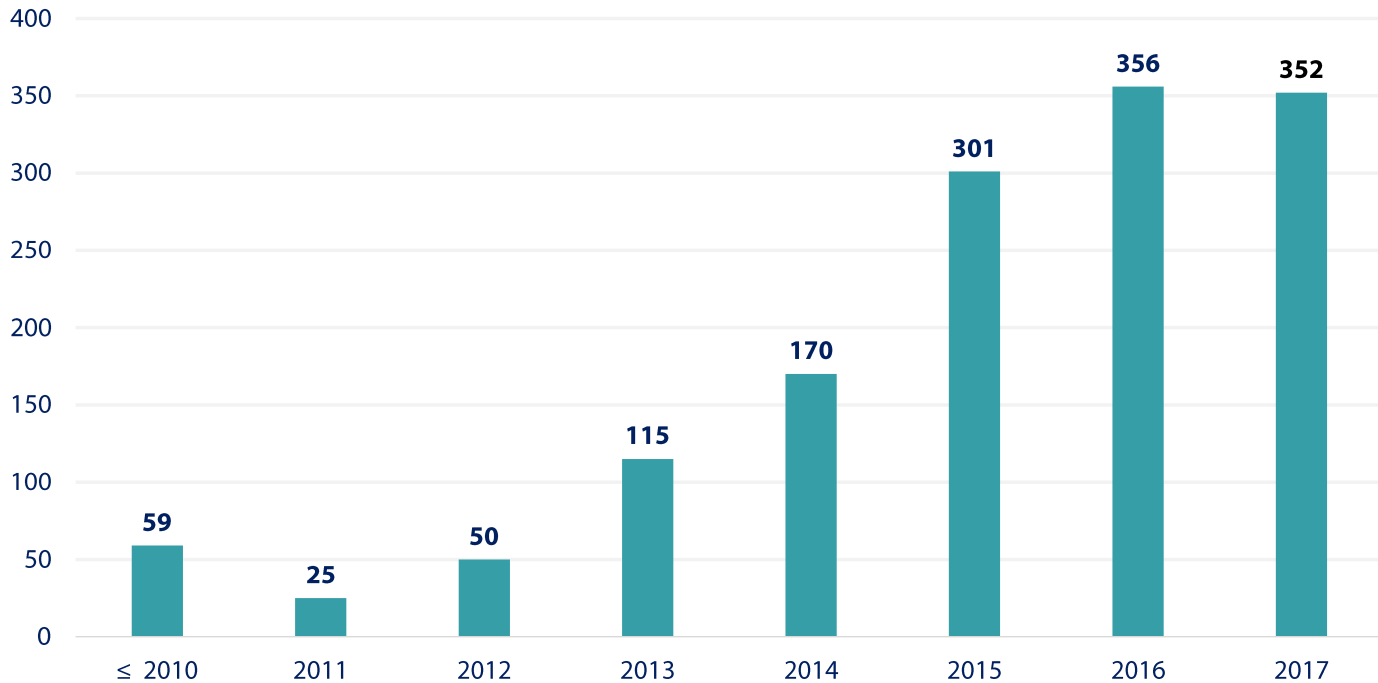
This figure includes the Beirut River Solar Snake Project (1.08 MWp) and the Zahrani Oil Installations Project (1.09 MWp) whereas the remainder comes from decentralized systems (33.28 MWp).

SOLAR PV CAPACITY AND GENERATION



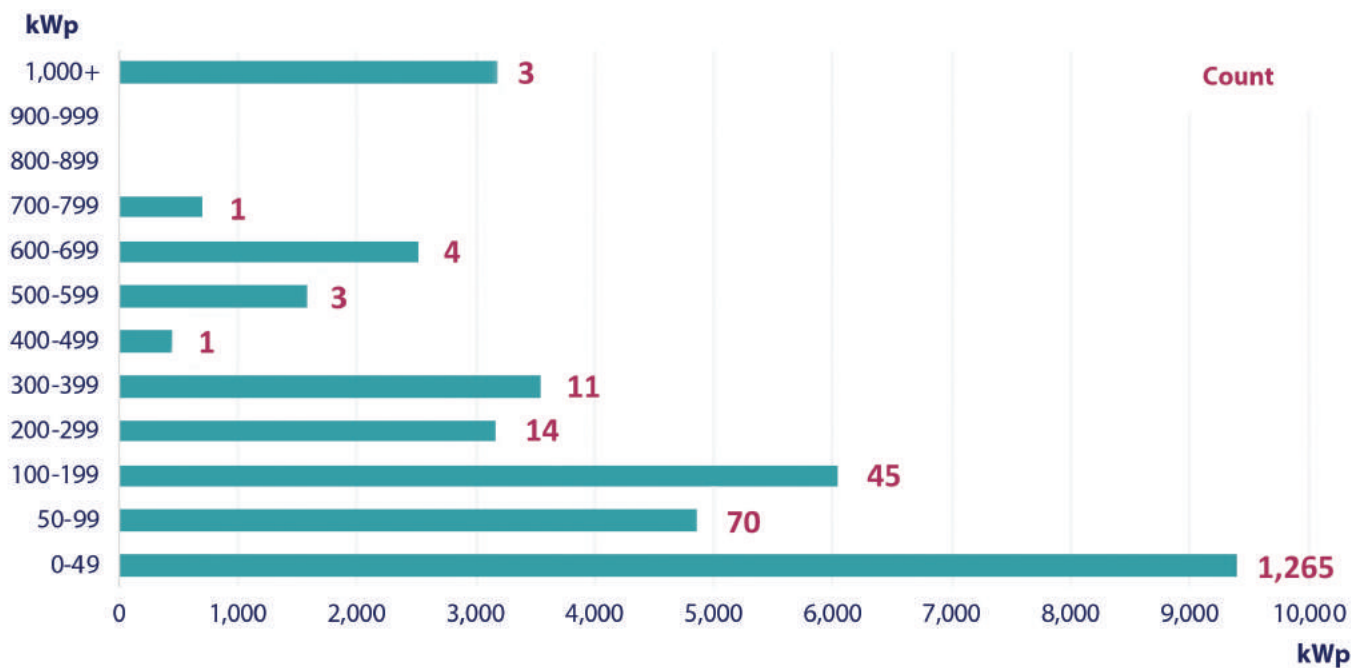
Solar PV electricity generation increased from 35,000 MWh in 2016 to 53,000 MWh in 2017 which constitutes 0.35% of the total annual electricity generation by EDL.

▶▶▶ SOLAR PV ANNUAL NEW PROJECTS COUNT



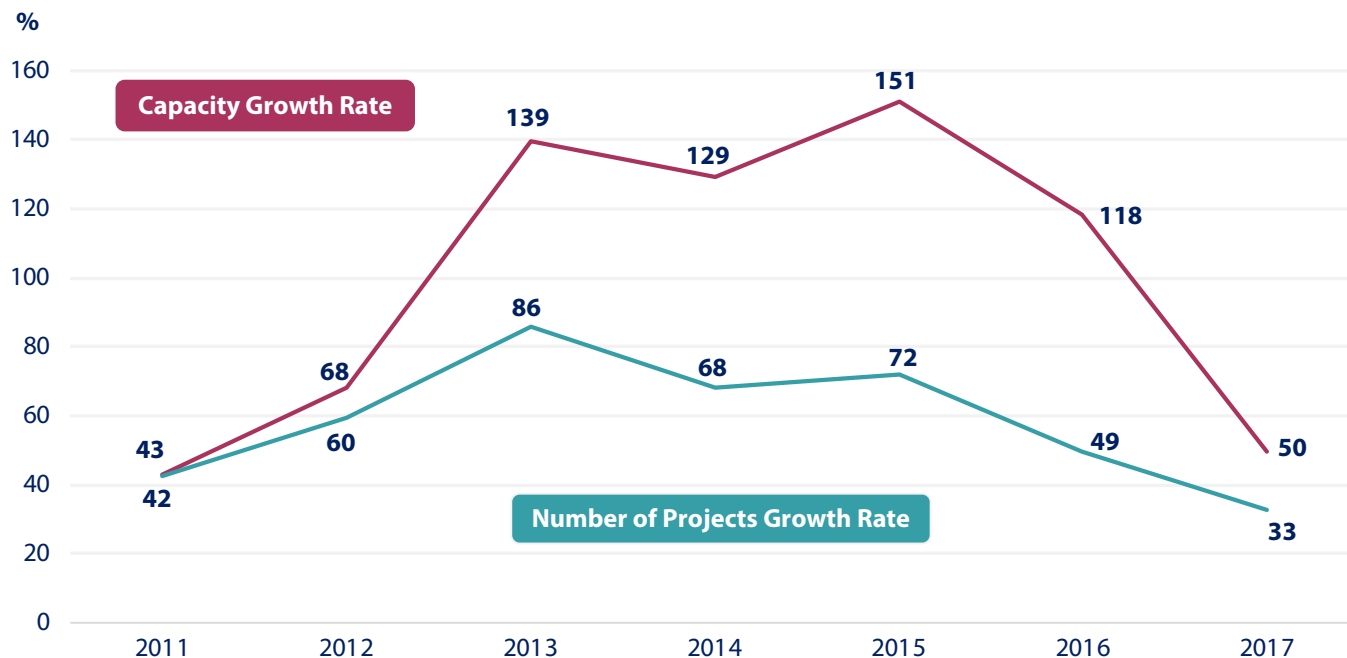
The number of new solar PV projects remained roughly the same at 352 in 2017 compared to 356 in 2016.

►►► SOLAR PV CAPACITY AND COUNT BY PROJECT SIZE GROUPS



The total number of solar PV projects reached 1,428 by the end of 2017.
Small-sized projects, up to 49 kWp, dominate the market in terms of capacity (27%) and count (89%).

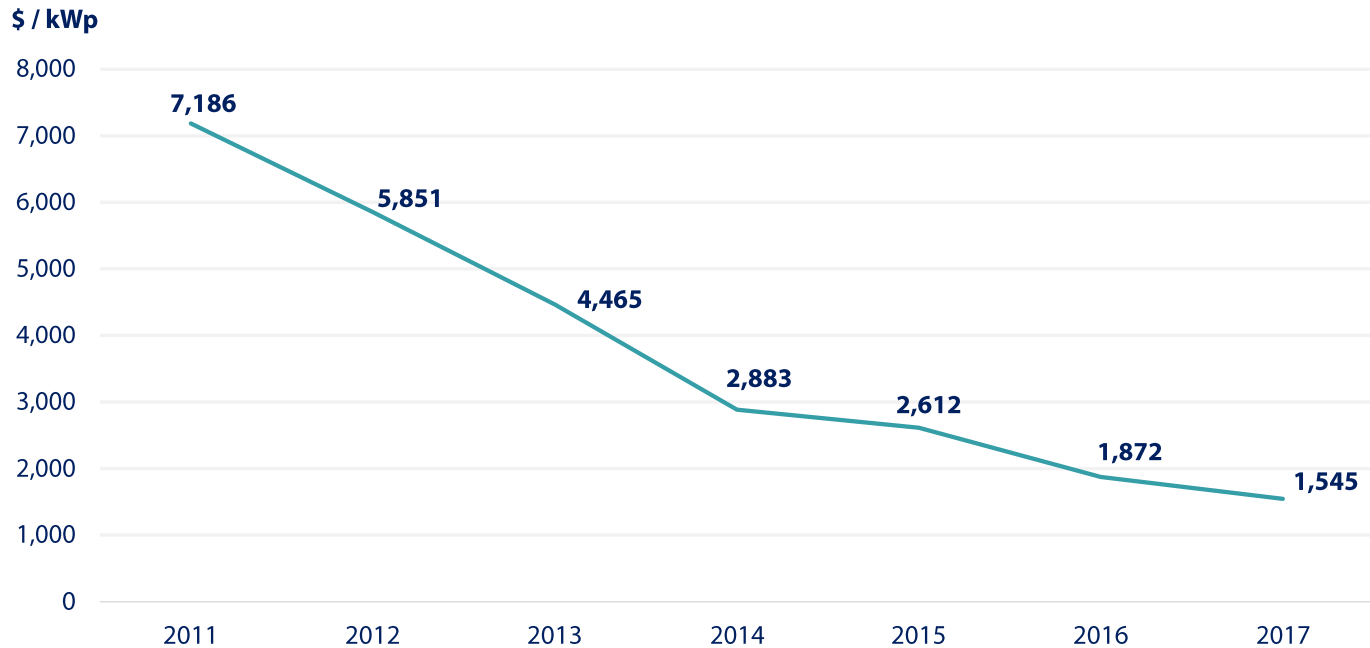
SOLAR PV CAPACITY AND NUMBER OF PROJECTS YEAR-OVER-YEAR GROWTH RATE (%)



The year-over-year growth rate for the solar PV capacity dropped to 50% in 2017.
The year-over-year growth rate for the number of new solar PV projects dropped to 33% in 2017.

Lebanon's growth rate of 50% in 2017 remains above the global growth rate of 33%.

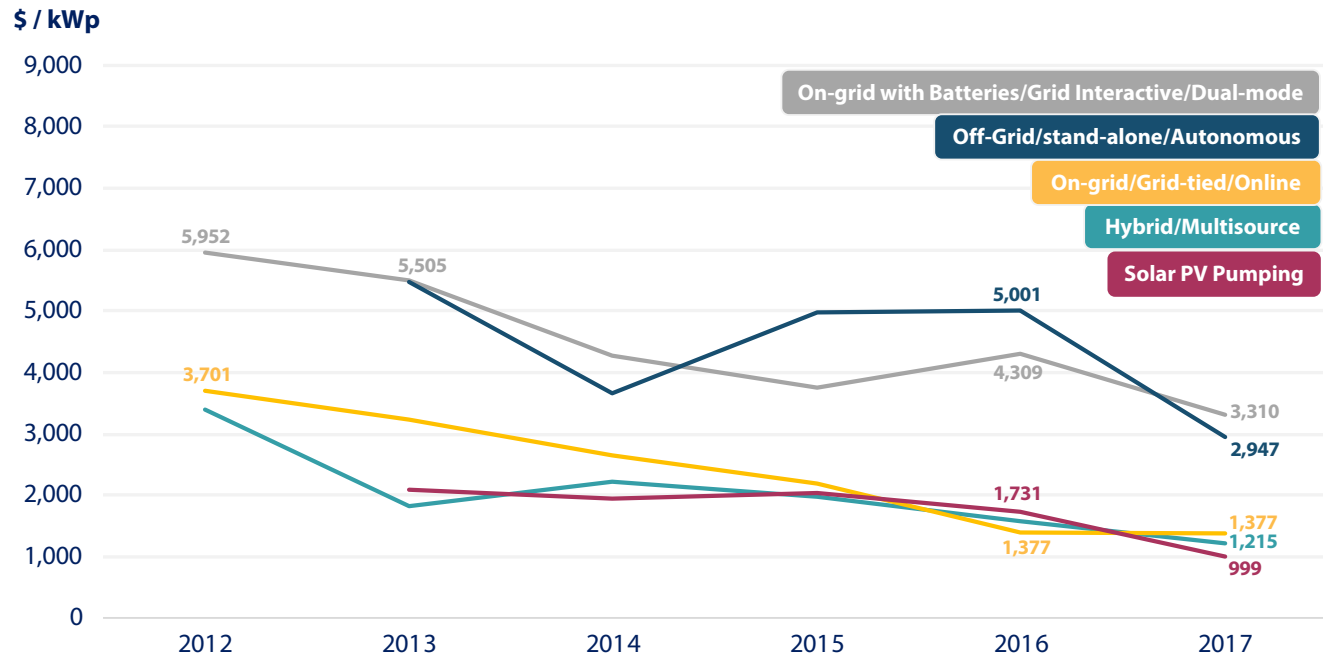
▶▶▶ YEARLY AVERAGE SOLAR PV TURNKEY PRICE (\$ / kWp)



The turnkey price for solar PV continued its steady decrease from \$7,186 per kWp in 2011 to \$1,872 in 2016 to \$1,545 in 2017.

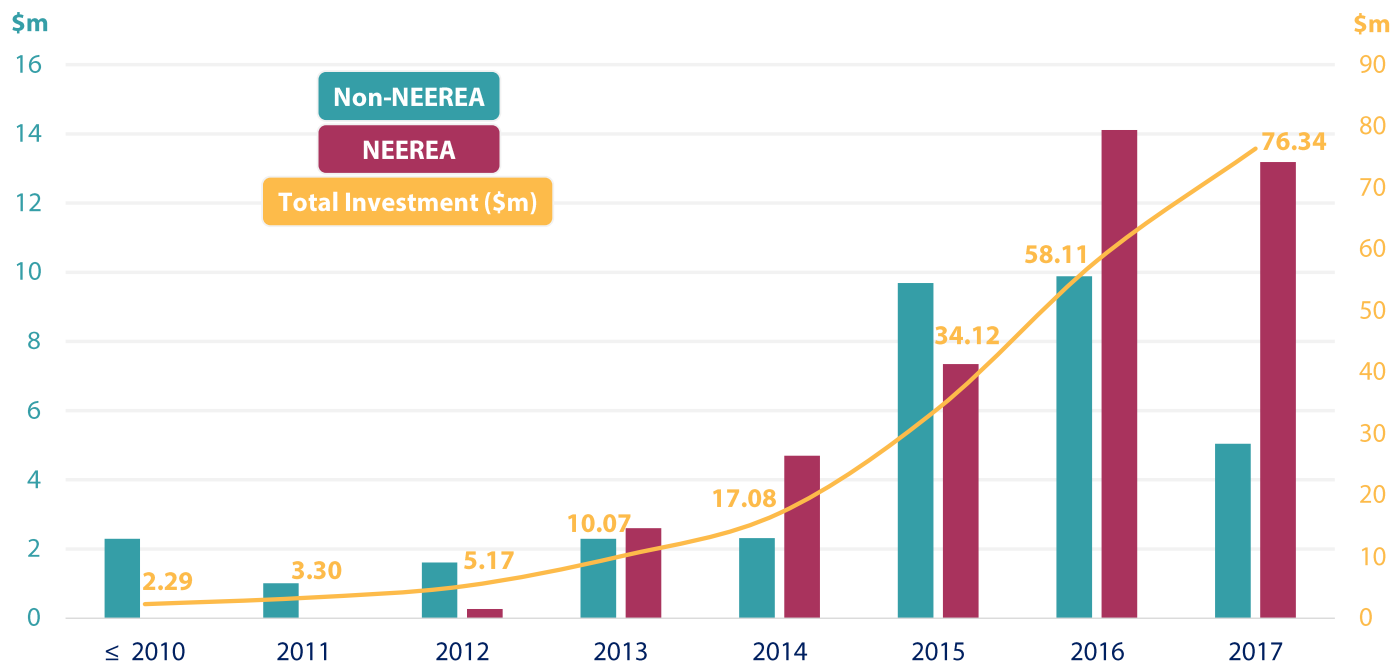
This constitutes a price drop of 79% in a span of seven years.

▶▶▶ YEARLY AVERAGE SOLAR PV TURNKEY PRICE BY PROJECT TYPE (\$ / kWp)



Turnkey prices continued falling for all project types but the average turnkey price for Solar PV Pumping projects fell by 42% in a single year from 2016 to 2017.

►►► SOLAR PV INVESTMENT (\$m)

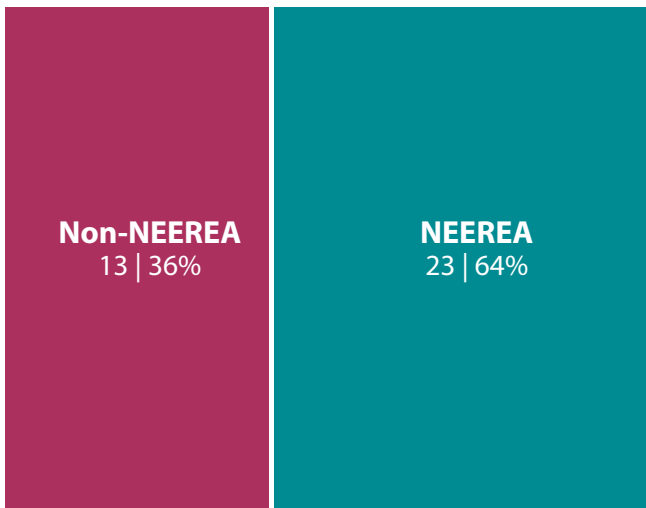


The total cumulative investment in the solar PV sector increased from \$2.29m in 2010 to \$76.34m in 2017.

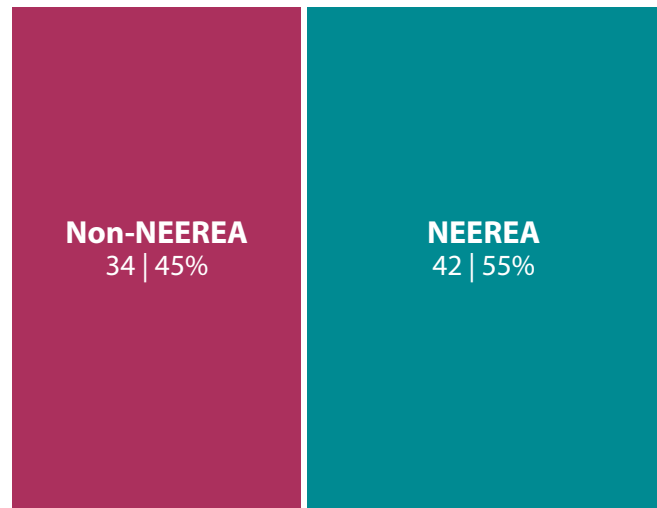
Investments in 2017 reached \$18.23m thanks to \$13.19m from NEEREA and \$5.04m from non-NEEREA investments.

▶▶▶ INVESTMENT IN SOLAR PV (\$m)

Capacity Share per Source of Funding (MWp | %)

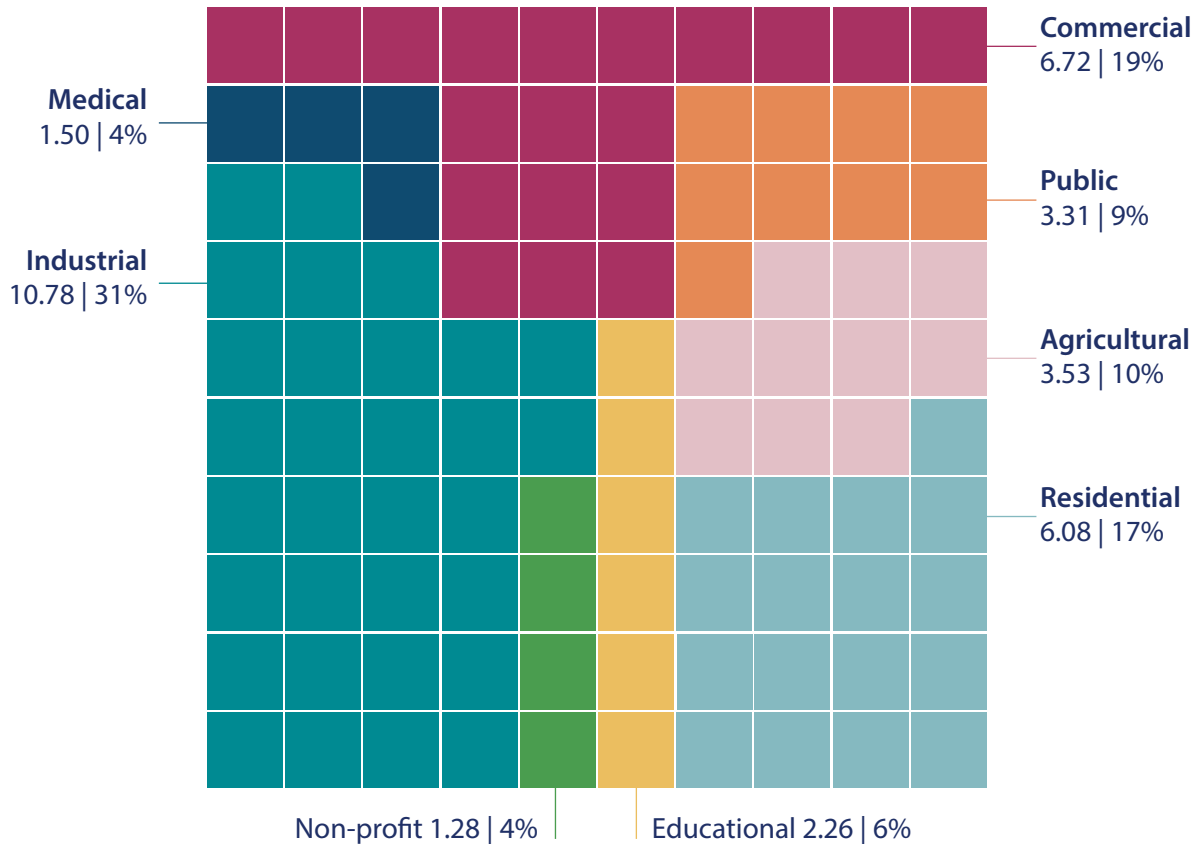


Funding Share per Source of Funding (\$m | %)



64% of the installed solar PV capacity to date is funded by NEEREA for a total investment of \$42m whereas the remaining 36% of installed capacity was funded by non-NEEREA investments totaling \$34m.

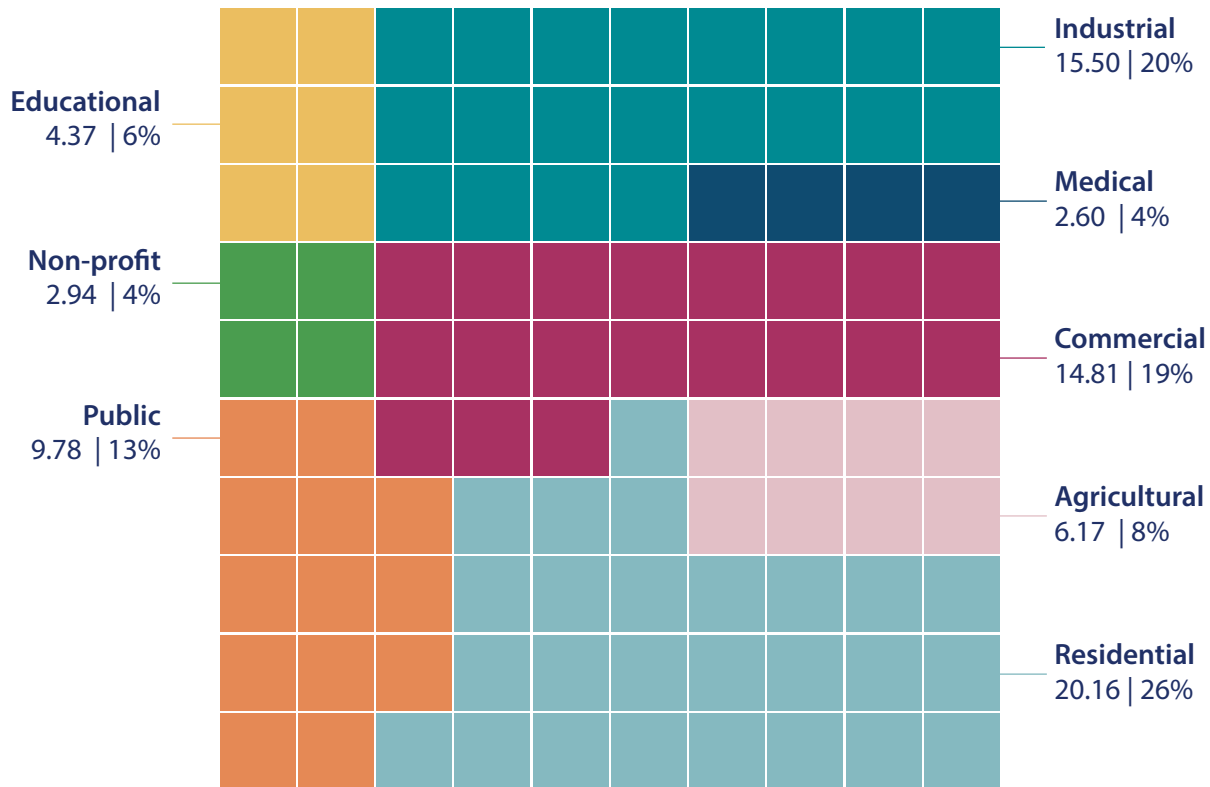
►►► SOLAR PV CAPACITY BY SECTOR (MWp | %)



The top 3 sectors leading the solar PV market in Lebanon in installed capacity are the Industrial sector with 10.78 MWp, the Commercial sector with 6.72 MWp, and the Residential sector with 6.08 MWp.

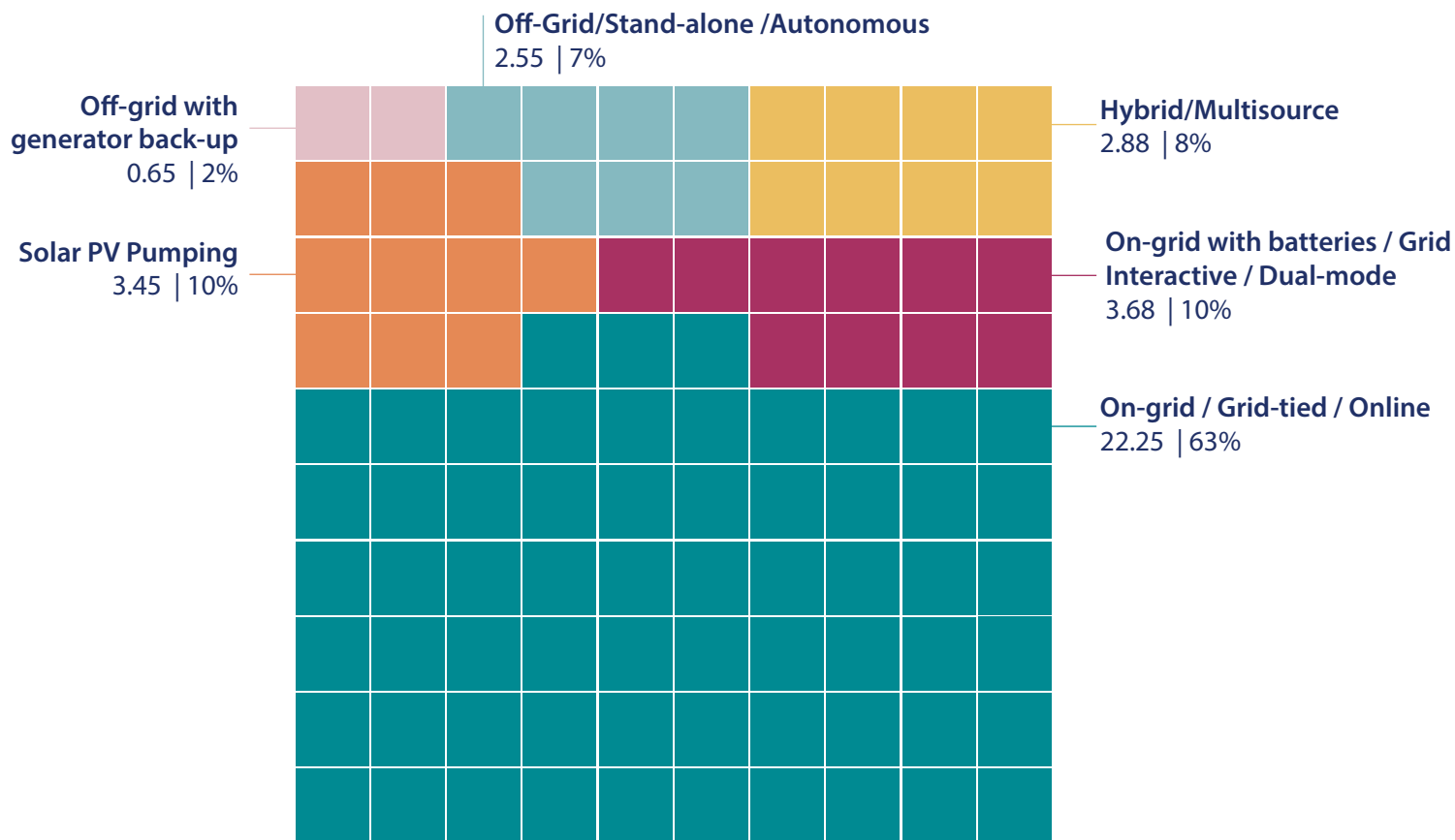
The Industrial sector continued to record the highest growth from 6.42 MWp to 10.78 MWp (68%) in a single year.

▶▶▶ SOLAR PV CAPACITY BY INVESTMENT (\$m | %)



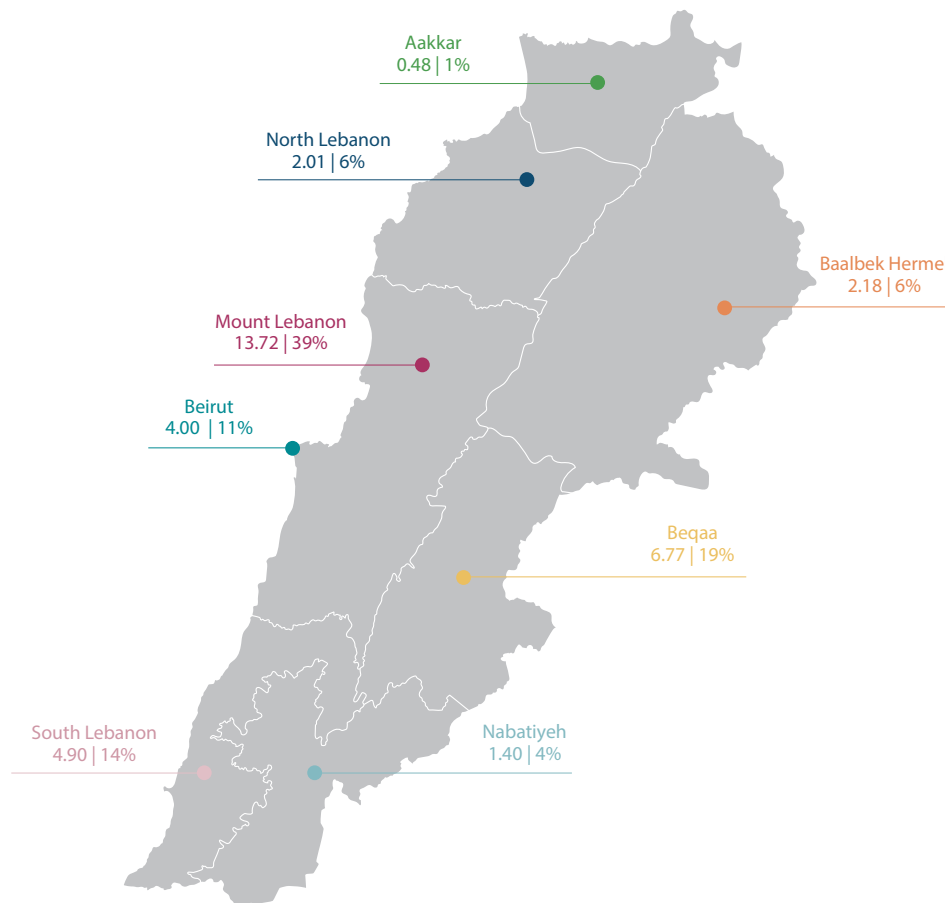
The top 3 sectors leading the solar PV Market in Lebanon in investment are the Residential sector with \$20.16m, the Industrial sector with \$15.5m, and the Commercial sector with \$14.81m.

SOLAR PV CAPACITY BY PROJECT TYPE (MWp | %)



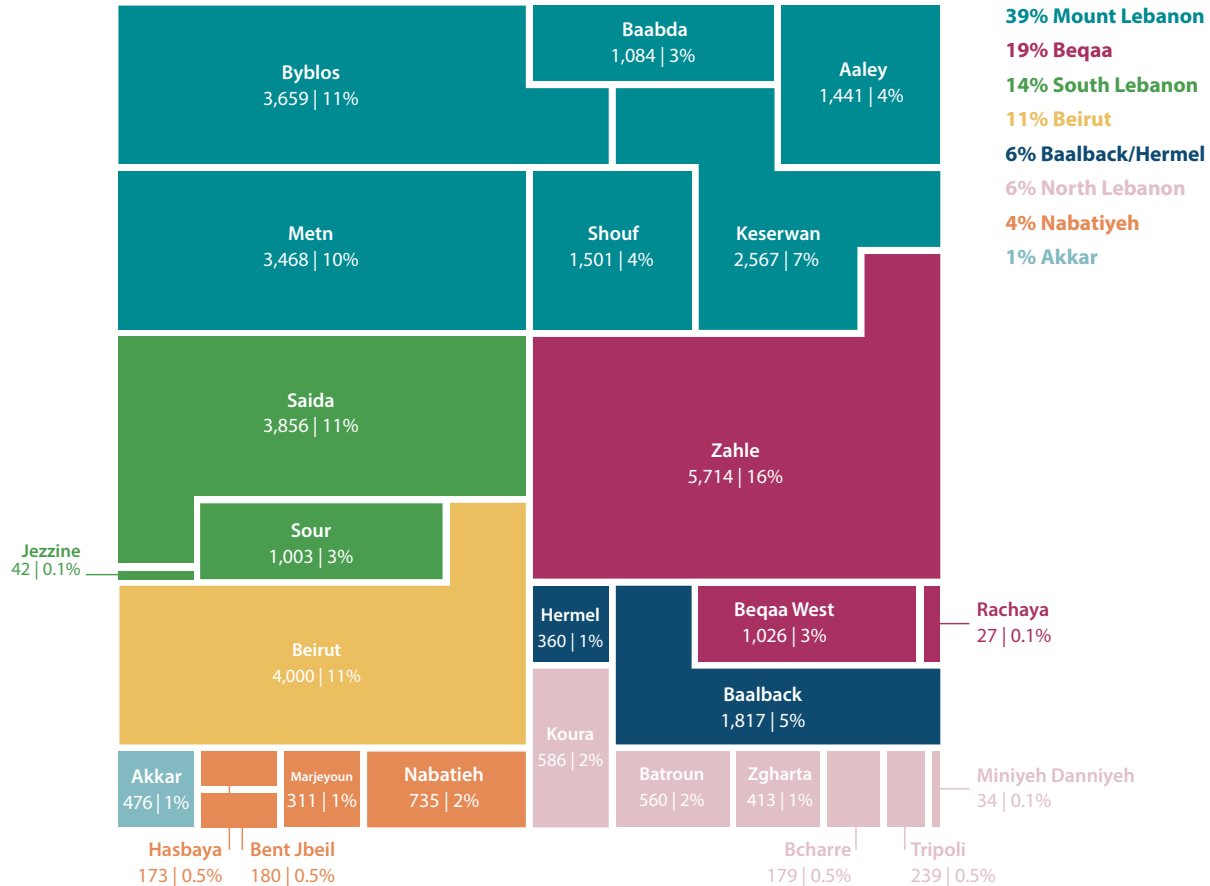
The Top 3 project types prevailing in the solar PV Market in Lebanon are On-grid/Grid-tied/Online with 22.25 MWp, On-grid with batteries/Grid-interactive/Dual-mode with 3.68 MWp, and Solar PV Pumping with 3.45 MWp.

►►► SOLAR PV CAPACITY BY GOVERNORATE (MWp | %)



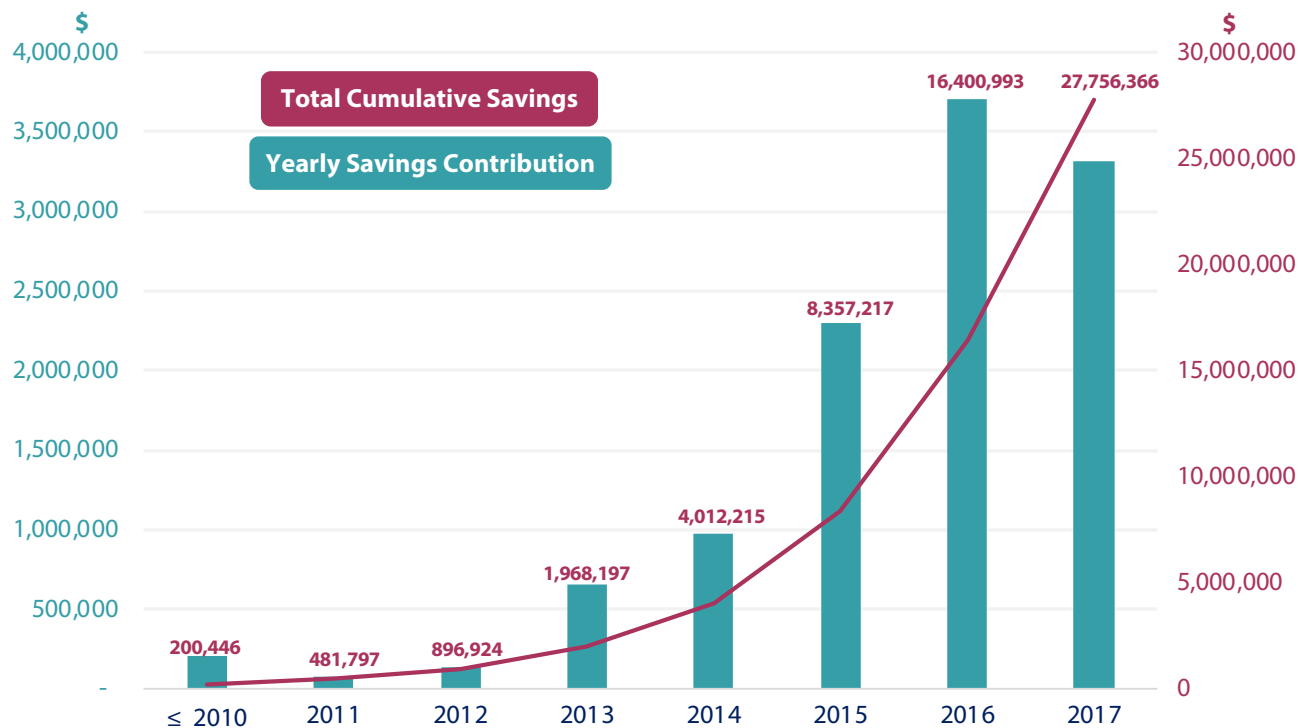
The top 3 Governorates leading the solar PV Market in Lebanon are Mount Lebanon with 13.72 MWp, Beqaa with 6.77 MWp, and South Lebanon with 4.90 MWp.

SOLAR PV CAPACITY BY DISTRICT (kWp | %)



The top 3 Districts leading the solar PV Market in Lebanon are Zahle with 5.71 MWp, Saida with 3.86 MWp, and Byblos with 3.66 MWp.

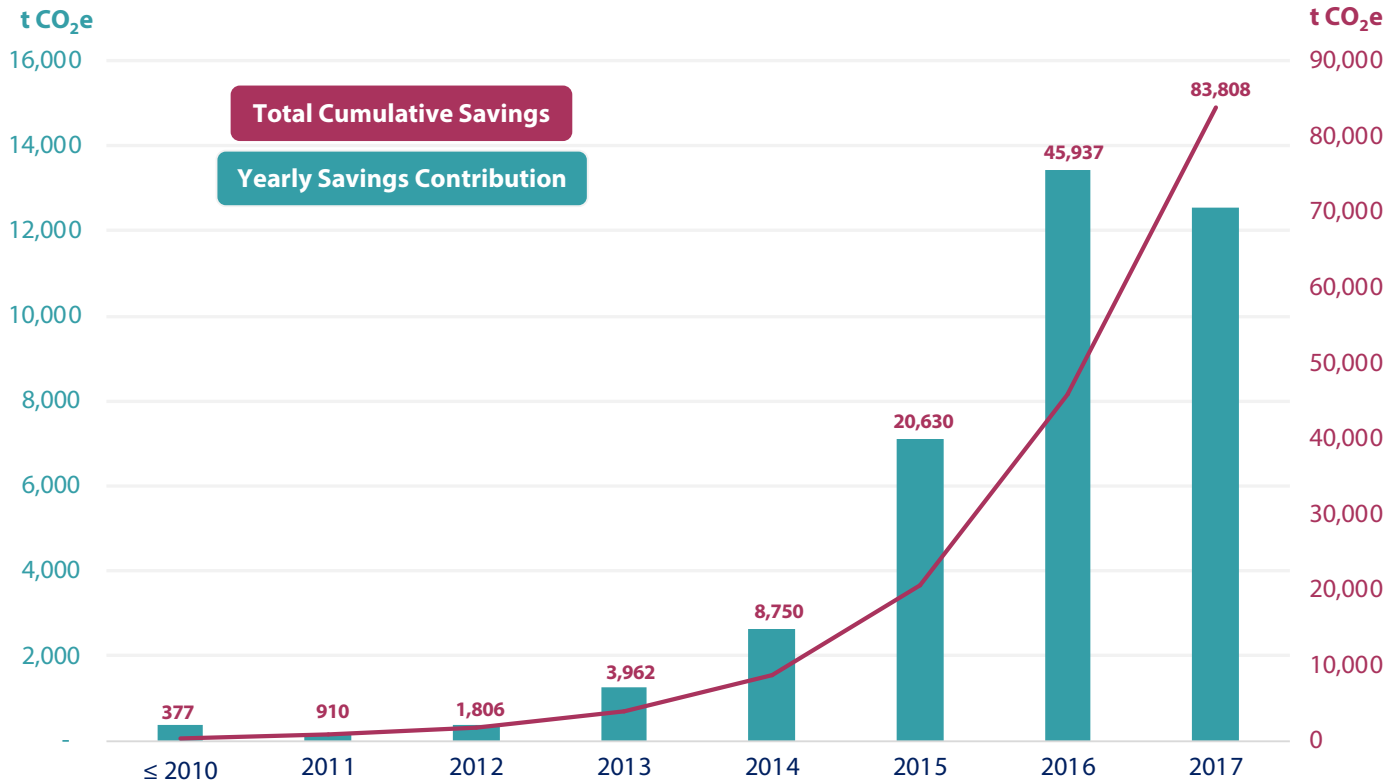
▶▶▶ SOLAR PV ESTIMATED MONETARY SAVINGS (\$)



The estimated monetary savings from all the solar PV projects in Lebanon grew from \$200k per year in 2010 to \$3.3m per year in 2017. The cumulative savings by the end of 2017 amount to \$27.8m.

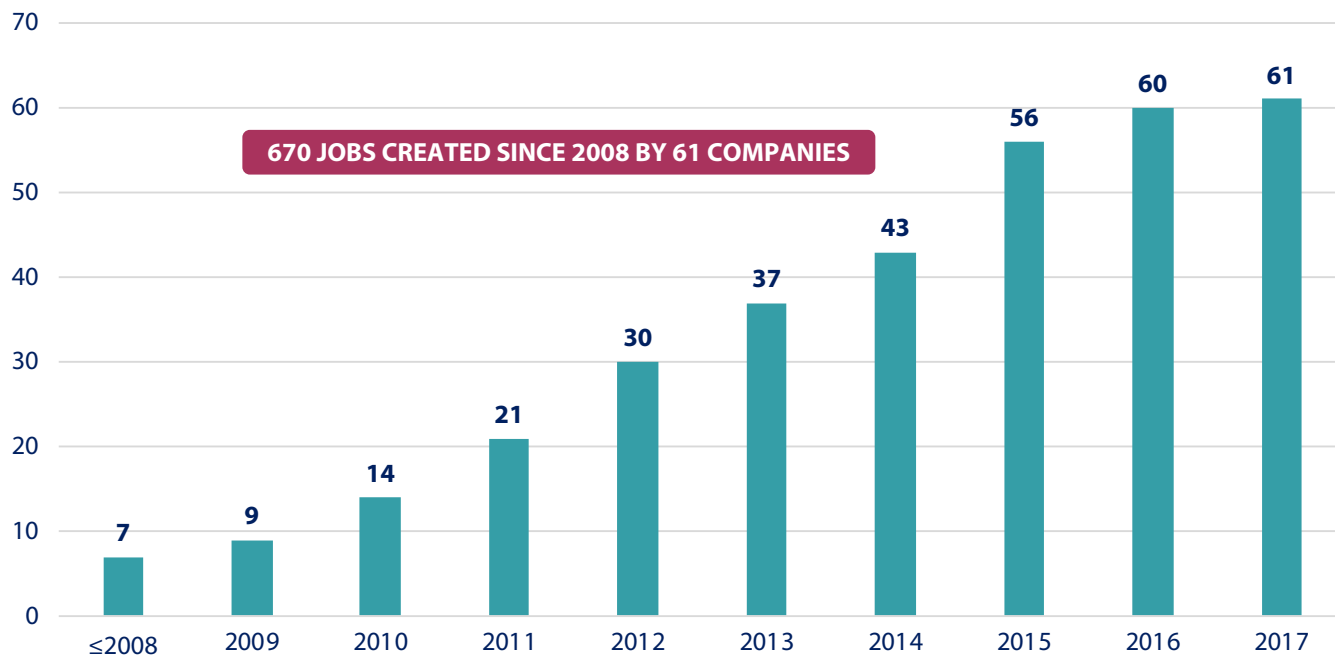
These are the savings achieved by the operators of solar PV systems in Lebanon by deferring a portion of their electricity consumption from the grid and diesel generators to solar PV generation.

SOLAR PV ESTIMATED EMISSIONS SAVINGS (t CO₂e)



The estimated emissions savings from all the solar PV projects in Lebanon grew from 377 t CO₂e per year in 2010 to 12,500 t CO₂e per year in 2017. The cumulative savings by the end of 2017 amount to 83,800 t CO₂e.

▶▶▶ SOLAR PV COMPANIES IN LEBANON



7 Lebanese solar PV companies were working in the sector up until 2008. This number started growing steadily from 14 companies in 2010 to 61 companies by the end of 2017. At least 670 jobs were created throughout.

* Companies that chose not to participate in the data collection conducted for this report could not be accounted for.

▶▶▶ TAKEAWAY POINTS

- ▶ For the market to reach the 2020 targets of **100 MWp** and **160 GWh** per year for decentralized solar PV, the NEEREA loan application, evaluation, and approval processes need to be further encouraged and expedited.
- ▶ The industrial sector continues to dominate the solar PV market with **10.78 MWp** of installed capacity while the Medical sector recorded the highest growth rate in 2017 at **240%** to reach **1.5 MWp**.
- ▶ Investing in solar PV continues to be more affordable year after year with the average turnkey price dropping from **\$1,872** per kWp in 2016 to **\$1,545** in 2017. In addition, in March 2018, the Lebanese Customs exempted imported solar PV panels from customs duty.
- ▶ With **64%** of total capacity and **55%** of total investments facilitated by NEEREA, the latter remains the market catalyzer it was designed to be.
- ▶ The solar PV sector's positive effect on job creation is clear with at least **670 jobs** created since 2008. Significantly more jobs will be created when Lebanon starts building its first utility-scale PV farms.
- ▶ With the GEF-funded UNDP DREG project coming to an end in September 2018, this 2017 edition of the report marks the last one to be developed and published by the project. Subsequently, the database will be transferred to the LCEC.

LIST OF PARTICIPATING LEBANESE SOLAR PV COMPANIES

A Energy Corner	DAWTEC	Manalco
ACEMCO S.A.L.	Earth Technologies	ME Green
AEMS S.A.L.	ECOSys-MDS	Nicolas Electric
AK Energy	EKT	Phoenix Energy
Albina S.A.L.	Elements Sun & Wind	RJR Trading and Contracting
Al Diyar	FREE S.A.L.	Salem International
Arina Energy	GAPS	Smart Age
ASACO	Green Energy	Solar Wind M.E.
Benta Power Tech	Green Essence Lebanon	Solaris Green Energy
Beta Engineering	GreenWise Energy	Solarnet
Cenpro Energy Co.	Issa Electric	Solec Energy Solutions
Control Panel S.A.R.L.	I Energy	Takom Energy
CTI	Ijazi Investment Company	







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UNDP is the UN's global Development network advocating for change and connections countries to knowledge, experience and resources to help people build a better life.