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Professional paper

# INVESTMENT NEEDS FOR SOLAR PV PERSPECTIVE

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**Abstract**

The problem developed in the paper is very specific, important, and current because it treats solar energy, and in this context, the research is mainly based on carefully selected and processed data on the capacity of solar photovoltaics to date, 2020 and their future development, by 2050. Among all renewable technologies, these installations have been dominating the renewables industry for many years. With continuous technological advancement and cost reductions, which are expected to reduce further, is foresees the solar PV market growing rapidly over the next three decades. Because of this, i.e., due to the economic competitiveness of solar photovoltaics, their investments will gradually increase by 2050, worldwide.

The paper is of special importance and aims to point out the impressive development and implementation of photovoltaic systems, which are favorites of investors and incomparable from an economic point of view, not to mention the range of environmental causes in air and environmental pollution, as opposed to the operation of existing fossil and nuclear systems. Hence, in the future, such energy projects will be motivated, promoted, and supported by various financial funds, with great security in the investment and without a doubt in the profitability of these systems. This is until a complete transformation of electricity production from fossil and nuclear fuels with RES production is achieved, especially from solar energy on a global level.

*Keywords:* solar photovoltaics, solar photovoltaics capacity, installation cost, solar photovoltaic market, solar photovoltaics investments.

## 1. Introduction

Today, electricity generation is a significant economic activity globally. Hence, the issue that has been developed is very topical because it treats solar energy and investments in the perspective of solar photovoltaics, for electricity production, in general and the global energy trend of solar energy utilization, through the construction of photovoltaic systems, separately.

It is very important to turn to sustainable energy sources, instead of continuing to rely on unsustainable and expensive systems. The most important advantage that the photovoltaic system offers is that it is very economical and with the fastest real return on the investor's investment.

The analysis in this paper is focused and aims to address and show that it is entirely possible to achieve 100% energy replacement of fossil and nuclear fuels with RES, for electricity production. This renewable electricity by 2050, will appear as the main carrier of energy in future energy systems.

In the context of what has been said, in the analysis in the paper is summarized in three parts, as follows: The first part briefly describes the capacity of solar photovoltaics and their development by 2050. The second part of the paper is devoted to the total installation cost of future solar

photovoltaic projects. The third part points out the investment needs for a perspective on the solar photovoltaic market, and finally, the paper ends with a conclusion.

## 2. Solar PV capacity to 2050

The deployment of renewables has been growing at a rapid pace in recent years, reaching record levels and outpacing annual conventional power capacity additions in many regions. Among all renewable technologies, solar PV power installations have been dominating the renewables industry for many years. As of the end of 2018, the global capacity of installed and grid-connected solar PV power reached 480 GW (Figure 1), representing 20% year-on-year growth compared to 2017 (386 GW) and a compound annual growth rate (CAGR) of nearly 43% since 2000 (IRENA, 2019c).

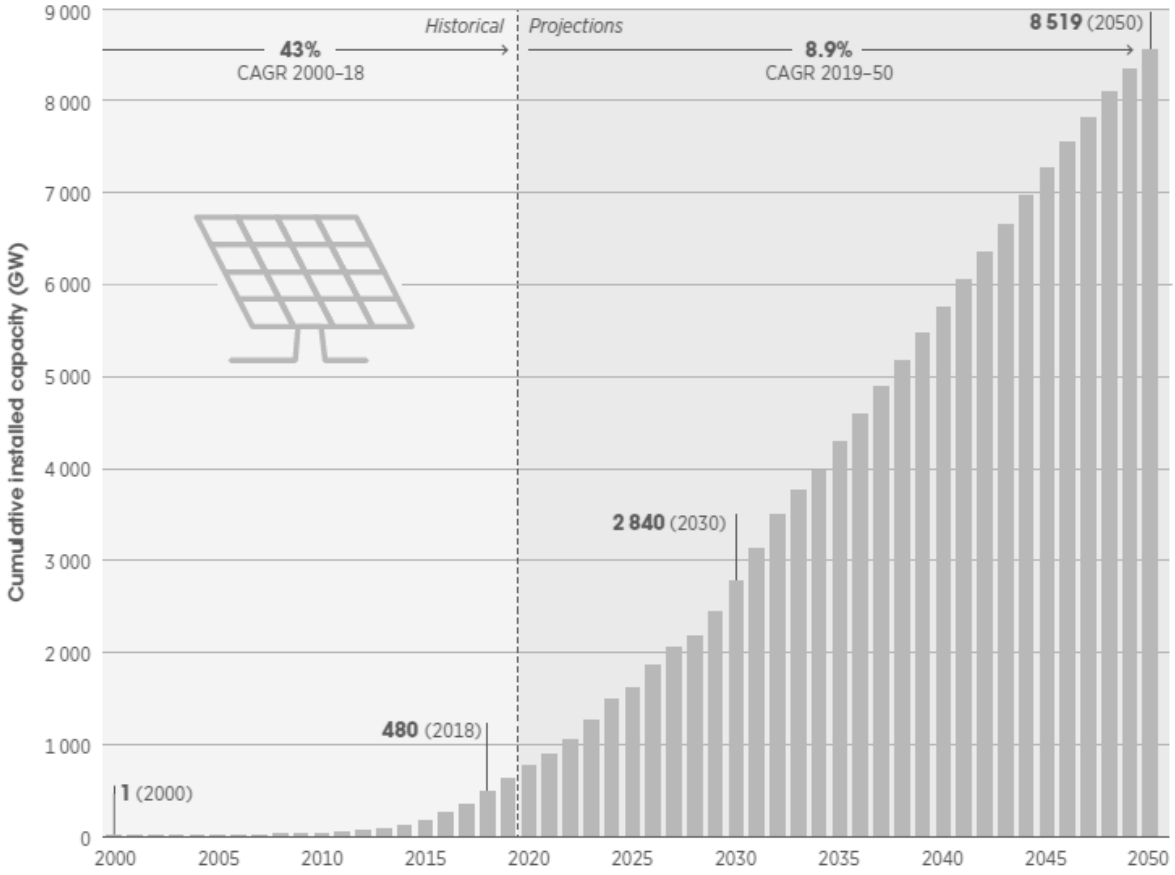


**Figure 1.** Compared to 2018 levels, cumulative solar PV capacity is expected to grow sixfold by 2030, with a CAGR of nearly 9% up to 2050

Sources: Historical values based on IRENA's renewable energy statistics (IRENA, 2019c) and future projections based on IRENA's analysis (2019a)

Considering ample resource availability, significant market potential and cost competitiveness, solar PV is expected to continue increasing overall renewables growth in several regions over the next decade.

From today's levels, IRENA's REmap analysis shows that solar PV power installations could grow almost six-fold over the next ten years, reaching a cumulative capacity of 2 840 GW globally

by 2030 and rising to 8 519 GW by 2050. This implies total installed capacity in 2050 almost eighteen times higher than in 2018 (Figure 6). At a global level, around 60% of total solar PV capacity in 2050 would be utility scale, with the remaining 40% distributed (rooftop). While utility-scale projects still predominate in 2050, the REmap analysis expects distributed solar PV installations to grow more rapidly, driven by policies and supportive measures, as well as consumer engagement in the clean energy transformation.

Rapid growth in solar PV installations to 2050 and the global installed capacity of solar PV would rise six-fold by 2030 (2 840 GW) and reach 8519 GW by 2050 compared to installations in 2018 (480 GW) **(**IRENA, 2019).

The global solar market in 2018 was dominated by Asia, accounting for over half of the world's addiction to solar capacity. The region's installed solar capacity reached 280 GW by the end of 2018, dominated by China with 175 GW. The European Union represented the world's second-largest solar PV market, mainly driven by Germany with 45 GW cumulative installed capacity by the end of 2018, followed by North America with 55 GW (Figure 2), of which the United States accounted for 90% (IRENA, 2019a).

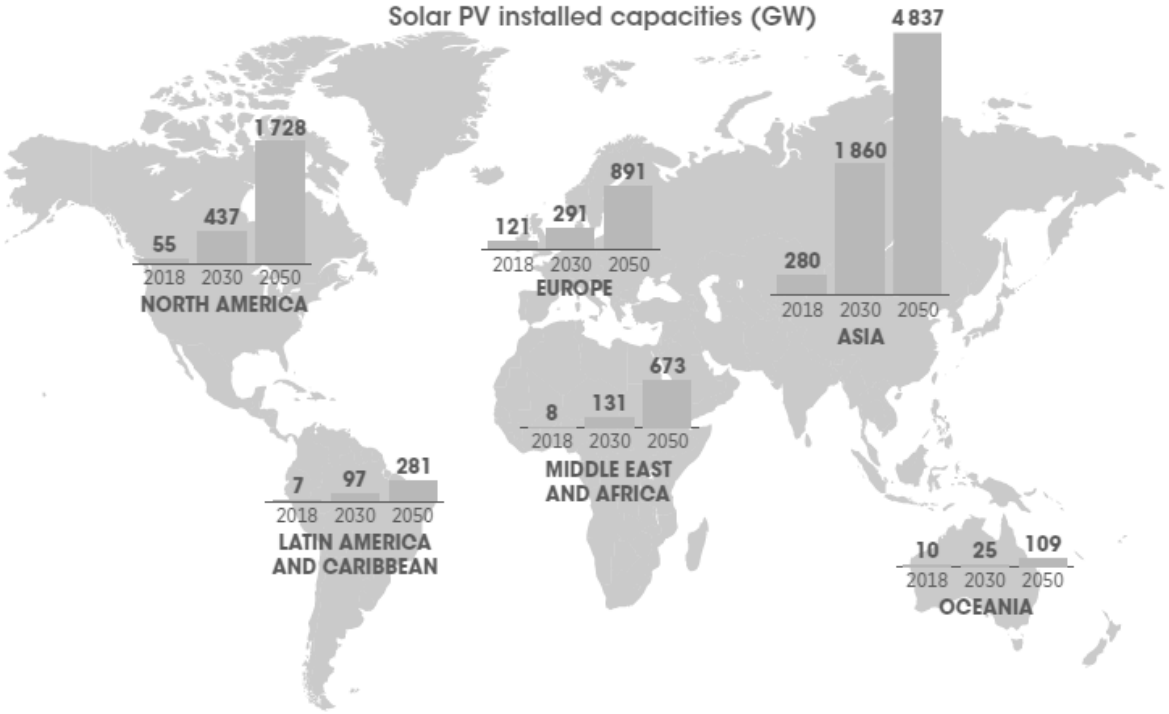


**Figure 2.** Among the world's regions, Asia is poised to dominate global solar PV installations in the REmap scenario, followed by North America and Europe

Sources: Historical values based on IRENA's renewable energy statistics (IRENA,2019c) and future projections based on IRENA's analysis (2019a)

Under the REmap scenario, Asia would continue to lead global solar PV installations, with 65% of the total capacity installed by 2030 (Figure 2). Within Asia, significant deployment would be seen in China, where installed capacity is projected to reach around 1 412 GW by 2030. North America would have the second-highest installed solar PV capacity, reaching 437 GW by 2030, with more than 90% of these installations in the United States.

Europe would represent the third-highest region by 2030, with 291 GW of solar PV capacity installed. A similar picture is expected on a 2050 horizon when Asia would still dominate the scene at almost half of the cumulative global capacity installed (4 837 GW). Within Asia, China would dominate the scene, with a CAGR of 9% after 2018 leading to the projected capacity of around 2 803 GW by 2050. North America would still have the second-largest installed capacity, reaching 1 728 GW by 2050, with the United States still dominating the region. Europe could still hold a third place among regions in 2050, with 891 GW of total solar PV capacity installed. More than 22% of these installations would be in Germany, where the installed capacity is projected to reach around 200 GW by 2050. Even though installed capacity may remain highest in Asia, North America, and Europe, market growth seems likely to shift to other regions, with large markets also expected to emerge in South America and Africa.

Annual solar PV capacity gradually increased until 2011, with a drop observed in 2012 (Figure 3). Then annual capacity growth rose and fell until the end of 2014. 2018 marked a record year when 94 GW of solar PV were added to the global power capacity mix, driven by tremendous cost reductions due to technological enhancements, and policy and supportive measures.

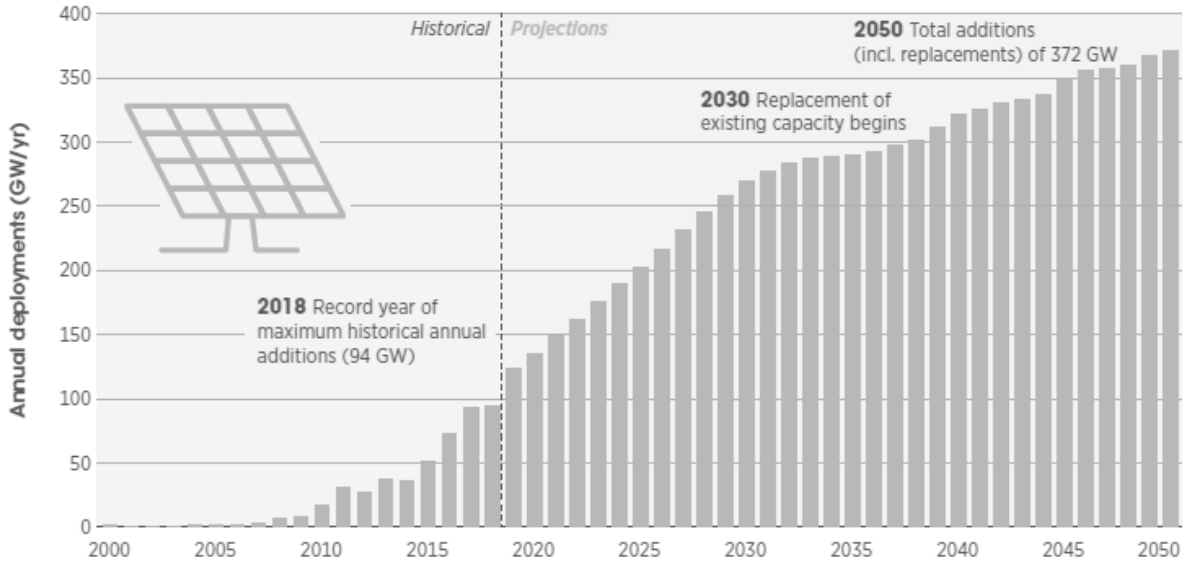


**Figure 3.** Annual Global solar PV additions are expected to reach to 270 GW in 2030 and 372 GW in 2050 under the REmap scenario, compared with 94 GW in 2018

Source: Historical values based on IRENA (2019b) and future projections based on IRENA (2019a)

With continuous technological advancement and cost reductions, IRENA foresees the solar PV market growing rapidly over the next three decades. Along with capacity additions, replacement of solar panels at the end of their lifetime is also essential and plays a key role, especially with the benefit of old panels giving way to advanced technologies. Annual capacity additions would more than double by 2030 (270 GW) compared to current levels, and by 2050 are fourfold higher than additions in 2018 (372 GW vs 94 GW per year) (Figure 3).

Currently, annual additions are largely driven by utility-scale projects, reflecting the policies and financial support in various countries. Whilst distributed solar is picking up pace in a few countries, such as Germany, at a global scale distributed levels are still much lower. Mitigating existing barriers and promoting DER is important to scale up solar PV deployment in the coming decades. On a positive note, the REmap analysis shows that after 2030, with the right market conditions for

DER, distributed PV's share of annual additions could start rising and even dominate total PV additions in some countries.

Significant growth in annual solar PV additions to 2050 and the annual capacity additions for solar PV would more than double to 270 GW in 2030 and reach more than 350 GW in the next 30 years, compared to 94 GW added in 2018 **(**IRENA, 2019).

## 1. The total installation cost of future solar PV projects

The breakthrough in renewables capacity additions over the past few years has been largely achieved due to significant cost reductions driven by enabling government policies, including deployment policies, research, and development (R&D) funding, and other policies that have supported the development of the industry in leading countries.

Key renewable technologies, such as solar PV, wind, CSP, and bioenergy, are already cost-competitive and costs are expected to reduce further, outpacing fossil fuels by 2020 (IRENA, 2019f).

Solar PV is emerging as one of the most competitive sources of new power generation capacity after a decade of dramatic cost declines. A decline of 74% in total installed costs was observed between 2010 and 2018 (Figure 4). Lower solar PV module prices and ongoing reductions in balance-of-system costs remain the main drivers of reductions in the cost of electricity from solar PV (IRENA, 2019f).

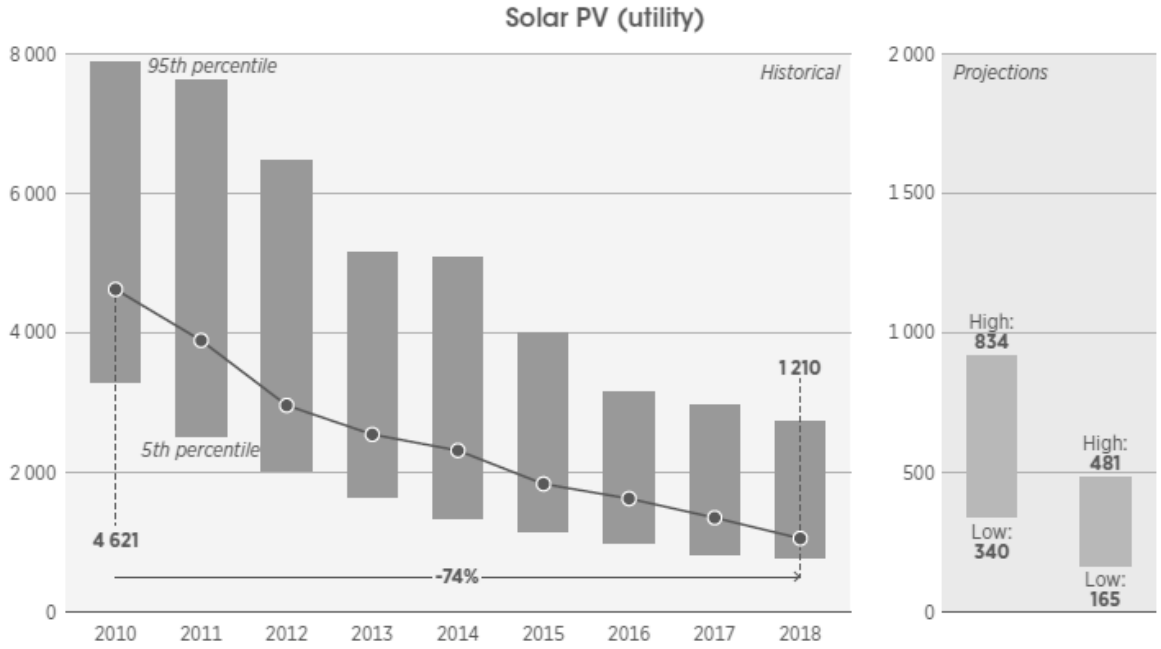


**Figure 4.** There has been a rapid decline in total installed costs of solar PV, with costs expected to further decline by 2050

Sources: Historical data based on (IRENA,2019c) and future projections based on IRENA's forthcoming report: Solar and wind cost reduction potential to 2030 in the G20 countries (IRENA, forthcoming a)

Solar PV installation costs would decline dramatically from now to 2050 and globally, the total installation cost of solar PV projects would continue to decline dramatically in the next three

decades, averaging in the range of USD 340 to USD 834/kW by 2030 and USD 165 to 481/kW by 2050, compared to the average of USD 1 210/kW in 2018 **(**IRENA, 2019).

At a country level, the average total installed cost of utility-scale solar PV projects has declined by between 66% and 84% in major markets during the period 2010–18 (Figure 5). Germany and France witnessed a reduction of 71%, while others have experienced reductions closer to 80%, such as China and Italy (77% and 78% respectively). India was estimated to have the greatest reduction, estimated at 80% (IRENA, 2019e).

Alongside the decrease in installed costs, the global weighted average capacity factor of utility-scale PV systems has been increasing. Between 2010 and 2018 capacity factors increased from an average of 14% to 18%. There are three major drivers for these increases: 1) the trend towards greater deployment in regions with higher irradiation levels, 2) the increased use of tracking systems, and 3) improvements in the performance of systems as losses have been reduced, for instance, though improvements in inverter efficiency (IRENA, 2019f).

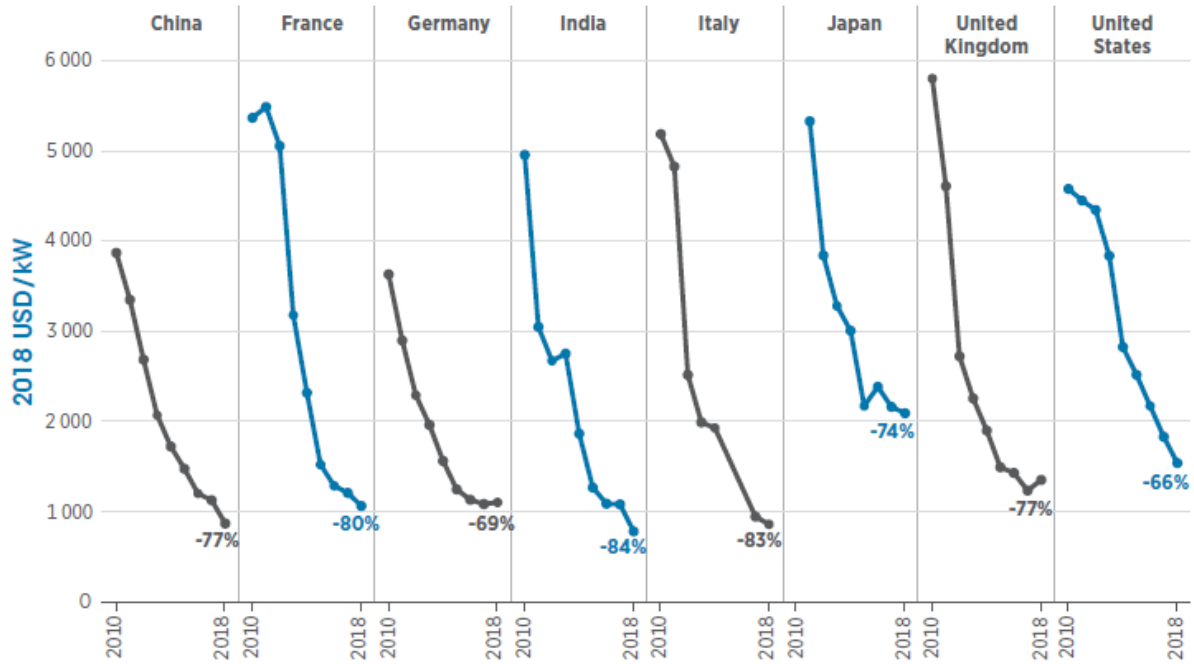


**Figure 5.** Total installed cost of utility-scale solar PV, selected countries, 2010–18

Source: IRENA (2019f)

Rapid declines in installed costs and increased capacity factors have improved the economic competitiveness of solar PV around the world (IRENA, 2019f). The global weighted average LCOE of utility-scale PV plants is estimated to have fallen by 77% between 2010 and 2018, from around USD 0.37/kWh to USD 0.085/ kWh, while auction and tender results suggest they will fall between USD 0.08/kWh and 0.02/kWh in 2030. By 2050, solar PV is expected to be among the cheapest sources of power available, particularly in areas with excellent solar irradiation, with 2050 costs in the range of USD 0.014-0.05/kWh (Figure 6).

Solar PV would be one of the cheapest generating sources and the levelized cost of electricity for solar PV is already competitive compared to all generation sources (including fossil fuels) and is expected to decline further in the coming decades, falling within the range of USD 0.02-0.08/kWh by 2030 and USD 0.014-0.05/kWh **(**IRENA, 2019).

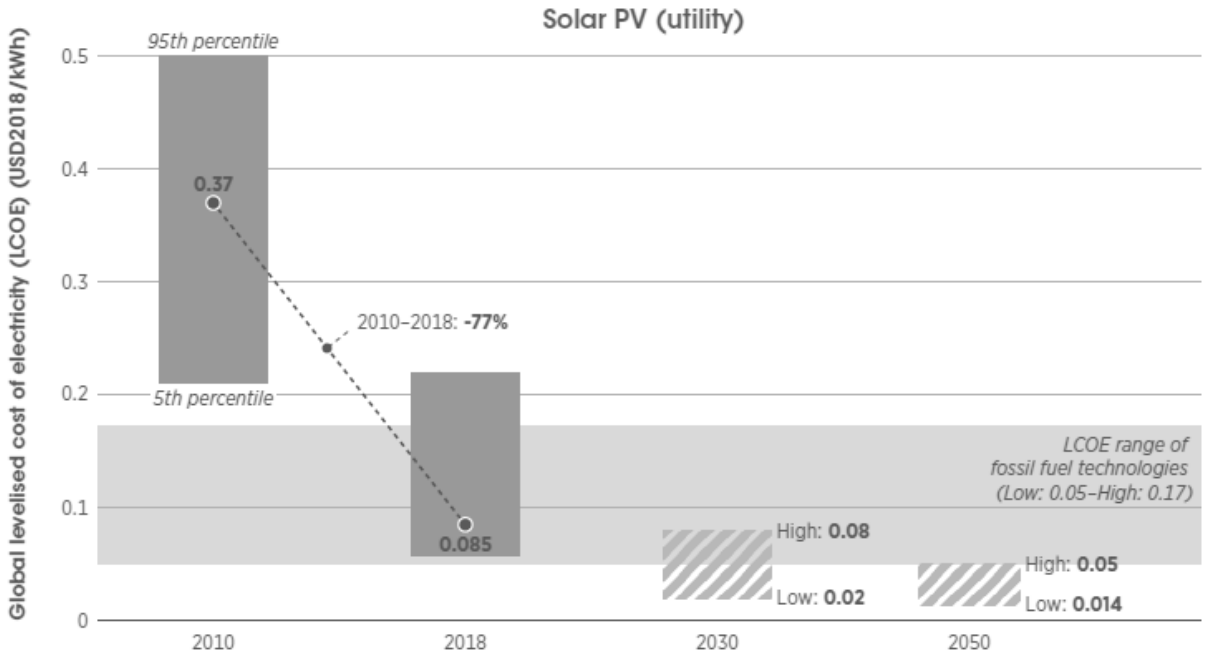


**Figure 6.** The levelized cost of electricity (LCOE) for solar PV is already competitive now compared to all fossil fuel generation sources and would be fully competitive in a few years.

Sources: Historical data based on (IRENA,2019c) and future projections based on IRENA's forthcoming report: Solar and wind cost reduction potential to 2030 in the G20 countries (IRENA, forthcoming a)

## 3. Investment needs of the solar PV market

The total volume of investment in solar PV is being heavily influenced by the technology's falling costs. It rose steadily from USD 120 billion in 2013 to reach record-high levels of USD 179 billion in 2015 as deployment accelerated faster than falling costs. Since then, the balance between these two factors has oscillated: in 2016 total investment fell to USD 141 billion, before rising in 2017 to USD 171 billion on the back of a significant increase in capacity additions, before falling again to USD 131 billion in 2018 as new additions remained more or less the same as in 2018, while costs continued to fall (BNEF, 2019). China saw a gradual increase in solar PV investment between 2005 and 2015, reaching record-high levels of USD 89 billion in 2017 before dropping to USD 40 billion in 2018. In North America, investment increased steadily between 2012 and 2015, when they reached USD 34 billion, before dropping again between 2016 and 2018, when they amounted to USD 25 billion (BNEF, 2019). In 2018, investments made in deploying solar PV capacities accounted for nearly USD 114 billion.

Deploying a total installed capacity of more than 8 000 GW of solar PV by 2050 would necessitate a cumulative investment of nearly USD 6.4 trillion from now until 2050. This would translate into the annual average investment of USD 192 billion per year over the period to 2050. That represents scaling up annual investment by around 68% from now until 2050 compared to solar PV investment in 2018 (Figure 7).

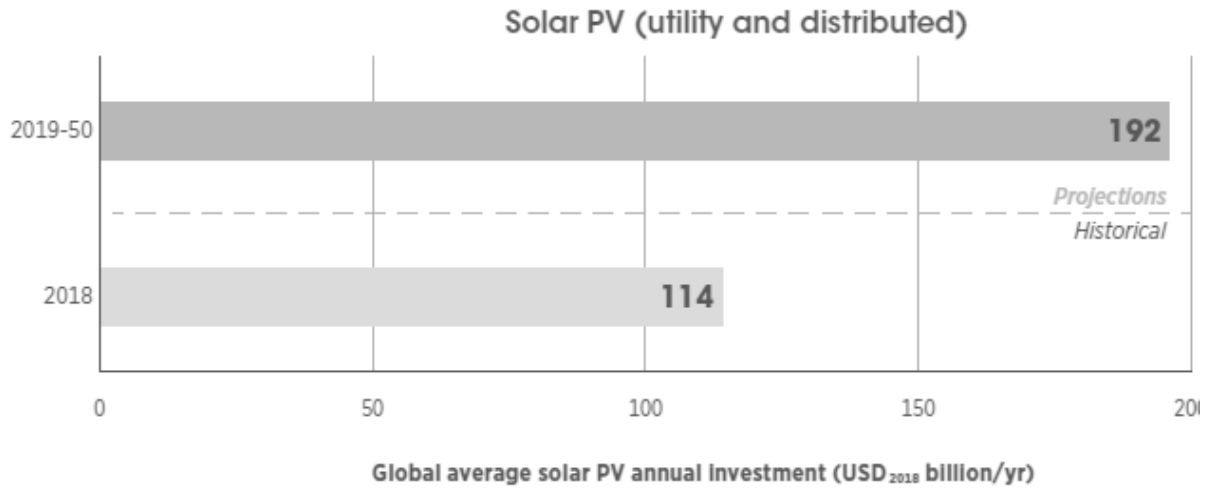


**Figure 7.** Scaling up solar PV energy investment is key to accelerate the pace of global solar PV installations over the coming decades.

Source: based on IRENA's analysis

Scaling up solar PV investment is key to facilitate the uptake of the solar PV market and the global average annual solar PV investment needs to scale up by 68% until 2050 (USD 192billion/year) compared to 2018 investment (USD 114 billion/year) **(**IRENA, 2019).

At the regional level the major share of global investment would shift to Asia, with USD 113 billion per year from now until 2050, and China and India at the forefront accounting for approximately 57% and 18% of total annual investment respectively. Asia is followed by North America at USD 37 billion per year and then Europe at USD 19 billion per year (Figure 8).


**Figure 8.** Regional annual investment in solar PV capacity (new and replacement), 2019–50 (USD billion/yr)

Source: IRENA's analysis

**Abbreviations used**

BNEF- Bloomberg New Energy Finance
CAGR-Compound annual growth rate
CSP-Concentrating solar power
DER-Distributed energy resources
G20-Group of Twenty
GW-Gigawatt
IRENA-International Renewable Energy Agency
kWh-Kilowatt hour
LCOE-Levelized cost of electricity
PV-Photovoltaic
R&D-Research and development
REmap-IRENA's renewable energy roadmap
RES- Renewable energy sources
USD-US dollar

## 4. Conclusions

From the detailed and practical processing of the selected data and their analysis, regarding solar energy and solar photovoltaic capacities, for electricity production, as well as the global energy trend of solar energy utilization and investments in the perspective of solar photovoltaics, we can conclude as it follows:

- In 2018, generation from combustible fuels accounted for 66.3% of total world gross electricity production, from nuclear sources 10.1%, while from RES 23.6%.
- Regarding the production of electricity from RES, the same is increasing from year to year, and also the production from solar energy, which in 2018 represents 2.1% of the total production.
- A global trend is the reduction, i.e., replacement of electricity production from conventional thermal and nuclear sources with RES.
- The increased share of RES in the production of electricity is of great importance in terms of reducing greenhouse gas emissions, and thus protection and preservation of the environment, in general and human life in particular.
- The production of electricity from renewable sources is growing at a rapid pace from year to year, and within that the construction of solar photovoltaic precursors in the renewable sources industry.
- In terms of high resource availability, significant market potential and cost competitiveness, the construction of solar photovoltaics is expected to continue in the next decade.
- Their global installed capacity is expected to increase sixfold by 2030 (2,840 GW) and will reach 8519 GW by 2050 compared to installations in 2018 (480 GW), with a compound annual growth rate (CAGR) of nearly 9% ap to 2050.
- The global solar energy market in 2018 was dominated by Asia, mainly driven by China, then the European Union was the world's second largest market for solar photovoltaics, mainly driven by Germany, followed by North America and mainly driven by the United States.

- Asia will continue to hold the top spot until 2030 and further until 2050, followed now first by North America and then by Europe.
- With continuous technological advancement and cost reduction, the solar photovoltaic market is projected to grow rapidly over the next three decades. The annual solar photovoltaic capacity will more than double, to 270 GW in 2030 and four times higher, to 372 GW in 2050, compared to 94 GW in 2018.
- Key renewable technologies, such as solar PV, wind, CSP and bioenergy, are already cost competitive and costs are expected to reduce further, outpacing fossil fuels by 2020.
- Globally, the total installation cost of solar PV projects would continue to decline dramatically in the next three decades, averaging in the range of USD 340 to USD 834/kW by 2030 and USD 165 to USD 481/kW by 2050, compared to the average of USD 1 210/kW in 2018.
- The levelized cost of electricity for solar PV is already competitive now compared to all generation sources (including fossil fuels) and is expected to decline further in the coming decades, falling within the range of USD 0.02-0.08/kWh by 2030 and USD 0.014-0.05/kWh by 2050.
- The latest global analysis compares leveled energy costs for the latest generation of USD / MWh-based technologies and shows that it is cheaper to build new solar power plants than to modernize existing thermal power plants.
- A new report by Solar Power Europe and LUT University shows that it is entirely possible to achieve a 100% renewable energy scenario in which Europe will meet its goal of climate neutrality by 2050.

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