

Factsheet

Low-cost PV - The Key for Sustainable Future Energy System

The cost of solar photovoltaic (PV) systems has decreased dramatically over the past decade. Market prices of PV modules have decreased by about 95% in real terms from 2011. PV has reached parity with retail and wholesale electricity in most countries. The concept of Levelised Cost of Electricity (LCOE) is used for making fair comparisons with electricity prices and the cost of other power generation technologies. In this factsheet, LCOE is defined to be the generation cost, i.e., including all the costs involved in supplying PV power at the point of connection to the grid. PV LCOE is based on PV system capital (CAPEX) and operational (OPEX) expenditures and includes the costs and profit margins of the whole value chain including financing, project development, manufacturing, installation, operation and maintenance.

PV system CAPEX can be divided into two parts: the modules and the Balance of System (BoS). For decades, module prices have very closely followed the so-called learning curve, which means that each time the global cumulative PV generation capacity doubles, the price of modules decreases by about 25%. It is expected that module prices will decrease according to the historical LR during the next decades, mainly because of better manufacturing processes, less use of materials and continuously improving module efficiencies. Since a large part of BoS depends on the area of the modules, higher efficiency will also drive down the BoS significantly. On the other hand, some BoS items like labour cost have recently increased because of high demand and shortage of skilled workers. Moreover, inflation has increased nominal prices by 20% since 2020.

According to the base scenario by the European Technology and Innovation Platform for Photovoltaics (ETIP PV), the cumulative global PV capacity would increase from the end of year 2023 figure of 1.5 TWp to about 5.5 TWp by 2030 and to 30 TWp by 2050. Applying this volume growth, a 25% LR and an average 0.5%-point annual average efficiency improvement, PV LCOE would decrease from 2024 by about 20% by 2030 and by 50% by 2050. Figures 1-4 show the PV LCOE at five European locations for four system sizes and with four different nominal Weighted Average Cost of Capital (WACC) rates. Annual inflation is set at 2% which means that e.g., 4% nominal WACC corresponds to 2% real WACC. PV system lifetime is 30 years for rooftop and 35 years for ground-mounted installations, and annual degradation is 0.5% in all cases. OPEX for utility-scale from 2023 to 2050 decreases from 12.5 to 9 €/kWp/a, for rooftop solar it is 10 €/kWp/a. All prices are given in start of the year 2024 real euros. Other input parameters are given in Tables I and II.

Table I. Yield parameters (in kWh/kW_p/a)

Location	Rooftop		Ground	
	2024	2040	2024	2040
Helsinki	920	970	1050	1110
Munich	1070	1130	1180	1250
Toulouse	1280	1360	1400	1480
Rome	1480	1570	1600	1700
Malaga	1700	1800	1790	1900

Table II. CAPEX parameters (without VAT, in 1/24 €/W_p)

PV system type	2024	2030	2040	2050
Residential 5 kW _p	1.62	1.28	0.98	0.81
Commercial 50 kW _p	0.97	0.76	0.58	0.48
Industrial 1 MW _p	0.68	0.53	0.40	0.33
Utility-scale 100 MW _p	0.46	0.36	0.28	0.23

CAPEX may vary by ±25% depending on project and location.

If compared with the average variable retail electricity prices, even excluding the fixed fees which cannot be saved by own PV consumption, PV electricity is already cheaper in all five locations with all realistic WACC rates and consumer segments. When comparing with the average wholesale (spot market) electricity prices of 2019-2021, utility-scale PV would be already competitive with nominal WACC well over 10% in all countries. During 2022 energy crisis in Europe, spot market prices were much higher making PV even more competitive. In Malaga, utility-scale PV LCOE with 7% nominal WACC is 24 €/MWh in 2024, decreasing to 19 €/MWh by 2030 and to 13 €/MWh by 2050.

In conclusion, affordable solar PV is the key for electrifying the future sustainable energy system where fossils are replaced by renewable fuels.

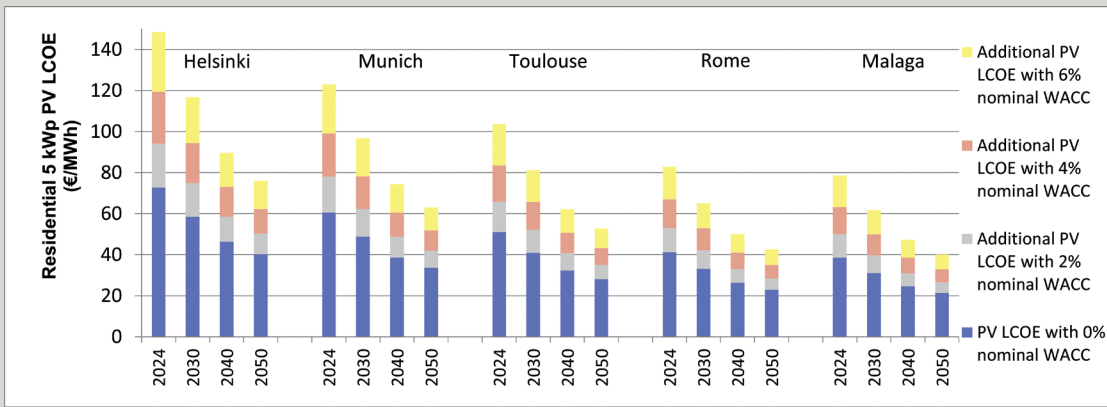


Figure 1. PV LCOE (in 2024 €) at five European locations with different nominal WACCs for 5 kWp residential rooftop PV. VAT (FIN 24%, GER 19%, FRA 20%, ITA 10%, ESP 21%) has been added to the residential PV CAPEX

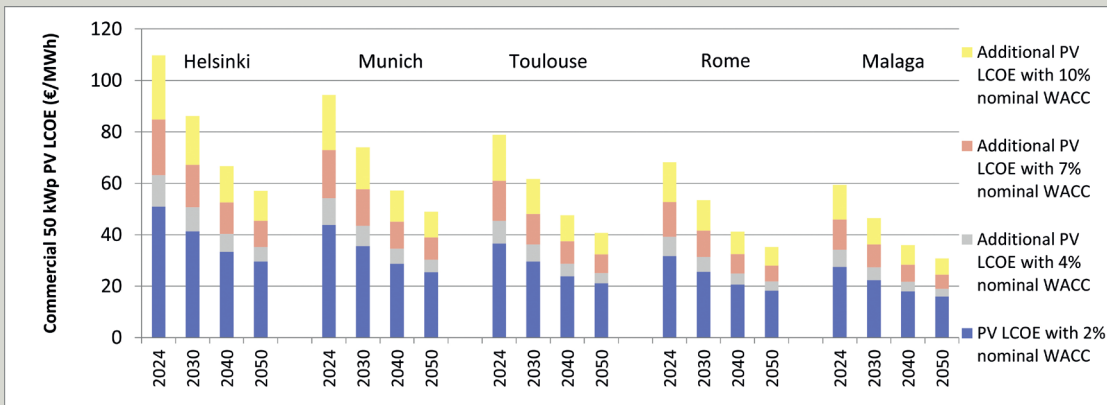


Figure 2. PV LCOE (in 2024 €) at five European locations with different nominal WACCs for 50 kW_p commercial rooftop PV

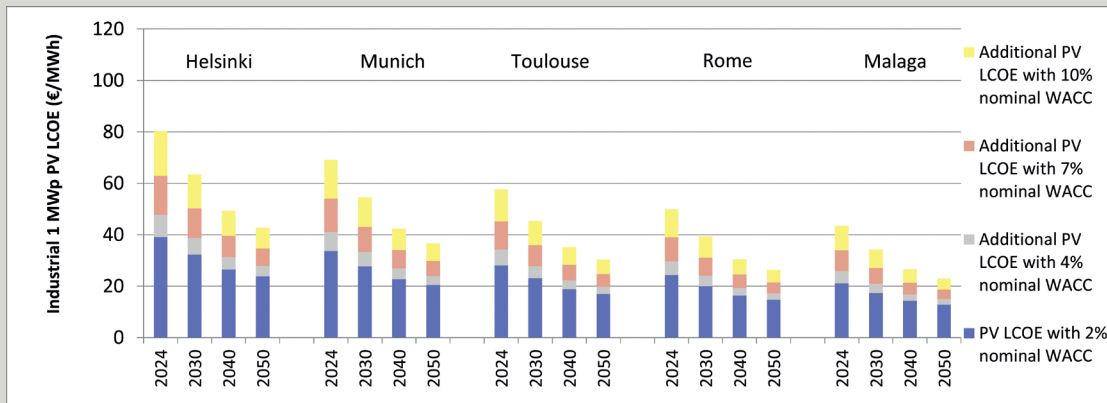


Figure 3. PV LCOE (in 2024 €) at five European locations with different nominal WACCs for 1 MW_p industrial PV

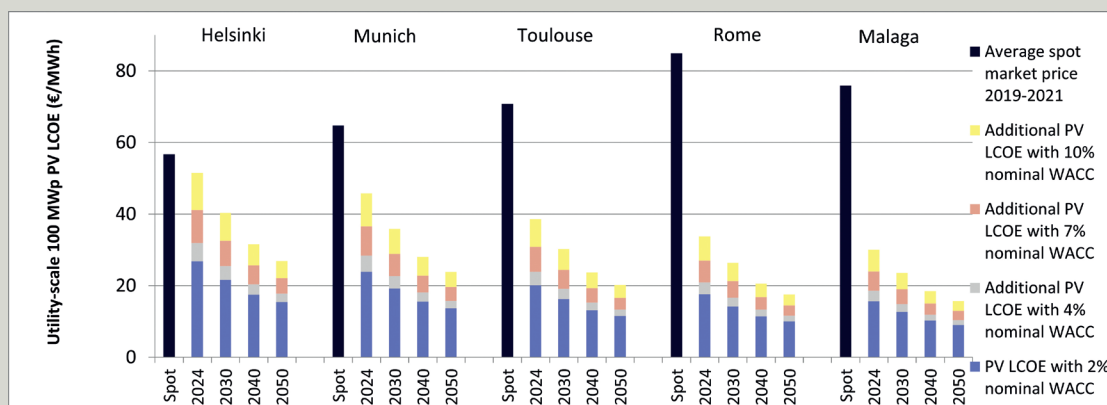


Figure 4. PV LCOE (in 2024 €) five European locations with different nominal WACCs for 100 MW_p utility-scale PV compared with average spot market electricity price of 2019-2021 (black column)

