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PRODUCTIVITY OF
PHOTOVOLTAIC
PANELS



THE THREE DISADVANTAGES CAUSED BY NOT CLEANING PHOTOVOLTAIC PANELS

Failure to Clean Photovoltaic Panels Can Lead to Several Disadvantages, Including:

- Reduced Energy Efficiency:
 - A layer of dust and debris decreases the amount of solar radiation reaching the cells. In Italy, the average energy loss ranges from 2% to 10%, and in very dusty environments it can reach up to 30%.
- Risks to System Longevity:
 - Persistent dirt, leaves, and bird droppings promote the formation of hot spots, scratches, and delamination, which can lead to the premature replacement of modules.
- Economic Impact:
 - Every percentage point of efficiency lost corresponds to unproduced kilowatt-hours: this means fewer incentives, less self-consumed energy, and more electricity purchased from the grid.





CLEANER MEANS MORE PROFIT

Only a Clean Photovoltaic System Operates at Maximum Efficiency and Ensures a Consistent Production of Renewable Energy — in This Case, From the Sun.

Here are some international studies that confirm this fact:

- University of California, San Diego (Mejia & Kleissl, 2013):
- After 145 days without rain, the test system recorded an average decrease in output of 7.4%; cleaning restored production levels.
- Solarplaza, database of 40 international systems (2016):
- Cleaning benefits ranged from 3% to 30%, depending on climate, panel tilt, and type of dirt.

These data show that regular cleaning of photovoltaic panels can lead to significant increases in energy efficiency and, consequently, in the financial returns of solar system investments.





CLEANING PHOTOVOLTAIC PANELS HELPS PREVENT POWER LOSSES CAUSED BY DIRT — LOSSES THAT CAN BE COSTLY.

Why It Pays to Act

A study led by Leonardo Micheli (Sapienza University of Rome) estimates that soiling reduces global solar energy production by 3–4%, resulting in annual losses of €3–5 billion. Without corrective actions, this figure could rise to 4–7% by 2025.



BEYOND FINANCIAL RETURNS: TECHNICAL BENEFITS

1. Reduced Thermal Stress and Hot Spot Prevention

Field measurements by NREL on modules with 5% soiling showed temperature differences of up to +22°C between shaded and clean cells. Hot spots accelerate microcracks and delamination, increasing the failure rate of bypass diodes and the risk of fire.

(Source: [nrel.gov](https://www.nrel.gov))

2. Protection of Anti-Reflective Coatings

The accumulation of calcium and marine salts leads to surface corrosion of the glass. Tests in coastal climates showed transmittance losses of 8% after just 24 months without scheduled cleaning.

(Source: [sciencedirect.com](https://www.sciencedirect.com))

3. Preservation of Manufacturer Warranty

Most manufacturers (e.g., Jinko, Trina) require proof of annual maintenance: without cleaning reports, coverage under the Performance Warranty may be voided.

4. Reduction of Apparent Degradation

The NREL Fleet Performance dataset (255 systems) indicates a median annual soiling loss of 5%, higher than the natural degradation rate of modules (-0.6%/year).

This means that a system that is never cleaned can double its output loss in just 5 years.

(Source: [nrel.gov](https://www.nrel.gov))



BEYOND FINANCIAL RETURNS: TECHNICAL BENEFITS

How Widespread Is the Problem?

- IEA PVPS reports that in Europe, over 60% of residential systems rely solely on rain for cleaning.
- (Source: [iea-pvps.org](https://pvps.iea.org/))
- AirDroneJet Site Inspections 2024:
- Out of 120 rooftops examined, 82% had not been cleaned in over 18 months, and 15% already showed cloudy or corroded glass.
- (Internal data)
- pv magazine / Ecoppia Survey 2022:
- Nearly 1 in 2 operators had no automated or regular cleaning procedures in place.
- (Source: [pv-magazine.com](https://www.pv-magazine.com/))

Technical Conclusion

Periodic cleaning is not an "extra", but a form of preventive maintenance that:

- Reduces ΔT between cells, preventing hot spots and fires
- Preserves optical coatings and frame integrity
- Maintains the validity of the module pass-through warranty
- Stabilizes performance and simplifies SCADA monitoring (fewer false alarms)

Implementing an annual drone-based cleaning program can extend the effective service life of the system by 5–7 years and protect its resale value.



THE IMPORTANCE OF MODELING

The research project led by the professor from La Sapienza University focuses on the analysis and modeling of photovoltaic energy, with recent years dedicated to studying the soiling effect on solar panels and optimizing PV cleaning cycles.

"Soiling" is the English term used to describe the accumulation of dirt on the light-collecting surfaces of solar energy systems. This phenomenon is influenced by several factors, the most significant of which is the concentration of airborne dust.





ABSENCE OF PROPER CLEANING OF THE PANELS

This photograph was taken at an agricultural plant company in Central California.

Cleaning is carried out by spraying water onto the panels from a truck every day. Visible calcium streaks have formed due to the use of hard water without filtration.

These panels have only been installed for two years, and it is unlikely they will last more than two or three more years without causing serious damage to the modules and a significant drop in system performance.





ABSENCE OF PROPER PANEL CLEANING

A photograph taken at a food production facility in Germany.

There are numerous bird droppings that have never been removed.

As a result, there is a significant loss in performance due to the lack of frequent cleaning.





LACK OF PROPER SOLAR PANEL CLEANING

On the surface of these rooftop panels, installed at an animal feed production facility, you can see residues of pork rind mixed with seagull droppings.

These residues have settled on the panels and, primarily due to heat exposure, have turned into hardened encrustations that are very difficult to remove.





LACK OF PROPER SOLAR PANEL CLEANING

Greenhouse with Photovoltaic System, Near the Sea.

Salt deposits are visible on the panels due to the proximity to the coast.





2025 Price List

Price List – Residential Solar Systems

System	FROM 1 TO 5 KW	Cost	FROM €100,00 TO €450,00
System	FROM 5 TO 10 KW	Cost	FROM €450,00 TO €800,00
System	FROM 10 TO 15 KW	Cost	FROM €800,00 TO €1.050,00
System	FROM 15 TO 20 KW	Cost	FROM €1.050,00 TO €1.400,00



ANNUAL ESTIMATE FOR 6 kW SYSTEM

Annual Estimate for a 6 kW Photovoltaic System

A 6 kW solar PV system can produce on average between 6,500 and 9,000 kWh per year, depending on geographic location and weather conditions.

🇮🇹 Average Annual Output in Italy:

6,500 – 9,000 kWh

💰 Energy Value at €0.35/kWh Tariff:

€2,275 – €3,150/year

📄 Brochure Conservative Estimate:

€2,000 – “minimum reference value”

🔧 Impact of Dirt (Soiling)

- Potential energy loss (up to 30%): → €600/year
- AirDroneJet cleaning cost: → €450
- Net gain from recovered performance: → ≈ €150

Conclusion

Regular cleaning of a photovoltaic system not only boosts energy production, but is also essential for fault prevention and for extending the system's operational lifetime.



ANNUAL ESTIMATE FOR 10 kW SYSTEM

Annual Estimate for a 10 kWp Photovoltaic System

A 10 kWp solar PV system typically produces between 12,000 and 13,000 kWh per year on average.

The financial value of this energy depends on the electricity rate:

at an average price of €0.35/kWh, the system could generate a value of approximately €4,200–4,550 per year.

⚡ Annual Production:

12,000 – 13,000 kWh

💰 Energy Value (€0.35/kWh):

€4,200 – €4,550

📉 Loss due to Soiling (30%):

≈ €1,300

🧼 Cleaning Cost:

€800

🔄 Recovered Value After Cleaning:

≈ €500

Conclusion

Regular cleaning of a photovoltaic system not only increases energy production, but is also critical to preventing failures and extending the system's useful life.



ANNUAL ESTIMATE FOR 100 kW SYSTEM

Annual Estimate for a 100 kW Photovoltaic System

A 100 kW PV system can produce between 120,000 and 150,000 kWh per year, resulting in an estimated revenue of €12,000 to €15,000, depending on geographic location and solar conditions.

⚡ Annual Production:

120,000 – 150,000 kWh

💰 Energy Value (Average Net-Metering Tariff: €0.10/kWh):

€12,000 – €15,000/year

📉 Potential Loss from Soiling (30%):

€4,000

🧼 Cleaning Cost:

€1,000

🔄 Recovered Value After Cleaning:

≈ €3,000

Conclusion

Regular cleaning of a photovoltaic system not only increases energy production, but is also crucial for preventing malfunctions and extending the system's operational lifespan.



ANNUAL ESTIMATE FOR 1,000 kW SYSTEM

Annual Estimate for a 1,000 kW (1 MW) Photovoltaic System A 1 MW solar PV system, depending on location and installation conditions, can produce approximately 1,100,000 to 1,500,000 kWh per year.

If the system is connected under the Net Metering scheme (Scambio sul Posto), the GSE (Gestore dei Servizi Energetici) pays for the energy fed into the grid at a variable rate, averaging between €0.10 and €0.16 per kWh.

This means a 1 MW plant could generate €132,000 to €180,000 per year, with an average value of around €144,000.

⚡ Annual Production:

1,100,000 – 1,500,000 kWh

💰 Energy Value (Net Metering @ €0.12/kWh):

€132,000 – €180,000

Average: ~€144,000

📉 Potential Loss from Soiling (25%): €36,000

🧼 Cleaning Cost: €9,000

🔄 Recovered Value After Cleaning: ≈ €27,000

Conclusion

Regular cleaning of a photovoltaic system is not just about maximizing energy production.

It is also essential for preventing failures and extending the system's operational life, protecting both long-term performance and financial return.



THE AIRDRONEJET METHOD

AirDroneJet provides high-altitude cleaning solutions using next-generation industrial drones.

Thanks to specialized professional detergents and ENAC-certified pilots, we guarantee fast, precise, and safe operations—even on surfaces that are hard to reach.

We operate during dedicated time slots to minimize disruption to surrounding activities, always in full compliance with safety regulations and privacy laws.

The result? Flawless surfaces—without scaffolding or inconvenience.

All our operators hold the ENAC UAS CRO license and are covered by professional liability insurance.

Before



After



“Top-Down Cleaning, Jet-Like Precision.”



THANK YOU

FOR YOUR TIME

