



Opportunities and Challenges of Solar Energy Systems

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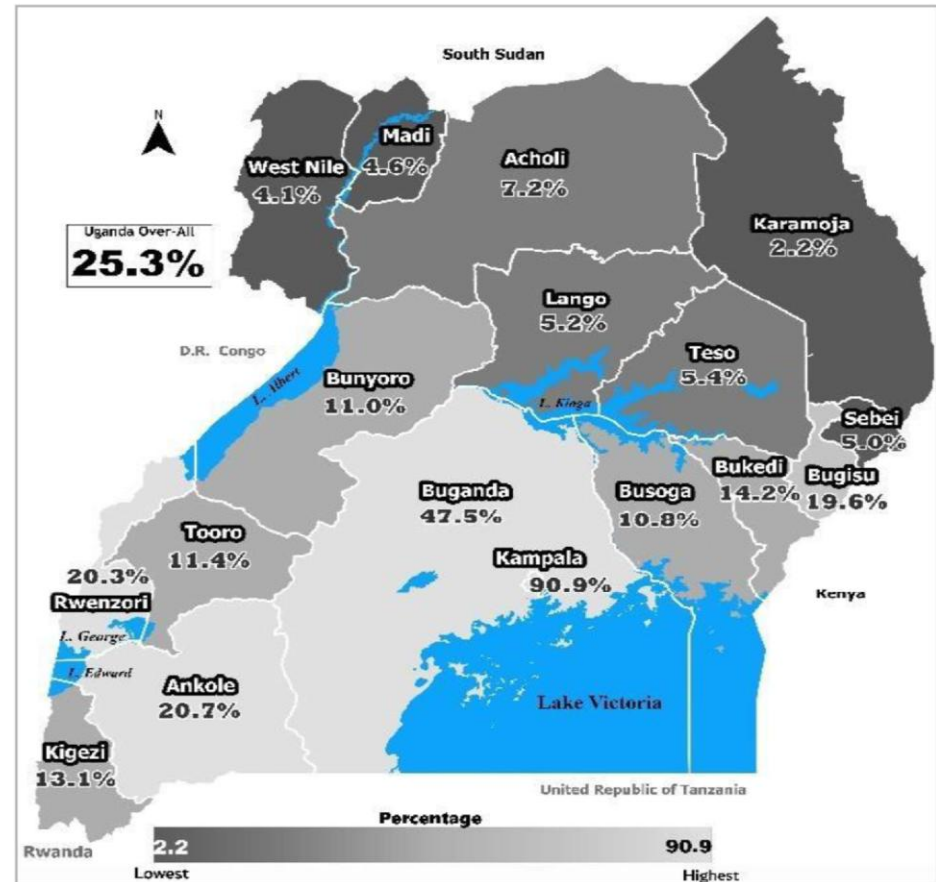
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Opportunities

- ❑ Energy demand growth and improved clean energy access
- ❑ Main component of most minigrid installations



Why is there low grid electricity access in rural Uganda? Evidence from the Uganda National Household Survey <https://doi.org/10.1016/j.enpol.2025.114652>



❑ Establishment of the energy sector reforms, feed-in tariffs and net-metering regulations

STATUTORY INSTRUMENTS
SUPPLEMENT No. 8

2nd April, 2024

STATUTORY INSTRUMENTS SUPPLEMENT

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STATUTORY INSTRUMENTS

2024 No. 14.

THE ELECTRICITY (NET METERING) REGULATIONS, 2024

ARRANGEMENT OF REGULATIONS

<https://www.era.go.ug/download/the-electricity-net-metering-regulations-2024/?wpdmdl=2426&refresh=6a917ecb38f9e1787920075>

Table A1: REFIT Phase VI Tariffs, O&M Percentage, and Payment Period.

No.	Technology	Generation Capacity	REFIT (US ¢ /kWh)	Split O&M of to be adjusted Annually	Payment Period (Years)
1.	Hydropower	0.5 MW – 5 MW	7.9	12.9%	20
2.	Hydropower	5.0MW – 50 MW	Linear tariff ¹	13.8%	20
3.	Bagasse	0.5 MW – 50 MW	6.2	45.8%	20
4.	Biogas	0.5 MW – 20 MW	9.8	19.23%	20
5.	Landfill gas	0.5 MW – 20 MW	6.6	19.71%	20
6.	WtE / Biomass	0.5 MW – 20 MW	9.5	16.23%	20
7.	Solar PV	0.5 MW – 50 MW	5.1	0%	20
9.	Wind	0.5 MW – 20 MW	7.8	6.34%	20
10.	Wind	20.5 MW– 50 MW	Linear tariff ¹	6.34%	20
11.	Geothermal	0.5 MW – 20 MW	11.1	4.29%	20

<https://www.era.go.ug/feed-in-tariff/>

☐ Modularity of solar PV systems

- Small-scale devices for small applications to large-scale applications



100W 400W 500W 600W 1000W
solar PV modules



❑ Reducing the carbon footprint

- Reduction of gasoline and diesel for electricity generation to supplement national grid – commercial and industrial uses
- Alternative energy sources (instead of using firewood/charcoal, etc.) for drying agricultural crops

❑ Improve livelihood – productive use of solar energy systems



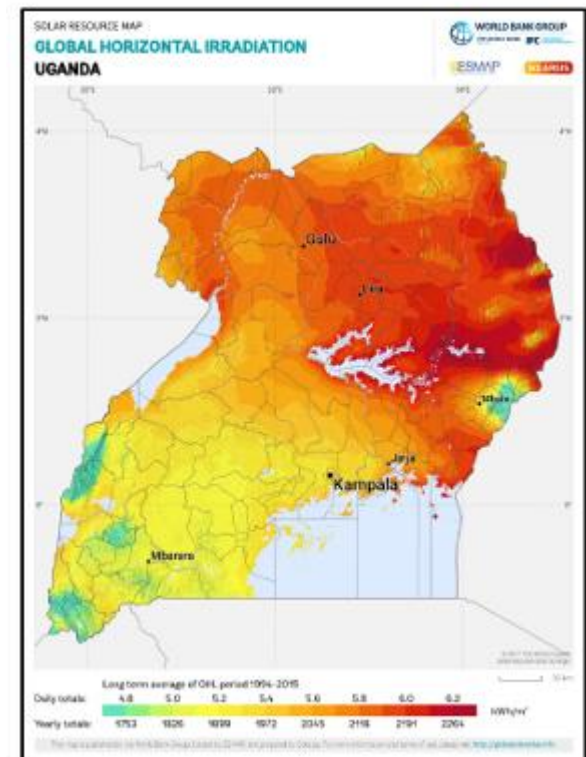
Opportunities of Solar Energy Systems



❑ Grid issues

- Grid extension cost
- Connections cost - big issues of rural households and low-income households
- Grid reliability – unreliable

❑ Availability of solar energy resources





Challenges



❏ Intermittency and unpredictable of solar radiation

- Daily and seasonal variation of radiation
- Cloud cover
- Insufficient forecasting tools

Impact

- Unpredictable and unreliable available of energy output from solar energy systems

Strategies to manage it

- Include energy storage systems, such as battery
- Flexible grid operations and demand response
- Improving solar radiation prediction forecasting



❑ Energy storage issues

- High initial cost
- Limited lifecycle
- Efficiency (charging and discharging)

❑ Land use

- Agricultural displacement
- Habitat disruption for local wildlife
- Visual and cultural impact
- Increasing land acquisition costs

Strategies to manage it

- Agrivoltaics (farming beneath panels)
- Floating solar farms
- Rooftop + parking lot solar
- High-efficiency bifacial panels



Challenges of Solar Energy Systems



❑ Grid Integration

- Most national grids were built for one-way energy flow — from power stations to consumers

Impact

- Reverse power flow
- Voltage fluctuations
- Limited hosting capacity
- Lack of synchronized inverters

Strategies to manage it

- Real-time grid monitoring
- Energy management systems
- Utility-scale battery buffers



[Home](#) [About Us](#) [Licensing & Permits](#) [Tariffs](#) [Statistics](#) [Consumers](#)

Notice on Grid Absorption Capacity and Interim Licensing Measures for Solar and Wind Projects

..... based on technical studies by the System Operator, the firm grid absorption ceiling for VRE has been revised from 250 MW to 200 MW. This adjustment ensures continued reliability in the national electricity supply

Interim Regulatory Measures

Pending completion of a comprehensive **Grid Stability Study** being undertaken by the System Operator in coordination with ERA, the following interim measures have been instituted:

1. **Temporary pause to New Licenses and Permits:**
The processing and issuance of new permits and licenses for grid-connected solar PV and wind projects will be temporarily paused.
2. **Priority for Hybrid and Storage-Based Projects:**
ERA will prioritise projects that incorporate hybrid systems or energy storage technologies, where these demonstrably enhance grid flexibility and reliability.
3. **Off-Grid Projects Unaffected:**
Licensing of off-grid renewable energy projects remains unaffected and will continue under the existing legal and regulatory framework.
4. **Encouragement of Base Generation Investments:**
Investors are encouraged to explore base-load generation technologies, such as large hydro, geothermal, and nuclear, which will support long-term renewable energy integration without compromising grid performance.

<https://www.era.go.ug/issues-notice-on-grid-absorption-capacity-and-interim-licensing-measures-for-solar-and-wind-projects/>

Challenges of Solar Energy Systems

❑ Duck curve effect

- As more solar power is introduced into grids, operators can face a problem of managing 'duck curve'.

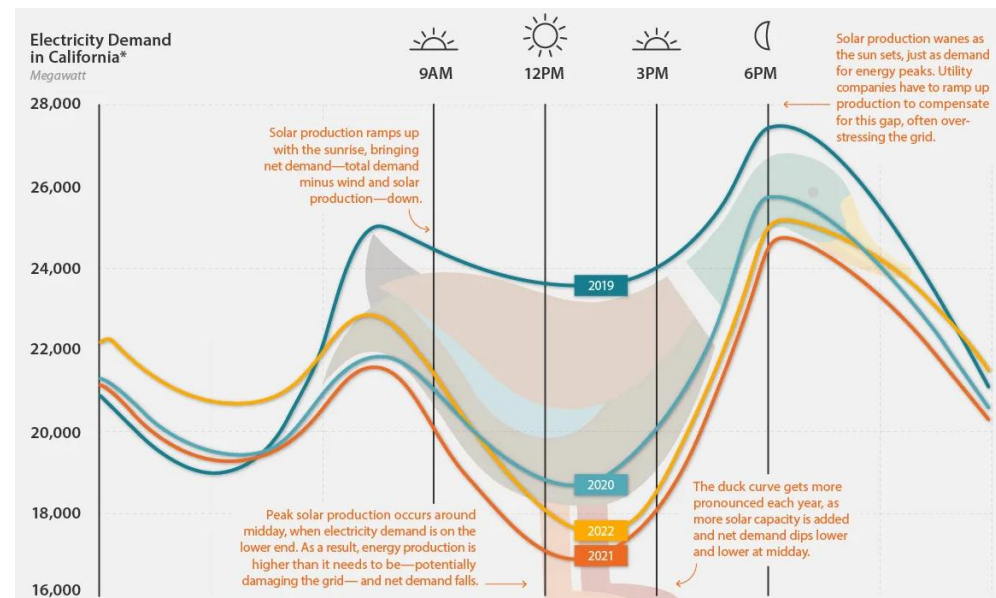


Impact

- Can underestimate energy demand, since consumers are generating energy for individual consumption

Strategies to manage it

- Energy storage
- Energy demand management
- Installing more dispatchable generation, such as hydropower

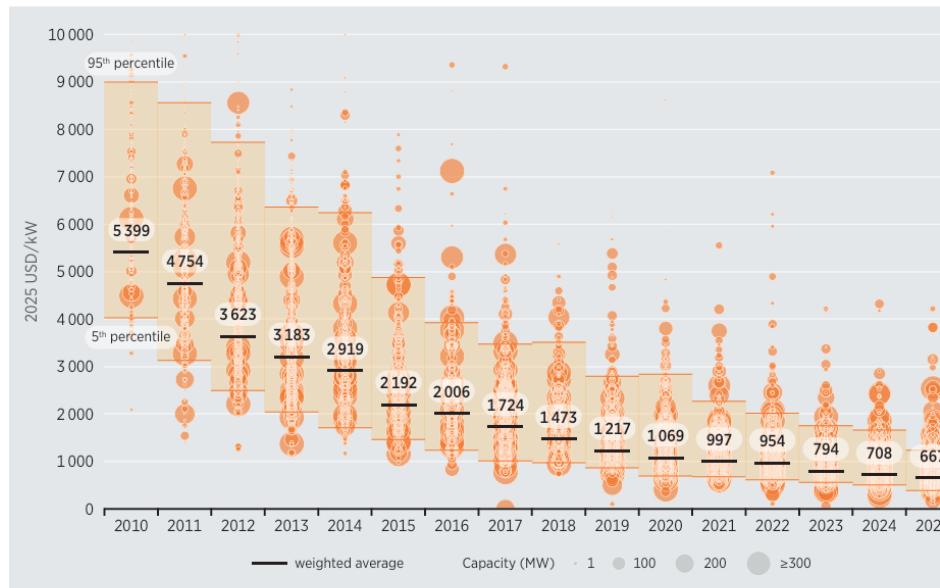


<https://elements.visualcapitalist.com/the-solar-power-duck-curve-explained/>

High initial costs and financing barriers

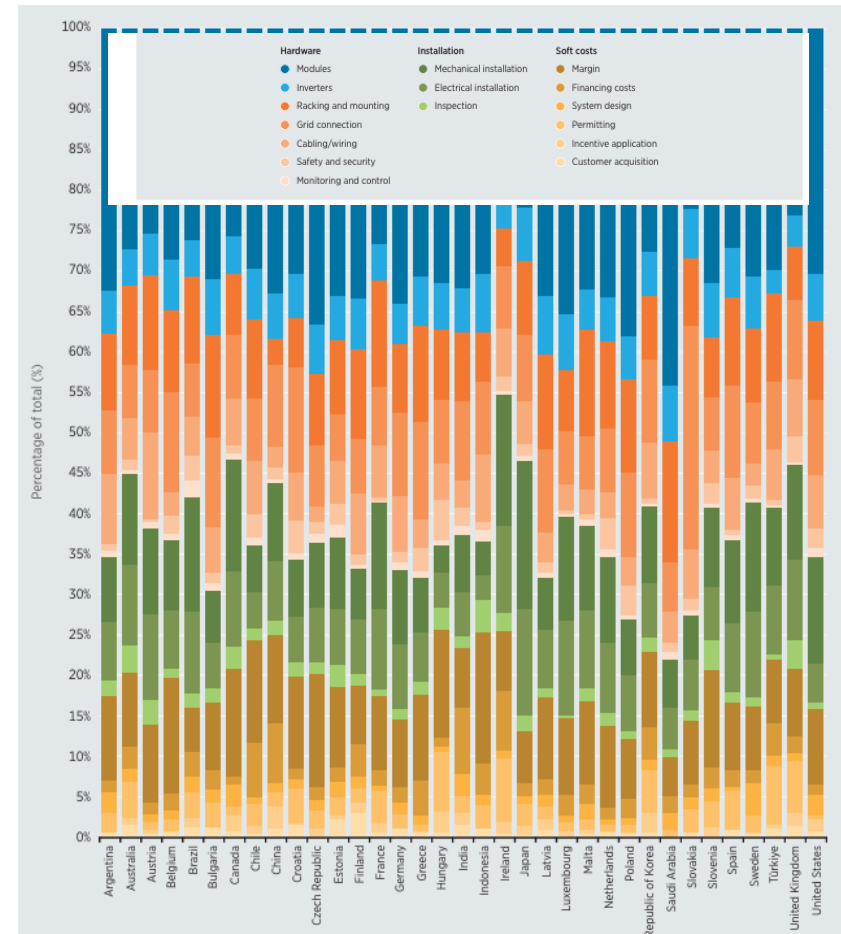
- Overall system costs – installation, batteries, inverters, permits, etc.
- Skilled labour cost
- Import duties
- Country-specific economic factors

Figure 3.1 TICs of utility-scale solar PV projects and global weighted-average, 2010–2025



Notes: MW = megawatt; kW = kilowatt; USD = United States dollar.

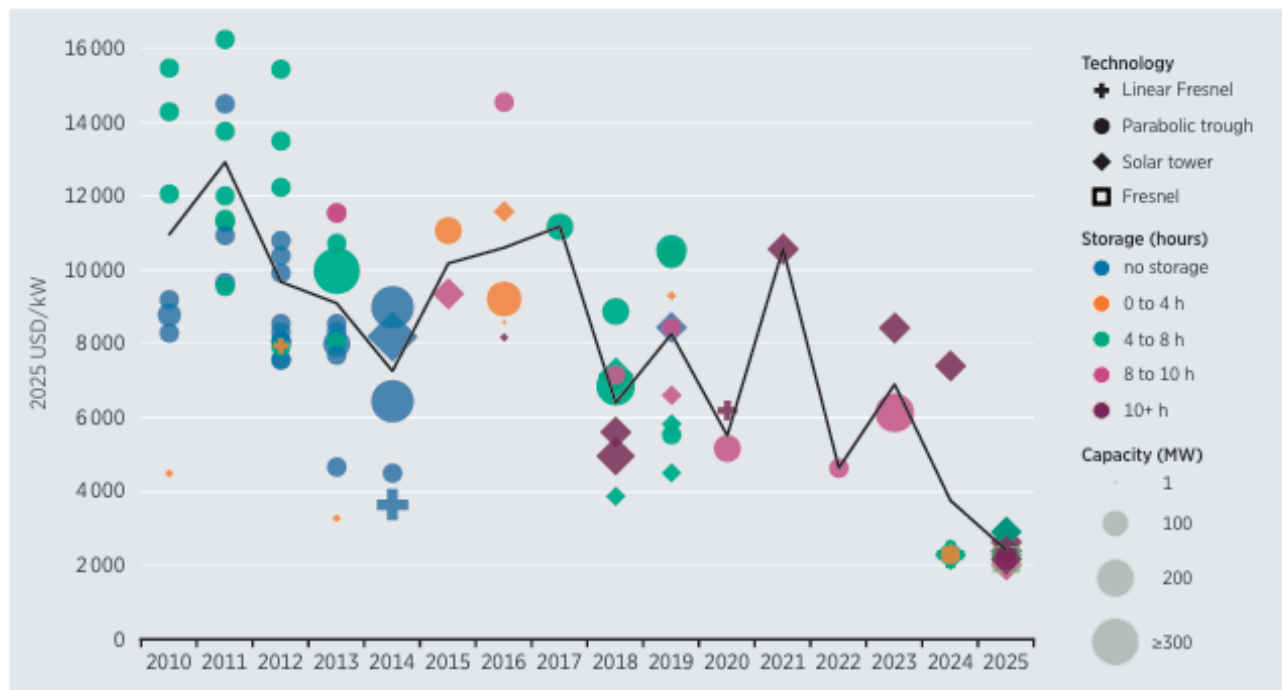
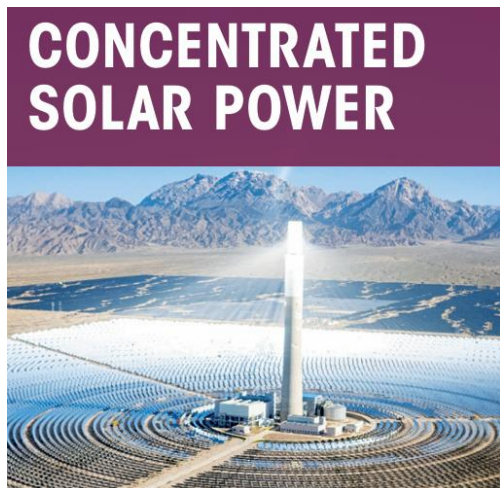
Figure 3.3 TICs by component in selected countries, 2025



IRENA (2026), Renewable power generation costs in 2025, International Renewable Energy Agency, Abu Dhabi; <https://www.irena.org/Publications/2026/Jul/Renewable-Power-Generation-Costs-in-2025>

Challenges of Solar Energy Systems

Figure 5.1 TICs for CSP by project size, collector type and amount of storage, 2010–2025



Notes: kW = kilowatt; MW = megawatt; USD = United States dollar.

IRENA (2026), Renewable power generation costs in 2025, International Renewable Energy Agency, Abu Dhabi; <https://www.irena.org/Publications/2026/Jul/Renewable-Power-Generation-Costs-in-2025>

Challenges of Solar Energy Systems



Solar Water Heaters

3 Products Found

Sort by



Solar Water Heater 300Ltr Vacuum Tube Technology Chloride

0.0 ★★★★★ (0)

UGX 5,921,000

Delivery: Delivery in 7 Days



Solar Water Heater 200Ltr Vacuum Tube Technology Chloride

0.0 ★★★★★ (0)

UGX 2,881,000

Delivery: Delivery in 7 Days



Solar Water Heater 100Ltr Vacuum Tube Technology Chloride Exide

0.0 ★★★★★ (0)

UGX 2,492,000

Delivery: Delivery in 7 Days



Masrcorp Solar Water Heater 300Ltr Vacuum Tube Technology

0.0 ★★★★★ (0)

UGX 6,756,750

Delivery: Delivery in 7 Days

<https://solarmarket.ug/category/solar-water-heaters>

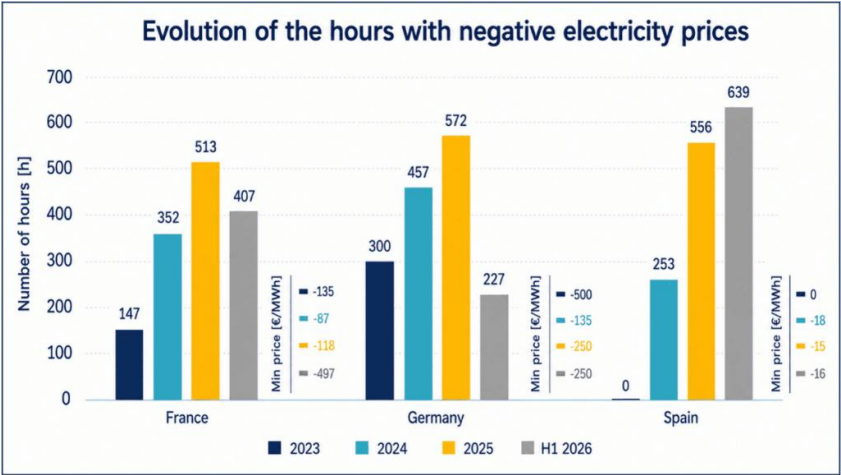
- **120 Liter System:** UGX 1,500,000 (Great for small households)
- **200 Liter System:** UGX 2,600,000 (Suitable for families of 7-10)
- **300 Liter System:** UGX 3,600,000 (Ideal for larger families)

<https://www.easypowerug.com/solar-water-heater-prices-in-uganda/>

Challenges of Solar Energy Systems

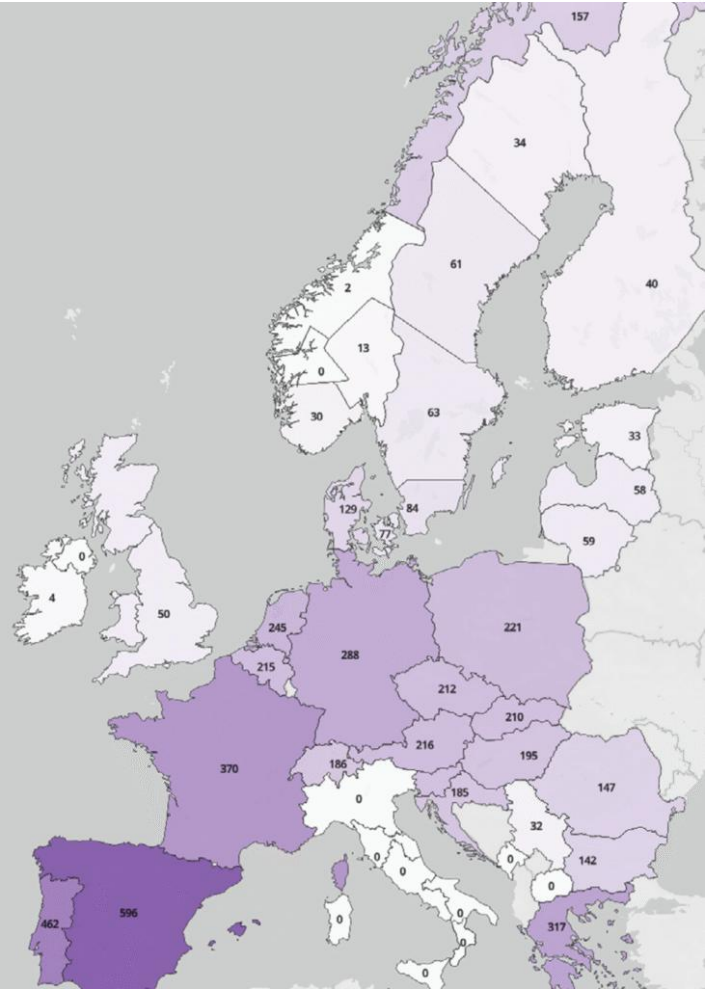
❑ Curtailment and negative negative electricity prices

- Transmission of excess generated electricity can lead to (in extreme cases) to negative electricity prices – **consumers are paid to use electricity!**



https://hayaenergy.com/blog_2026_negative-electricity-prices-in-europe/

Europe's record solar output drives surge in negative electricity prices

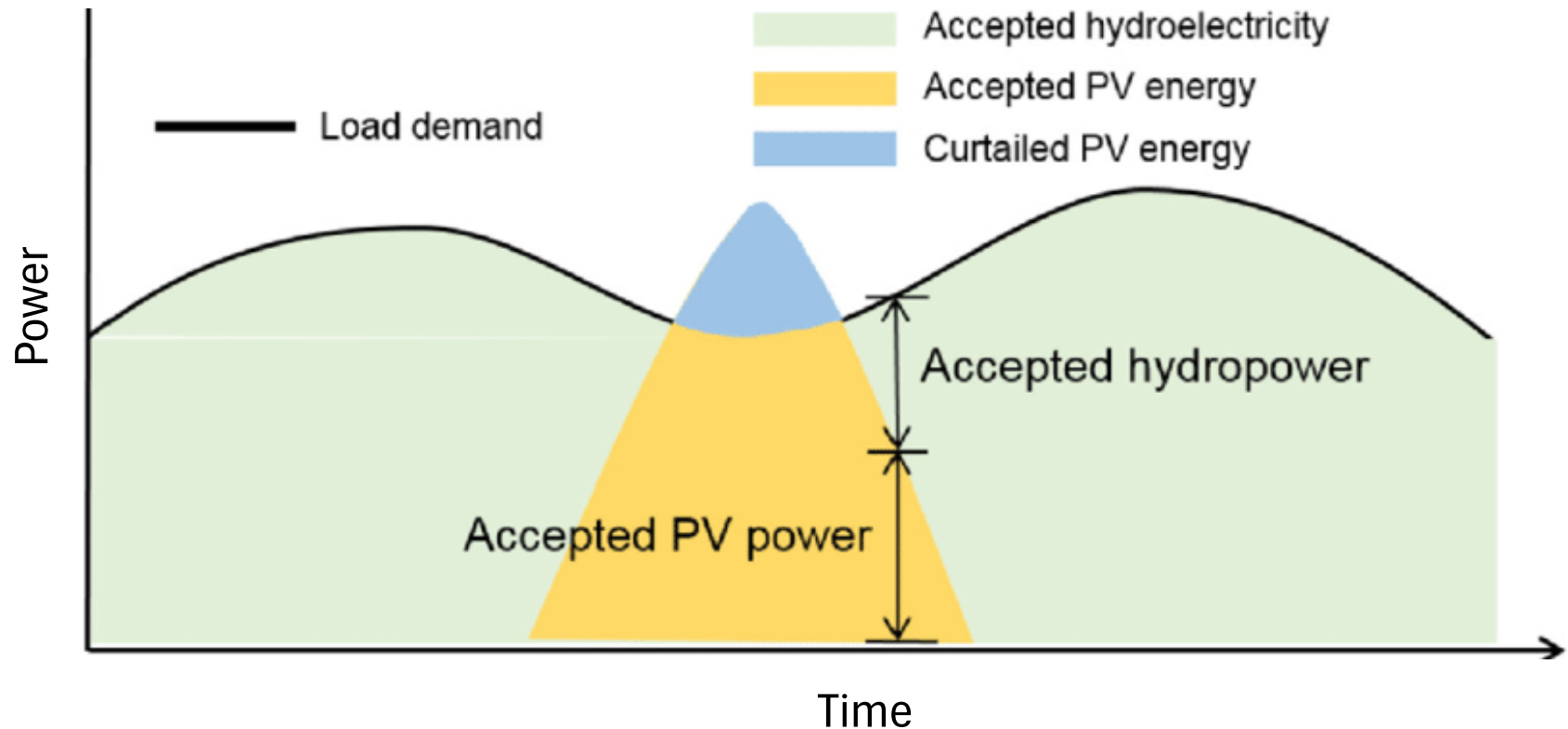


<https://www.pv-magazine.com/2026/07/15/europes-record-solar-output-drives-surge-in-negative-electricity-prices/>



❑ Curtailment and negative negative electricity prices

- Curtailment – transmitted electricity is limited to predetermined amount, irrespective of the amount of electricity generated - waste!.

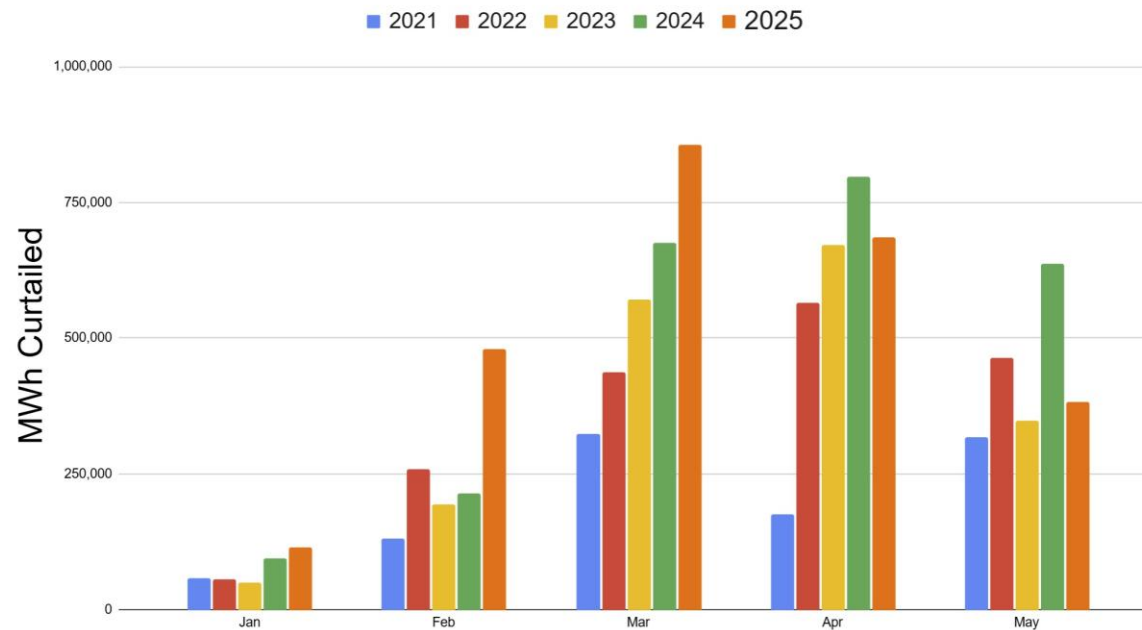




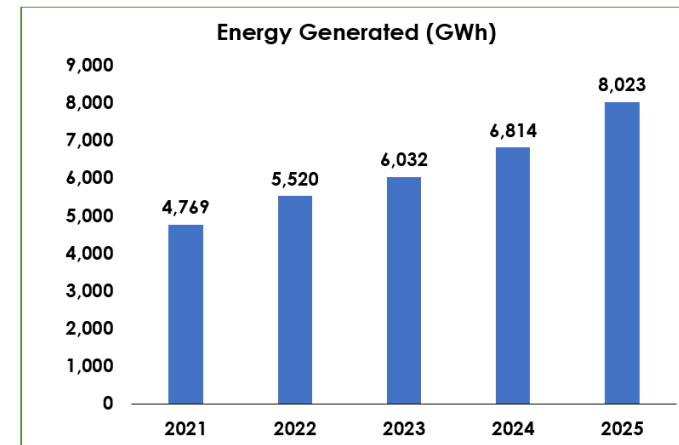
❑ Curtailment and negative negative electricity prices

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Solar Electricity Curtailed in California



In Uganda



Energy Generated to the National Grid – Electricity Regulatory Authority

<https://pv-magazine-usa.com/2025/07/22/california-solar-curtailment-down-12-on-back-of-batteries/>

Challenges of Solar Energy Systems

Other adoption barriers

Table 2

Overview of the barriers to adopting solar PV systems and strategies used to overcome them by the Finnish adopters. This information especially concerns those who participated in a joint order.

Barriers to adopting solar PV systems (as reviewed in Ref. [29], see Section 2.2)		Strategies of adopters to overcome the barriers (according to the interviews)
Sociotechnical barriers	Low quality standards for PV systems in some countries	The products were ordered jointly and those products known to be of good quality were chosen based on expert advice. Expert advice, including volunteer activism. Cooperation between adopters. Self-sufficient operation. Shared knowledge between adopters. Choosing products with high usability based on expert advice. Sharing realistic information. Roof space normally available for installation (one respondent installed some the panels at ground level). (Not a relevant barrier for a high-income country.)
	Lack of knowledge	
	Lack of knowledge on the supply side (e.g. among architects and planners)	
	Perceived complexity of interaction between people and PV systems	
	Perceived complexity of solar PV technology	
Management barriers	Negatively perceived attributes of PV systems, e.g. low battery storage and low power capability	Co-operation between adopters. Expert advice, including volunteer activism. Sharing realistic information.
	Inadequate installation space	
Economic barriers	Lack of appropriate financial schemes for low-income markets	The cost of PV system was reduced by installing the systems by themselves (except the electricity connections) and participating in a joint order of products. Most adopters have a good financial situation. Few have taken a loan to acquire a PV system.
	Weak after-sales services	
	Ineffective marketing and education campaigns	
Policy barriers	High cost of PV systems	The long payback period is accepted (but cannot be calculated accurately because the future price of electricity is not known). Many adopters compare solar PV investment costs to those of a new car or kitchen renovation (which they consider less economically beneficial than PV systems). The realized costs of maintenance have been negligible, as the PV systems have worked properly. No economic support received except a minor tax credit for paid installation work (if panels self-installed this only concerns connection of the PV system to the electricity grid). (In contrast, companies and farmers are eligible for support for solar PV system investments.) (Not a relevant barrier for Finland where no support has been removed.) Current policies do economically support other energy sources, which is not seen to be fair.
	Long payback period	
	High cost of maintenance	
	Ineffective policy measures: PV systems are often not economically profitable without policy support	
	Removal of government support	
	Policy support for other energy sources	

Source: [Pleasure is the profit - The adoption of solar PV systems by households in Finland - ScienceDirect](#)

Challenges of Solar Energy Systems



Other adoption barriers

Category	Discussion		
Economic / financial barriers	High initial cost of installation, maintenance and repairs.as well as the risks related to the suitability and reliability of technologies and to the solvency degree of the project.		
Legal / institution barriers	lack of stability of incentives for the adoption of photovoltaic like inconsistencies between policy measures and socio economic factors, or the sudden removal of existing subsidies		
Political / policy issues	Lack of long term policies, lack of political will to diversify into clean energy, constantly changing of government and reshuffling institutions.		
Technology	Market	The risks directly related to technology are high. Because the technology is at a development stage, the risks are not clearly known even if the same technology is working else where	Social/ Behavioural
Market		Competition from wealthier industries that benefit from subsidies and incentives and difficulties in market entry as most investors want large quantities of energy, ideally at times when solar aren't available.	
			Institutional barriers
Siting and transmission	Locating solar farms in and transmission lines requires negotiations, permits contracts and community approval which increase		
		the cost and duration of the projects General information and awareness in relation to new technologies and understanding the practical Problems in implementing and maintaining projects is limited	[24]
		Lack of coordination and cooperation within and between various ministries agencies, institutes and other stakeholders delays and restricts the progress in solar energy development.	[24]

https://www.academia.edu/36168304/Uganda_Solar_Energy_Utilization_Current_Status_and_Future_Trends

Other adoption barriers

Table 1: Barriers to Solar energy implementation in Nigeria

Barriers category	Barriers	Remarks	Sources
Technical Barriers	Lack of skilled personnel, lack of code of standard, lack of maintenance and operation, lack of training facilities and entrepreneur's development mechanism, lack of Reliability.	The barriers lead to poor plans, poor standard, constraints of the competitive market, inadequate knowledge to know-how about the technology and risk acceptance. All these barriers resulted in technology locked -up.	[1]; [30]; [31]
Social; Cultural Behaviour	Lack of consumer awareness about the product, lack of understanding of benefit of solar PV and public resistance to chance for new technology.	The barrier, affect the market projection negatively, cultural and religious faith controversies towards economic development and sustainability.	[32]; [33]; [34]
Economic/ Financial Barriers	Lack of access to capital, credit to consumers and financial instrument. Lack of support to R & D, high interest rate, import duties subsidies to support local manufacturing.	At the early stage, solar projects need incentives to encourage entrepreneurs. The barriers make it difficult to adopt and sustain due to financial constraints.	[13]; [17]; [35]
Institutional/ Legal barriers	Institutional barriers, legal framework, regulatory issues, non-integration of energy mix, non-participation of private sector, poor R & D culture and stakeholder's non-interference.	The barriers cause risk of uncertainty in support of solar energy, lobbies against RET, poor communication mechanism to reach the institutional policy makers for improvement and negative perception about the technology.	[7]; [36]
Political/ Policies Issues	Lack of long term policies, lack of political will to diversify into clean energy, constantly changing of government and re-shuffling of institutions.	These barriers serve as a deterrent to future planning for solar and other renewable energy adoption and sustainability. There is the fear of uncertainty in government.	[1]; [3]; [30]
Market Distortions Issues	Trade barrier for new product, energy sector controlled, lack of access to diversified technology, lack of facilities and backup technology, non-market oriented research for solar energy technology and application.	The barriers cause hindrance to market penetration and hence new technology failed at some point.	[3] [37]

Key Barriers to the Implementation of Solar Energy in Nigeria: A Critical Analysis

To cite this article: D Abdullahi *et al* 2017 *IOP Conf. Ser.: Earth Environ. Sci.* **83** 012015



❑ Solar PV systems - support schemes

- Feed-in tariffs (FiT))
- Feed-in premium (FIP)
- Corporate power purchase agreements (PPA)
- Renewable portfolio standards and green certificates
- Direct subsidies and tax credits
- Carbon taxes - Emission Trading System in Europe (ETS)
- Self-consumption and Net-metering
 - net-billing system - attributes different prices to consumed electricity and the electricity fed into the grid

For detailed information see Trends in Photovoltaic applications 2022. Available on: https://iea-pvps.org/wp-content/uploads/2023/02/PVPS_Trend_Report_2022.pdf

☐ Solar PV systems - support schemes



FIGURE 3.2A: MAIN DRIVERS OF THE DISTRIBUTED PV MARKET IN 2021

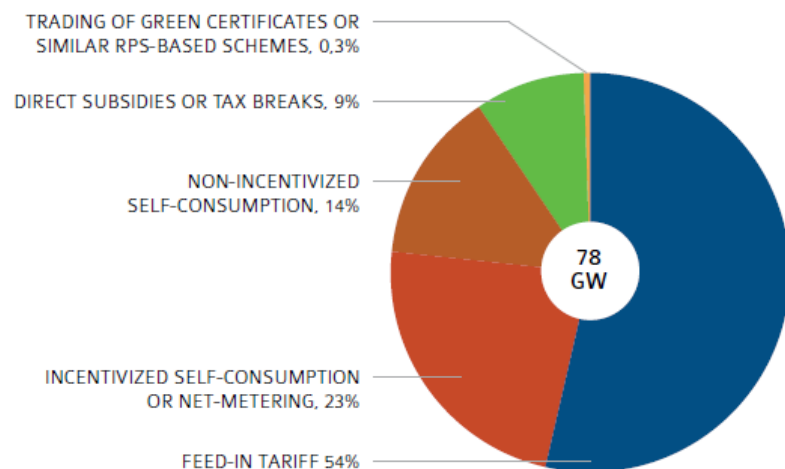
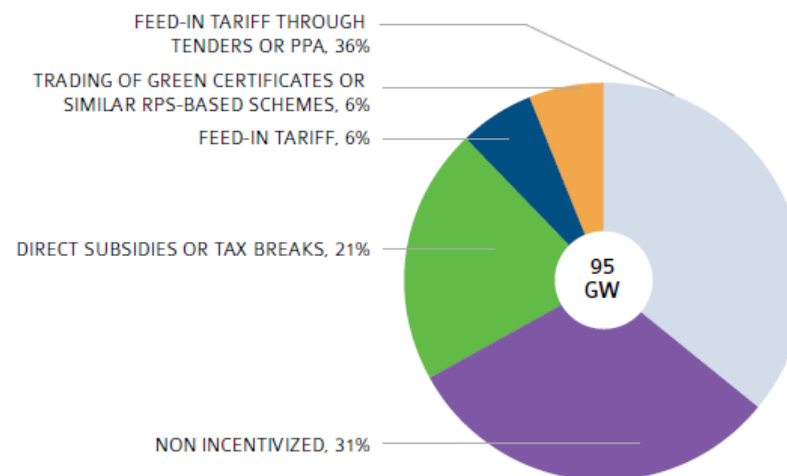


FIGURE 3.2B: MAIN DRIVERS OF THE CENTRALIZED PV MARKET IN 2021



For detailed information see Trends in Photovoltaic applications 2022. Available on: [https://iea-pvps.org/wp-content/uploads/2023/02/PVPS Trend Report 2022.pdf](https://iea-pvps.org/wp-content/uploads/2023/02/PVPS_Trend_Report_2022.pdf)



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Useful reading materials

Aarakit SM, Ntayi JM, Wasswa F, Buyinza F, Adaramola MS, Ssennono VF. The role of financial inclusion in adoption of solar photovoltaic systems: A case of Uganda. *Renewable Energy* 2022 (198); 984-998 <https://doi.org/10.1016/j.renene.2022.08.056>

Aarakit, S.M., Ntayi, J.M., Wasswa, F., Adaramola, M.S., Ssennono, V.F. Adoption of solar photovoltaic systems in households: Evidence from Uganda *Journal of Cleaner Production* 2021, 329, art. no. 129619. <https://doi.org/10.1016/j.jclepro.2021.129619>

TRENDS IN PHOTOVOLTAIC APPLICATIONS 2025 [IEA-PVPS Trends 2025-.pdf](#)



Questions?