



Managing Electricity Scarcity in Ukraine: From Rolling Blackouts to Load Limiting

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May 2026

Executive summary

Key messages

1. Ukraine's reliance on rolling blackouts to manage electricity shortages is highly inefficient, imposing disproportionate welfare losses by cutting power entirely rather than limiting consumption to essential levels.
2. Load limiting—capping maximum household consumption via smart meters rather than severing supply—can deliver equivalent energy savings while preserving access to critical services like lighting, refrigeration, and communications.
3. Even partial deployment on existing infrastructure can meaningfully reduce demand and shorten blackout durations system-wide.
4. Industrial users are better served by price-based scarcity programs.

Core recommendations

1. Deploy appropriately calibrated load limiting immediately where appropriate smart meters already exist, prioritizing high-density urban areas.
2. Using donor and reconstruction funds, accelerate rollout of advanced meters as critical resilience infrastructure.
3. Adopt a tiered regime guaranteeing a universal base level of power while providing higher allocations for medically vulnerable households.
4. Transition industrial consumers to scarcity-responsive pricing.
5. Formally integrate load limiting into emergency rationing protocols, retaining rolling blackouts only as a last resort.

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Background

Since late 2022, repeated Russian attacks on Ukraine's electricity generation and transmission infrastructure have forced system operators to rely on severe rationing regimes to preserve grid stability. The dominant tool has been rotational blackouts, often leaving households and small businesses without power for 12–16 hours per day or more, followed by periods of unrestricted consumption when electricity is restored.

While this approach is operationally simple, it is highly inefficient and welfare-reducing. Households face extreme discontinuity: refrigerators, communications, medical devices, heating systems, and small-scale economic activity are fully disabled during outages, while demand surges immediately upon restoration. This “all-or-nothing” rationing amplifies peak loads, complicates grid management, and concentrates hardship on those unlucky enough to be scheduled for longer cuts. Furthermore, power outages push households and firms to adopt expensive alternatives to ensure stable access to electricity. For example, before the recent surge in oil prices, electricity from a diesel generator was roughly 4 to 5 times more expensive than the standard residential grid tariff, and 2 to 3 times more expensive than the commercial grid rate. The blackouts also significantly inhibit economic activity: according to the National Bank of Ukraine, a 3-percentage-point increase in the deficit of electricity translates into a 0.4-percentage-point decrease in the growth rate of GDP (Zhyrii 2026).

Ukraine's challenge is not merely insufficient supply, but how scarcity is allocated. When electricity is treated as either fully available or fully unavailable, the system may seem fair, but it also sacrifices large amounts of output and welfare that could be preserved by allowing limited but continuous access to power.

Rolling blackouts versus load limiting

Rolling blackouts are the most extreme form of quantity rationing: consumption is reduced to zero for selected users, while others face no constraint. Recent research on electricity shortages shows that this approach is dominated by mechanisms that limit consumption rather than eliminate it (Reguant and Wagner 2025).

Three drawbacks of rolling blackouts are particularly relevant for Ukraine:

1. **Excess welfare loss.** The marginal value of the first units of electricity (lighting, phone charging, refrigeration, internet routers) is extremely high. Cutting consumption from a low level to zero imposes disproportionately large costs relative to cutting high consumption (e.g., electric water heaters, hair dryers, and dishwashers).

Rolling blackouts represent one of the most extreme forms of quantity rationing: an “all-or-nothing” mechanism that can leave households and neighborhoods exposed to vulnerable conditions.

2. **Ineffective demand smoothing.** When power returns after long outages, households simultaneously resume deferred activities. This produces demand spikes that strain already fragile infrastructure and increase the risk of secondary failures.
3. **Inequitable and opaque burden sharing.** Random or geographic blackout schedules do not systematically target high consumption. As a result, low-use households lose all access even though they do not strain the grid much, while high-use households consume a disproportionate amount during “on” periods. Households with sufficient resources to purchase batteries, accumulators, and backup charging equipment are also better able to smooth outages and maintain essential services, while poorer households bear the full cost of prolonged power cuts.

In short, rolling blackouts reduce demand, but they do so in basically the costliest way possible. By contrast, load limiting (or power limits) uses smart meters to cap the *maximum instantaneous consumption* of a household rather than cutting supply entirely. Under this approach, households retain continuous access to electricity up to a predefined threshold—sufficient for essential uses—while energy-intensive appliances are constrained.

Evidence from large-scale smart-meter data shows that such limits can deliver blackout-equivalent energy savings while (1) preserving access to essential services, (2) affecting fewer households in practice, and (3) concentrating reductions among high-consumption users (Reguant and Wagner 2025).

Electricity consumption is heavy-tailed: a relatively small share of users accounts for a disproportionate share of demand at peak times. Even when a uniform power limit binds for many households, the required savings are achieved primarily by throttling the heaviest users and the most energy-intensive appliances, rather than by shutting off entire neighborhoods.

Crucially, even households that are constrained remain better off than under blackouts, because they avoid total loss of power. Under standard assumptions about risk aversion, load limiting can be a Pareto improvement (win-win) over rolling blackouts.

Implementing load limiting in Ukraine

We now describe a sample winter two-tier load-limiting regime for Ukraine that replaces prolonged rotational power outages with continuous minimal service plus staggered “boost windows” to preserve refrigeration and other essentials. For example, to maintain total residential hourly consumption below 3.6 GWh, *average* hourly

Load limiting provides a superior alternative to rolling blackouts by ensuring continuous access to basic electricity consumption and avoiding neighborhood-wide shutdowns.

consumption needs to be no more than 0.25 kWh per household, which requires substantial limits. For comparison, a typical refrigerator consumes 0.1 to 0.4 kW when a compressor is running, a common internet router consumes 0.01 kW, and a standard washing machine typically consumes 0.3 to 2.0 kWh per load.

A sample allocation to implement load limiting in this case is as follows:

- Standard (Tier 1) households would receive a 24/7 power cap of 0.25 kW and a daily 120-minute boost to 2 kW,
- Vulnerable high-need households (Tier 2, capped at ~5% of customers;) would receive a 0.6 kW base and a 120-minute boost to 3 kW.²
- Customers would be divided into 12 rotating groups so only one group receives a boost at any time, preventing rebound peaks and allowing regional parameterization (red/amber/green) according to local grid constraints.

One may contemplate additional tiers depending on the penetration of meters and severity of power outages. For example, households with electric stoves or electric heating may have higher daily quotas when electricity is scarce (an electric stove burner consumes 1-3 kW). If late-night boosts are too inconvenient for households to utilize, then 90-minute-long boosts can be deployed, with each household assigned to two boost windows, one late-night and one not.

Ukraine cannot immediately implement this regime nationwide because it faces two binding constraints:

- Smart meter penetration is only ~20%, and
- Most deployed smart meters lack remote load-limiting capability.

These constraints mean that load limiting cannot be implemented universally in the short run. However, this by itself does *not* invalidate the approach. Instead, it calls for a phased and prioritized deployment strategy, which we now describe.

Phase I (0–12 months): Targeted Load Limiting Where Technically Feasible

Even partial deployment can generate meaningful benefits:

- Critical urban feeders, apartment blocks, and commercial–residential mixed areas where advanced meters already exist should be prioritized.

Even partial deployment of the proposed load-limiting scheme can generate meaningful benefits.

² For comparison, approximately 14% of American households rely on electricity-dependent medical equipment.

- Load limits can be applied during peak stress hours, rather than continuously, reducing implementation complexity.
- Exemptions or higher limits should be provided for medically vulnerable households, building on existing social-protection registries to identify eligible users quickly.
- Rollout should be paired with clear public communication explaining what appliances can be used under each limit and emphasizing that limits are designed to extend access for more people, for longer.
- These areas would shift from 12–16 hour outages to near-continuous supply at reduced capacity, immediately improving welfare and grid stability.

Importantly, partial load limiting reduces aggregate demand and therefore shortens blackout durations elsewhere, benefiting even customers without smart meters. Prioritizing the rollout of smart meters with load-limiting capabilities will ensure that load limiting becomes a powerful tool in the medium term.

Phase II (1–3 years): Accelerated Smart Meter Rollout with Load-Limiting Capability

Emergency conditions justify treating advanced metering infrastructure as critical resilience infrastructure, not a long-term efficiency upgrade. Priorities should include:

- Mandatory remote load-limiting capability in all new meter installations.
- Deployment focused on high-load regions and consumers, where marginal control yields the largest system benefits.
- Leveraging donor financing and reconstruction funds, as the welfare gains during shortages far exceed installation costs.

International experience shows that utilities can roll out millions of such meters within a few years when politically prioritized, as seen in Spain, France, and South Africa. These smart meters are very common in countries like Spain and France and can also facilitate cost allocation and pricing during non-scarcity periods. Existing meters can be used to test emergency protocols.

Phase III (1–3 years): Full Integration into Emergency Rationing Protocols

Once sufficient coverage is achieved, Ukraine can formally replace most rolling blackouts with uniform or tiered power limits as the primary tool for managing system stress. The exemption protocols and communication practices established in Phase I should be extended system-wide, with vulnerable-household registries and consumer guidance updated to reflect broader smart-meter coverage and any

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additional tiers introduced (e.g., for households with electric stoves or electric heating). Rolling blackouts would remain only as a last-resort fallback rather than the primary rationing tool.

Political and Social Acceptability

Load limiting is likely to be more publicly acceptable than blackouts for three reasons:

1. It guarantees some electricity to everyone, reducing fear and uncertainty.
2. It is perceived as fairer, because high users bear more of the burden.
3. It avoids the social externalities of darkness—crime, isolation, and economic paralysis—that accompany long outages.

Clear communication is essential: households must understand that limits are designed to extend access for more people, for longer, rather than to punish consumption.

Industrial Users

Industrial electricity consumers pose a fundamentally different rationing problem than households. For many industrial processes, electricity demand is not smoothly adjustable: operations often require a minimum level of continuous power to function safely or economically. Below that threshold, output may collapse entirely, equipment may be damaged, or restarting costs may be prohibitively high. As a result, imposing fixed quantity or power limits on industrial users risks causing disproportionate economic harm while delivering uncertain system-wide savings.

A key practical difficulty is that these minimum operating loads vary widely across firms and technologies and are difficult to observe or verify administratively. Determining a “fair” or “efficient” minimum for each industrial user would require firm-specific engineering assessments, continuous updating, and extensive monitoring—an approach that is unlikely to be feasible, especially under emergency conditions. Blunt limits risk either being set too high (yielding little demand reduction) or too low (effectively forcing shutdowns).

For these reasons, direct power limits of industrial users is likely to perform poorly relative to price-based mechanisms. A more effective approach is to place industrial users on real-time or scarcity-responsive pricing, where the cost of electricity rises sharply during system stress. Firms can also participate in interruptibility contracts, ensuring sharp reductions when needed. These contracts compensate large industrial consumers for closing operations during emergencies, e.g., when industrial demand is still too high at the highest scarcity prices, and can be procured in transparent auctions to ensure reduced costs.

The most effective approach to managing industrial electricity demand is to place such users on price-based scarcity programs.

These mechanisms preserve incentives to conserve where feasible (e.g. rescheduling production, reducing non-essential loads) while allowing firms who value electricity highly to continue operating if they are willing to pay the true scarcity cost. In other words, this market-based approach directs scarce electricity to activities that generate the highest value in the economy.

Crucially, price-based mechanisms also create incentives for self-provision and resilience investment. Firms facing high and volatile prices have strong motivation to invest in economically efficient on-site generation, cogeneration, storage, or contractual backup supply where technically feasible. Over time, this reduces pressure on the public grid precisely during peak stress periods. High prices also encourage more entry into the power-generation sector, thus further raising the resilience of the sector and the broader economy.

Smart meters capable of real-time measurement and billing for industrial users are a prerequisite for efficient scarcity pricing and should be deployed ahead of, or at least in parallel with, residential smart-meter rollouts. Given the scale of industrial loads, even limited coverage can deliver significant system benefits.

Conclusion

Ukraine's current rationing regime sacrifices large amounts of welfare by relying on prolonged, complete outages followed by unrestricted consumption. Load limiting offers a technologically feasible and economically superior alternative that can dramatically improve outcomes even under severe infrastructure damage. While we propose different models for households and industrial users, we envision that, over time, one can implement a mixture of these models as needed. For example, some households may opt into real-time-pricing plans while others can choose to stay with load-limit plans.

Although limited smart-meter penetration constrains immediate universal adoption, a targeted rollout combined with accelerated investment in load-limiting infrastructure can transform how scarcity is managed. In a context where every kilowatt-hour and every hour of electricity matters, shifting from “who has power” to “how much power everyone has” is one of the highest-return reforms available.

References

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Appendix: sample load limit calculations

Note: translating power *limits* to consumption hourly *averages* requires detailed energy consumption data because households are likely to consume substantially less than the limit during many hours. To calibrate this illustrative example, we use Spanish data during winter months (see Reguant and Wagner, 2025). Smart-meter data from Ukraine would allow for more precise calibrations.

Basic assumptions:

- Total electricity available for residential consumption: 3.6 GWh
- 14.3 million households in Ukraine
- 95% (13.585 million) are in Tier 1 (standard)
- 5% (0.715 million households) are in Tier 2 (protected)
- Implies **target hourly average consumption of 0.25 kWh** (3.6 GWh/14.3M)

Proposed limits:

- Tier 1 assigned a base limit of **0.25 kW**, and a boost limit of **2 kW**
 - Based on Spanish data, expected average consumption is about 0.15 kWh under the base limit, 1.2 kWh under the boost limit
- Tier 2 assigned a base limit of **0.60 kW**, and a boost limit of **3 kW**
 - Based on Spanish data, expected average consumption is about 0.4 kWh under the base limit, 1.8 kWh under the boost limit
- Staggering groups: $G = 12$ (only 1 group boosted at a time, for 120 minutes).
- Tier 2 is also split into the same G groups and boosted in sync.

Calculations supporting base and boost limits:

- Tier 1 additional per-household use during boost: $1.05 \text{ kWh} = 1.2 - 0.15$
Tier 2 additional per-household use during boost: $1.40 \text{ kWh} = 1.8 - 0.40$
- **Base residential load** (always on)
 - Tier 1 base: $13.585\text{M} \times 0.15 \text{ kWh} = 2.038 \text{ GWh}$
 - Tier 2 base: $0.715\text{M} \times 0.40 \text{ kWh} = 0.286 \text{ GWh}$
 - **Total base = 2.324 GWh**
- **Extra load from boost** (only $1/G$ households boosted at a time)
 - Tier 1 boosted households at any moment: $13.585\text{M}/12 = 1.132\text{M}$. Extra electricity consumption = $1.132\text{M} \times 1.05 \text{ kWh} = 1.189 \text{ GWh}$
 - Tier 2 boosted households at any moment: $0.715\text{M}/12 = 0.0596\text{M}$. Extra electricity consumption = $0.0596\text{M} \times 1.40 \text{ kWh} = 0.083 \text{ GWh}$
 - **Total extra from boost = 1.272 GWh**
- **Peak residential load = 3.596 GWh**

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The group brings together expertise across macroeconomics, finance, behavioral economics, environmental economics, governance, and game theory to produce policy-relevant analysis. Its work includes research publications, policy briefs, and collaboration with initiatives such as the International Working Group on Russian Sanctions, with the aim of informing effective economic and financial measures targeting the Russian economy.

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