Reducing Energy Poverty in Germany: The Case for a Decentralized, Asynchronous Power Grid

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Abstract

This paper asks why increased and cheap renewable electricity generation has coincided with rising household electricity costs in Germany, and whether SAFErGrid, a proposed decentralized and asynchronous grid architecture, could reduce this. A significant driver of energy poverty is argued to be grid fees - levied to recover the cost of managing congestion and redispatch on the centralized synchronous grid. Current reforms, such as dynamic tariffs and time-variable grid fees, are shown to address symptoms rather than the underlying cause. The paper then illustrates two channels through which SAFErGrid could potentially in future reduce energy poverty: eliminating the redispatch costs that drive grid fees, and Quality-of-Service pricing - through which the grid can recover part of its fixed costs from those most willing and able to pay without spreading that cost uniformly – and regressively – across all consumers.

Keywords: Electricity, Energy Poverty, Renewables, Power Grids, Germany

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JEL Codes: Q41, I32, L94, O33

1 Introduction

In Germany, since the country adopted its Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz*, EEG) in 2000, the share of renewable energy sources (RES) in its electricity supply has expanded to 59% by 2025. This expansion has put downward pressure on electricity prices[1] (Liebensteiner et al., 2025). The puzzle is that German households are, however, facing some of the highest electricity prices in the world (Frondel and Sommer, 2015; Amelang, 2025). Energy poverty – measured on several distinct indicators – has been rising rather than falling (Henger and Stockhausen, 2022; Kyllmann, 2025).

This puzzle arises as a result of the cost of managing a power grid that is more than a century old. Germany's power grid, part of the Continental Europe Synchronous Area (CESA), is a centralized, synchronous alternating-current (AC) system. It requires instantaneous power balance, physical inertia, and congestion-free transmission lines to remain stable (Ulbig et al., 2014; Titz et al., 2023). As RES penetration has risen, so has the cost of meeting these requirements. In broad, these costs are partly recovered from households through grid fees - which makes up more than a quarter of the average household electricity bill (Wehrmann, 2025; Hanny et al., 2022). Because grid fees are levied largely on a per-unit or fixed basis, rather than in proportion to income, they fall disproportionately on low-income households (Deller et al., 2021; Neuhoff et al., 2013).

Decentralized, asynchronous alternatives have been proposed to the synchronous grid architecture (Ecker et al., 2017; Kendziorski et al., 2022). One recent radical proposal is *SAFErGrid* (Schwarz et al., 2026). SAFErGrid compartmentalizes the power system into interconnected "A-grids" linked by to-be-developed smart "Energy Routers", replacing continuous synchronized power flow with a store-and-forward, internet-like routing paradigm.

[1] Cevik and Ninomiya (2022, p.1) found from 24 EU countries that between 2014 and 2021, RES were "associated with a significant reduction in wholesale electricity prices in Europe, with an average impact of 0.6 percent for each 1 percentage points increase in renewable share." RES are also more efficient: burning coal or gas to make electricity is wasteful; about 60% of the energy is lost in conversion (Sanchez, 2020).

The market-design economics of this proposal – how energy balance, congestion and inertia can be priced under an asynchronous architecture - is explored by Naudé (2026b,a). This paper asks a narrower and more directly policy-relevant question: could such a redesign meaningfully reduce energy poverty in Germany, and through which specific channels?

The paper proceeds as follows. Section 2 sets out the German context. Section 3 documents how energy poverty is measured in Germany and tracks its recent evolution. Section 4 argues that grid fees link the synchronous grid's costs to household energy poverty. Section 5 reviews current reform proposals and note their limitations. Section 6 explores the specific mechanisms through which SAFErGrid could reduce energy poverty. Section 7 discusses the implications from these mechanisms. Section 8 concludes.

2 Germany's Energy Transition and the Price of Electricity

Germany is Europe's largest electricity market, consuming roughly 497 TWh in 2024. Following the adoption of its EEG in 2000, the country raised the renewable share of its electricity supply to 59% by 2025,[2] with more than 5.5 million solar PV installations and over 29,300 onshore wind turbines now feeding into the grid;[3] Germany aims for an 80% renewable share by 2030.[4]

This growth has occurred within a physical grid architecture – the Continental Europe Synchronous Area (CESA)[5] – designed around large, centralized, dispatchable fossil-fuel and nuclear plants, which must keep AC frequency stable at 50 Hz through continuous power

[2]See: https://ember-energy.org/countries-and-regions/germany
[3]See: https://tinyurl.com/573suwsc
[4]See https://tinyurl.com/wevhz5b
[5]It is the largest synchronous grid in the world, covering 32 countries, and connected to various proximate synchronous grids via direct current (DC) lines, such as the Nordic Grid, the electricity grids of the United Kingdom and Ireland, and the Baltic electricity grid (Westphal et al., 2022; Alexandrin, 2025).

balance, physical inertia, and congestion-free transmission (Smahi and Makhloufi, 2025).

As renewable penetration has risen, the cost of satisfying these requirements has risen with it. German wholesale electricity prices are notably volatile: on 1 May 2026, for example, prices moved from - €450/MWh in the early afternoon to €279/MWh by evening, a swing of over €700/MWh within a single day. More structurally, redispatch costs – the payments made to curtail cheap northern wind generation and ramp up expensive southern fossil generation to relieve transmission congestion – rose from roughly €400–600 million in 2014 to €4.2 billion in 2022, with German grid congestion costs projected by Allianz Research to reach €12.3 billion by 2030 and €56.7 billion by 2040 without network upgrades (Allianz Research, 2025).

The mechanism by which these costs reach households is grid fees (*Netznutzungsentgelte*), which recover the cost of operating, maintaining and expanding the transmission and distribution network, including the cost of redispatch. By 2025, the average monthly electricity bill for a three-person German household had reached roughly €116, more than double its 2005 level, of which around 25–30% consisted of grid fees. It is this specific component of the bill – not the cost of renewable generation itself (which is falling) that links the management of the synchronous grid directly to the affordability of household electricity, and hence to energy poverty.

3 Measuring Energy Poverty in Germany

The cost of Germany's energy transition, starting with the enacting of the EEG in 2000, has substantially been borne by household consumers (Priesmann et al., 2022). The costs for expanding renewable infrastructure and stabilizing the grid are borne by households via grid usage charges from redispatch and curtailment (see e.g. Hofer and Madlener (2021)) and in Germany, including up to 2022, the so-called EEG surcharge.[6] The EEG surcharge increased from 0.08 ct/kWh in 1998 to 6.5 ct/kWh in 2021 (Wehrmann, 2025).

This has contributed to German households facing some of the highest electricity prices in the world (Frondel and Sommer, 2015). By 2023-2026 average residential electricity prices in Germany was the fifth highest in the world (Amelang, 2025). By 2025, the average monthly electricity bill for a 3-person household in Germany had reached EUR 116, more than double what us was in 2005.[7]

Around 30% of the baseline price for retail electricity in Germany is due to grid fees (Netznutzungsentgelte). Grid fees are "*fees for using the public electric grid on the TSO and Distribution System Operator (DSO) level for the transportation of electricity*" (Hanny et al., 2022, p.2).

Grid fees disproportionately impact low-income households, and their structure and upward trend have made them a primary driver of energy poverty in Germany (Meza, 2025). In this regard, Figure 1 shows the electricity prices faced by households in Germany since 2004 and the share therein of grid fees.

Energy poverty is, according to the European Commission[8], "*when a household must reduce its energy consumption to a degree that negatively impacts the inhabitants' health and wellbeing.*" It is caused by low income, high energy prices, and poor energy efficiency.

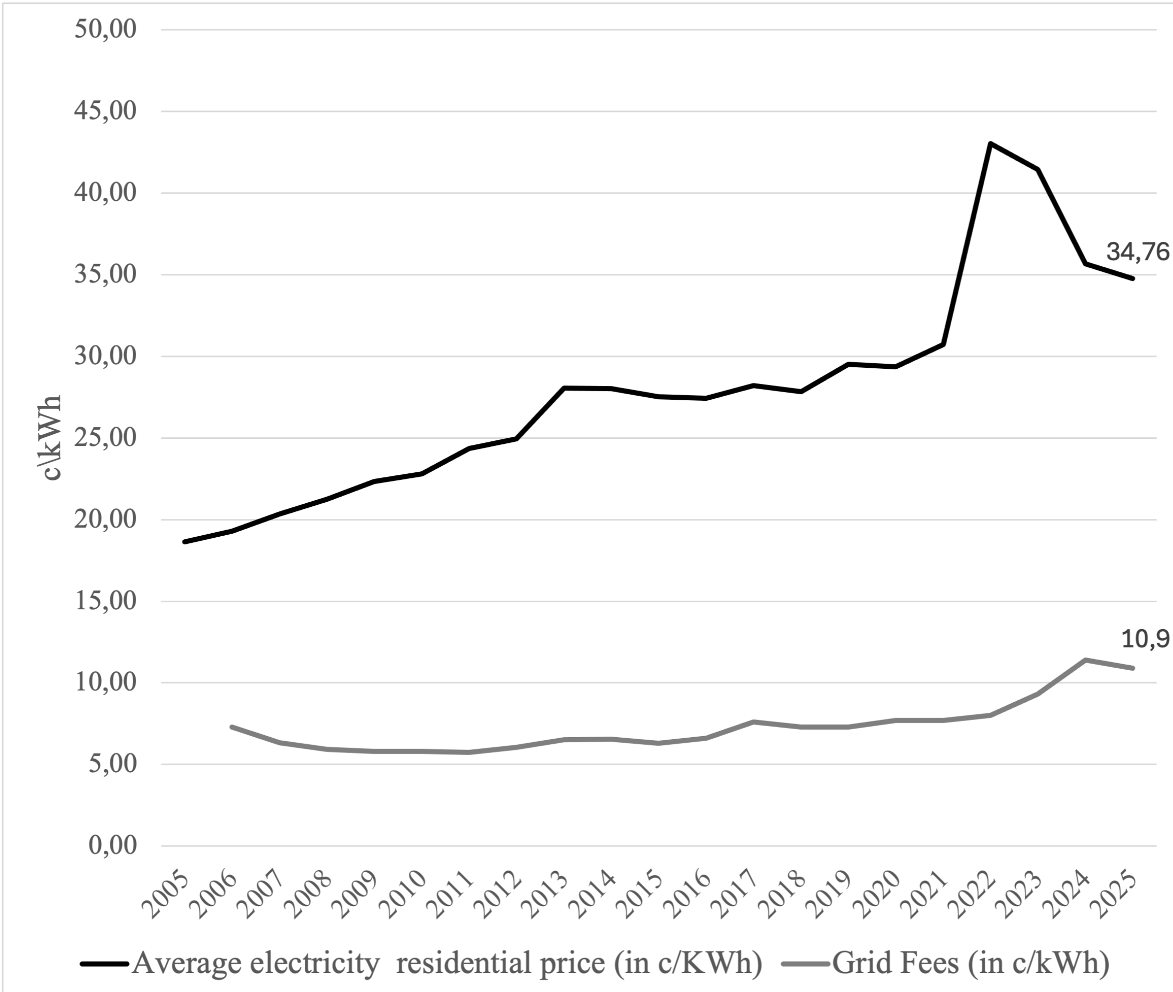
Drescher and Janzen (2021) discusses four measures of energy poverty. The first is the Ten-Percent-Rule (TPR), in terms of which a household as energy poor if the share of its energy expenditure exceeds a fixed threshold of 0.10 (10%). The indicator $EP_{i,TPR}$ is defined,

[6] The EEG surcharge was levied to fund the difference between electricity wholesale prices and legally guaranteed feed-in tariffs for renewable energy power generators - according to the EEG Law, these were guaranteed for 20 years (Wehrmann, 2025).

[7] See: `https://tinyurl.com/33h7pfev`

[8] See: `https://tinyurl.com/347w9dkx`

Figure 1: Average electricity price and grid fees, based on an annual consumption of 4,000 kWh, in c/KWh



Source: Author's compilation based on data from `https://www.verivox.de/strom/strompreise/` and BDEW

following Buchner and Rehm (2025), as:

$$EP_{i,TPR} = \begin{cases} 1 & \text{if } \frac{E_i}{Y_i} > 0.10 \\ 0 & \text{otherwise} \end{cases}$$

Where E_i is total annual energy expenditure of household i, and Y_i total annual disposable income of household i.

A second measure of energy poverty is known as the Low Income High Costs indicator

(LIHC). The LIHC metric is a dual-condition indicator. It requires a household to simultaneously face high energy costs and have a low residual income. As set out by Buchner and Rehm (2025) a household i is energy-poor if both of the following conditions are met:

$$EP_{i,LIHC} = \begin{cases} 1 & \text{if } E_i > \text{med}(E) \text{ AND } (Y_i - E_i) < 0.6 \times \text{med}(Y) \\ 0 & \text{otherwise} \end{cases}$$

Note, here the household's energy expenditure is E_i; the median energy expenditure of the total population is (med(E)). The equation indicates that to be in energy poverty the household's residual income (disposable income minus energy costs) must be below the official poverty line, typically defined as 60% of the national median disposable income.

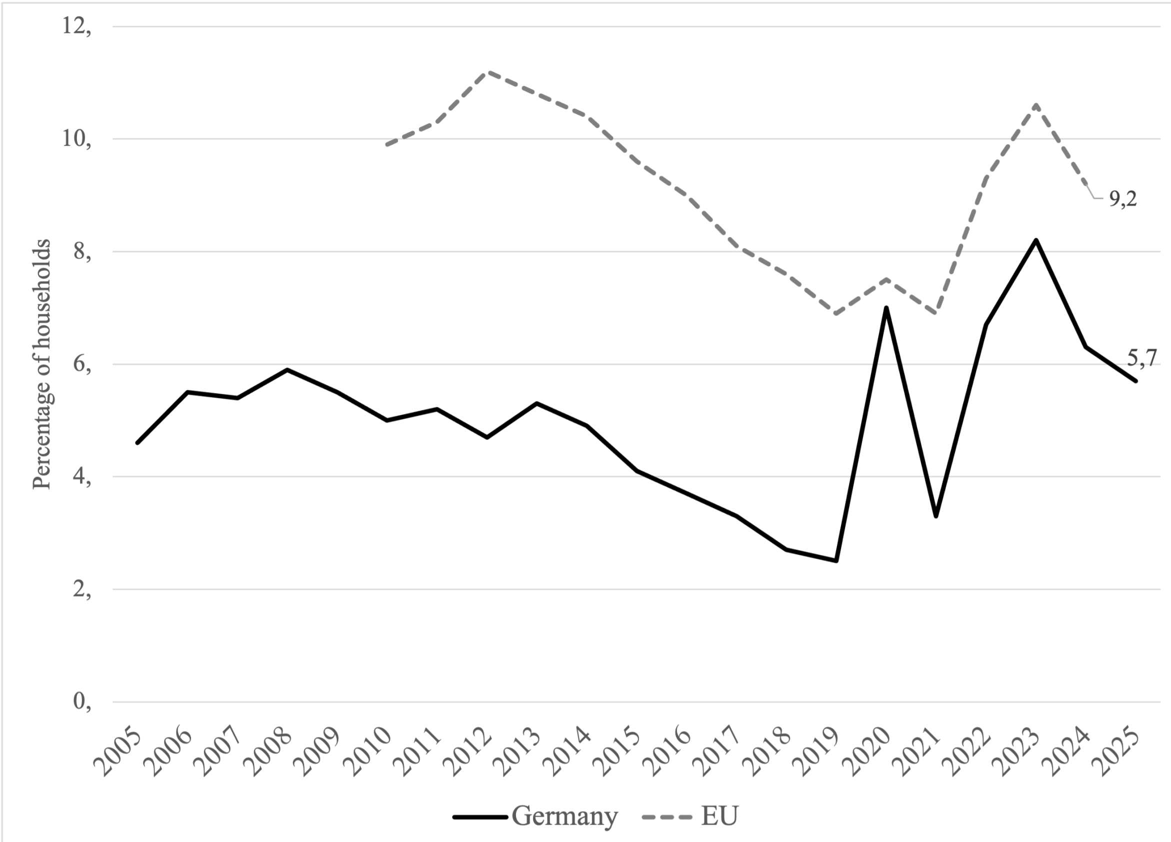
A third energy poverty measure that Drescher and Janzen (2021) calculate for Germany is a consensual based indicator reflecting the household's subjective experience in keeping their home adequately warm during winter.

A fourth energy poverty measure is the the number of households in utility bill payment arrears.

As far as the TPR and LIHC measures are concerned, Drescher and Janzen (2021, p.5) found that the "*prevalence of expenditure-based energy poverty in our pooled sample ranges between 8.78% (LIHC) and 21.43% (TPR) over the period 2013 to 2019*." More recent estimates based on the TPR established that the proportion of households in energy poverty in Germany rose from 14.5% in 2021 to 25.2% in May 2022 - as a result of spiraling electricity prices following the Ukraine war (Henger and Stockhausen, 2022).

In terms of the third measure, the household's subjective experience in keeping their home adequately warm, Figure 2 shows that in in 2025, approximately 5.7% of German households - roughly 2.4 million - reported being unable to keep their homes adequately warm.

Figure 2: Energy Poverty: Inability to keep home adequately warm



Source: Author's compilation based on data from Eurostat

According to the fourth measure, "*Around five percent of Germany's population (4.2 million people) reported being late in paying their utility bills in 2024*" (Kyllmann, 2025).

These reported energy poverty rates are roughly in line with a recent study by the German Environment Agency who considered vulnerability to energy poverty, using various indicators and combinations of indicators that found that "*about 3 million households in Germany are identified to be vulnerable with respect to increasing fossil energy or CO_2 prices*" (Schumacher et al., 2025, p.12).

Drescher and Janzen (2021) further find that, except under the TPR measure, most German households do not experience energy poverty persistently, and that one-person households, non-working individuals, and households with lower education are at greatest risk of becoming trapped in it – evidence that electricity costs specifically, rather than income alone, are a primary driver.

Because electricity is a basic necessity, high prices act as a regressive burden that disproportionately affects lower-income populations (Deller et al., 2021; Neuhoff et al., 2013). Zweifel et al. (2017, p.7) describe how this burden can generate a broader poverty trap: low income limits the ability to pay for energy, rising energy prices worsen this constraint, which in turn reduces household productivity, further lowering income and deepening energy poverty.

The following section argues that this dynamic is substantially driven by the synchronous grid's difficulty in accommodating renewable energy – in particular, the congestion this creates and the redispatch costs that follow.

4 Why the Synchronous Grid Drives Energy Poverty: The Role of Grid Fees

Grid operators hold a natural monopoly: the large sunk cost of transmission and distribution infrastructure makes competing networks wasteful, so average cost typically exceeds marginal cost, and fees are levied to recover the user cost of capital (Zweifel et al., 2017). In Germany, grid fees are set at such a level so that the grid operators can make a profit. This profit is subject to a revenue cap that is set every five years.[9] In Germany, the Federal Network Agency (*BNetzA*) sets a revenue cap for grid operators every five years, varying by network area, provider, population density, and required load-management measures; grid fees are collected by TSOs such as *TenneT* and *50Hertz* as a fixed component of the electricity bill (see also Hanny et al. (2022)).

Grid fees contribute roughly a third of the electricity price. Because the distribution of

[9] See `https://www.tennet.eu/nl/de-en/nl/node/1620`

German households around the 10% TPR expenditure threshold is dense, removing grid fees entirely could be expected to lift on the order of 650,000 households out of energy poverty – a roughly 15% reduction in the national energy poverty rate.

Beyond their absolute level, grid fees increase relative poverty because their structure is regressive in at least four distinct ways.

First, low-income households tend to live in smaller dwellings, and consume less electricity, yet the fixed component of the grid fee does not scale down proportionately.

Second, wealthier households can install rooftop PV and battery storage, drawing less power from the grid and avoiding variable grid charges – self-consumption from small-scale PV is in fact exempted[10] from most taxes and levies (Fett et al., 2019, p.867) – while total network costs (including rising redispatch costs) are unchanged or increasing, and are redistributed among the remaining, mostly lower-income, passive consumers whose per-kWh charges rise to cover the shortfall (Kyllmann, 2024).

Third, until 2025/2026 reforms, grid fees were significantly higher in rural, wind-rich regions (such as Brandenburg or Schleswig-Holstein), where local populations bore the cost of the grid expansion needed to export wind power southward, despite these regions having lower average incomes than industrial centers in the south – meaning households least able to afford it were effectively subsidizing the national energy transition through their local grid fees. A 2025 reform socialized these costs nationwide via a special grid-use surcharge, adding roughly €33/year to the average household bill to relieve wind-heavy regions - but at the cost of spreading a burden, rather than removing it.

Fourth, households do not benefit from the grid-fee exemptions granted to large, energy-intensive companies: German industrial users with consistent consumption of at least 10

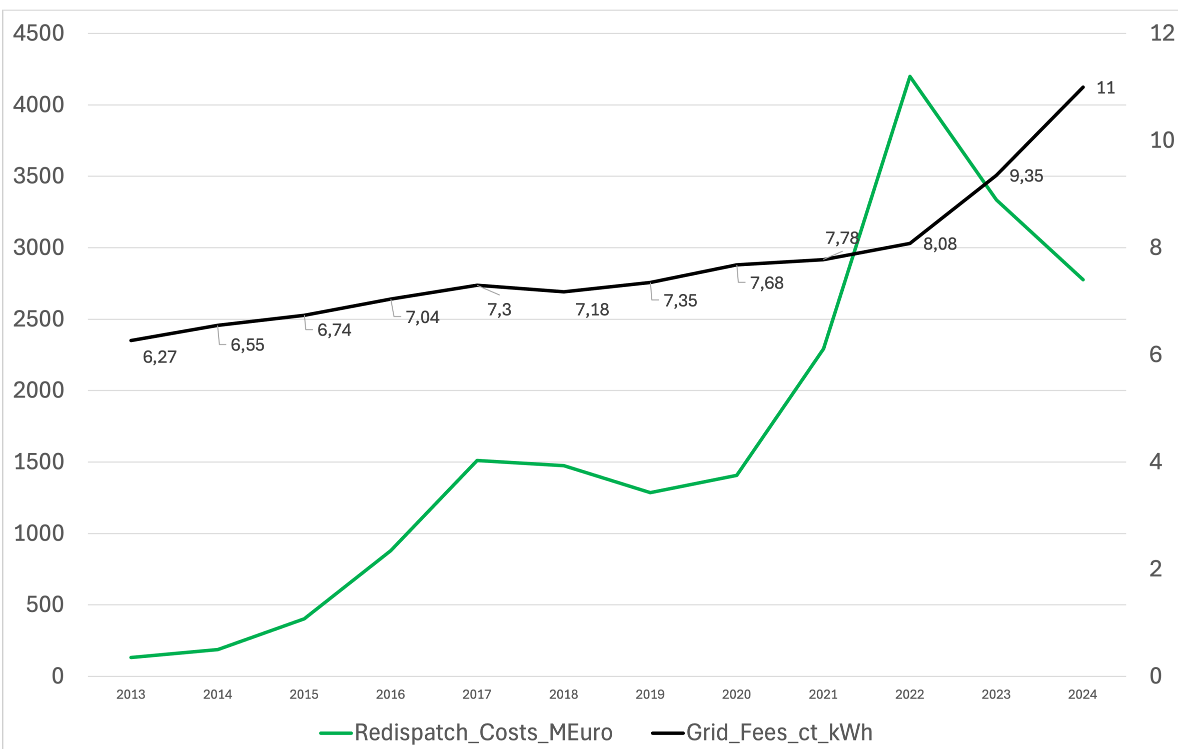
[10] As Fett et al. (2019, p.867) discusses, "Self-consumption from small-scale PV systems ($< 10kWp$) is exempted from most taxes and levies, such as grid charges or the renewable energy levy."

GWh per year and 7,000 utilization hours can apply for grid fees as low as 10% of the standard rate (von Thadden del Valle et al., 2026). This is financed through an "industry rebate levy" that added an additional 3.9% (1.56 ct/kWh) to the 2025 household electricity price – households effectively cross-subsidizing industrial grid access.[11]

Figure 3 shows the parallel rise of redispatch costs and grid fees over the past decade, illustrating the link between the synchronous grid's escalating congestion-management costs and the component of the household bill most directly implicated in energy poverty.

The Figure 3 shows that the costs associated with this rise in redispatch have surged from roughly €400–600 million in Germany in 2014 to €4.2 billion in 2022 and €3.1 billion in 2023 (Donnelly, 2025). The historically high cost of €4.2 billion in 2022 was due to grid bottlenecks and the rising price of natural gas following the start of the Ukraine War.

Figure 3: Redispatch Costs and Grid Fees in Germany



Source: Author's compilation based on data from BNetzA Monitoring Reports and BDEW Electricity Price Analysis

[11]From Netztransparenz, see `https://tinyurl.com/5n6ehm9k`.

According to Allianz Research (2025, p.3) grid congestion costs in Germany "*are projected to surge to €12.3 billion by 2030 and €56.7bn by 2040 without upgrades*" and that "T*hese costs ultimately impact electricity prices, with potential increases of +22% by 2030 and up to +103% by 2040 under a business-as-usual (BAU) scenario.*" For Europe as a whole, the cost of redispatch was around €5 billion in 2022 - and is forecasted to increase to between €11 billion and €26 billion by 2030 and possibly €103 billion by 2040 (Thomassen et al., 2024).

It is not only rising grid congestion as a result of the growth of renewable energy supply that will be driving redispatch costs, but it is also likely that TSOs will increasing make use of redispatch to "reduce the necessity for grid and storage expansion" (Büttner and Müller, 2024, p.129).

5 Current Reform Proposals and Their Limits

Addressing energy poverty in Germany requires coherent energy-poverty policy, structural reform of household price determination, and evolution of the grid itself. On policy, Cludius et al. (2018, p.6) note that "*in Germany there are relatively few policies that directly address energy poverty,*" and propose four thrusts drawn from practice elsewhere in Europe: extending the reimbursement of heating costs, introducing electricity allowances for low-income households, supporting renovation measures for low-income housing, and encouraging energy savings – including through dynamic pricing that low-income households can actually access.

On structural reform, proposals include dynamic and variable electricity and grid prices, already being partly introduced (Stute and Klobasa, 2024; Ganz and Vollmuth, 2025), local (nodal) market prices (Neuhoff and Stolle, 2026), and the splitting of Germany's single price zone (Hladik et al., 2017; Titz et al., 2023).

German power companies have been required to offer dynamic electricity prices since 2025, but as Kyllmann (2024) notes, benefiting from this requires smart meters, whose uptake in Germany is “among the lowest in the EU.” Time-variable grid fees (*zeitvariable Netzentgelte*) were introduced under Section 14a of the EnWG in April 2025, but these are not truly dynamic; fully dynamic grid fees remain only a BNetzA proposal, targeted for 2029.[12]

High redispatch costs motivated the German government in 2026 to provide a subsidy of €6.5 billion to reduce the impact of grid fees on household energy poverty. However, as Collins (2026) discusses, this subsidy is “*failing to reach many end consumers and distorting competition among energy providers*.” A reason is that the major electricity suppliers - such as E.ON, EnBW and EWE - are apparently not passing on the subsidy in the case of fixed-contract household customers.

The reforms mentioned in the previous paragraphs carry a specific regressive risk. Time-variable grid fees and dynamic prices reward households with controllable equipment – heat pumps, EV chargers, home batteries – but low-income households who cannot afford such assets face a net cost increase without access to the corresponding savings (Kyllmann, 2024).

Moreover, if regional price signals are insufficiently granular and decentralized, they risk overreaction in the market, potentially raising wholesale prices by up to 13% and further straining low-income household budgets (Stute and Klobasa, 2024).

In short, current reforms address the symptom of static, poorly targeted pricing, but not the underlying structural driver identified in Section 4: a centralized grid architecture whose congestion-management costs are recovered through fees that fall disproportionately on those least able to invest their way out of them.

[12] See: `https://www.energymarketprice.com/home/en/news/1178855`

6 SAFErGrid as a Poverty-Reduction Mechanism

SAFErGrid (Schwarz et al., 2026) is a forward-looking proposal that is supported by the European Research Council (ERC). [13] It proposes compartmentalizing the power grid into autonomous "A-grids," interconnected by smart Energy Routers that manage energy flows the way internet routers direct data packets, prioritizing delivery according to an AFSC principle: Aggregate locally, Forward to neighbors, Store in buffers, or Convert to other carriers such as hydrogen.

The architecture envisaged in SAFErGrid is of a layered, bottom-up model. It is inspired by the Internet's *Open Systems Interconnection* (OSI) model. The architecture is summarized and explained with the help of Table 1. Note that various technological advances are still required for the operationalization of SAFErGrid.

Table 1: Proposed A-grid Architecture

Layer	Primary Function	Key Features
4. Energy Application Layer	Enables high-level services and business models.	Supports dynamic pricing, demand response, and power-on-demand services.
3. Energy Streaming Layer	Coordinates global energy balance across the grid.	Replaces traditional secondary and tertiary control; manages energy availability without overloading segments.
2. Energy Routing Layer	Physically forwards energy between neighboring A-grids.	Uses the AFSC principle (Aggregate, Forward, Store, then Convert) to move energy streams.
1. A-Grid Layer	Manages local power flow within a single subgrid.	Operates on existing technology and primary control principles; performs local balancing and energy distribution.

In Table 1 above the first layer is the *A-Grid Layer*. Each A-grid functions as an autonomous island that manages its own internal frequency and voltage. Any a-grid can support any mix of AC or DC technologies, legacy equipment, or renewable sources.

[13] See `https://cordis.europa.eu/project/id/101166783`

The second layer is the *Energy Routing Layer*. This is where the interconnection with other A-grids is based. Energy routers on this layer apply what Schwarz et al. (2026) terms the "store-and-forward" paradigm, utilizing the AFSC principle: Aggregate, Forward, Store, and then Convert. This enables an A-grid to decouple electricity supply and demand over time (Schwarz et al., 2026, p.5).

The third layer is the *Energy Streaming Layer*. It uses Internet-inspired protocols to schedule energy streams rather than requiring the instantaneous matching as in a traditional synchronous grid. By treating electricity as a stream of data-like energy packets, the layer ignores the local technical details (like whether a subgrid is 50 Hz or 60 Hz) and focuses solely on energy availability.

The fourth, top, layer is the *Energy Application Layer*. This is a service layer, which allows for a plug-and-play ecosystem to develop. Here new business models, for example based on peer-to-peer (P2P) energy trading, or localized grid-service marketplaces, can evolve without requiring a redesign of the underlying electrical infrastructure. See section 5.2. for an illustration of these business models.

Rather than requiring instantaneous, continent-wide synchronization, each A-grid balances its own supply and demand locally, exchanging energy with neighbors only as capacity allows. The market mechanisms that this enables – a continuous double auction for local energy balance, a priced synthetic-inertia stability market, and continuous congestion pricing in place of after-the-fact redispatch - is explored by **?**.

This section focuses specifically on the channels through which these mechanisms translate into lower energy poverty.

6.1 Reducing Grid Fees by Eliminating Redispatch

The most direct channel operates through Section 4's central finding: German grid fees are driven substantially by redispatch costs incurred to manage congestion between renewable-rich northern regions and demand-dense southern regions.

In 2026, grid fees contributed approximately a third to the average electricity bill for households in Germany,[14] which is on average $37,2ct/kWh$, which is composed of $15,4ct/kWh$ (procurement and sales) + $9,3ct/kWh$ (grid fees) + $12,6ct/kWh$ (taxes).[15]

As a result of rising grid fees due to infrastructure cost and redispatching due to RES and more demand of electricity, the outcome is, as Hanny et al. (2022, p.5) discuss, "*market price signals are distorted [...] This leads to a situation in which electricity prices can no longer serve as an indicator for system scarcities.*"

This distortion contributes to energy poverty. The way in which market clearing can potentially take place in the SAFErGrid can help alleviate energy poverty. In a SAFErGrid architecture, each A-grid's Energy Router routes surplus energy to neighboring A-grids only up to the physical capacity of the connecting line, storing or converting any excess locally (for example as green hydrogen) rather than forcing flow through a constrained line and settling the resulting cost later through grid fees.

Because this eliminates the specific mechanism – after-the-fact redispatch – that Section 4 identifies as the principal driver of rising grid fees, and because grid fees alone account for an estimated 650,000 households in energy poverty in Germany, this channel represents the single largest potential poverty-reduction effect that a transition to SAFErGrid could offer.

[14]See also : `https://www.bdew.de/service/daten-und-grafiken/bdew-strompreisanalyse/`
[15]See: `https://www.bdew.de/service/daten-und-grafiken/bdew-strompreisanalyse/`.

6.2 Quality-of-Service Pricing as a Distributional Tool

A second, distinct channel operates not through the level of prices but through their structure. In the current synchronous grid, all users pay for the same uniformly high level of reliability, including low-income households who have no option but to pay for a reliability standard they may not require for every appliance.

SAFErGrid's packet-based architecture allows this to be unbundled through Quality-of-Service (QoS) pricing, based on the Priority Service concept introduced by Chao and Wilson (1987): because the (to yet be developed) *Energy Router* treats electricity as a stream of packets carrying packet-priority signals indicating delivery urgency, a decentralized electricity market can segment consumption into reliability tiers in the way internet service is tiered.

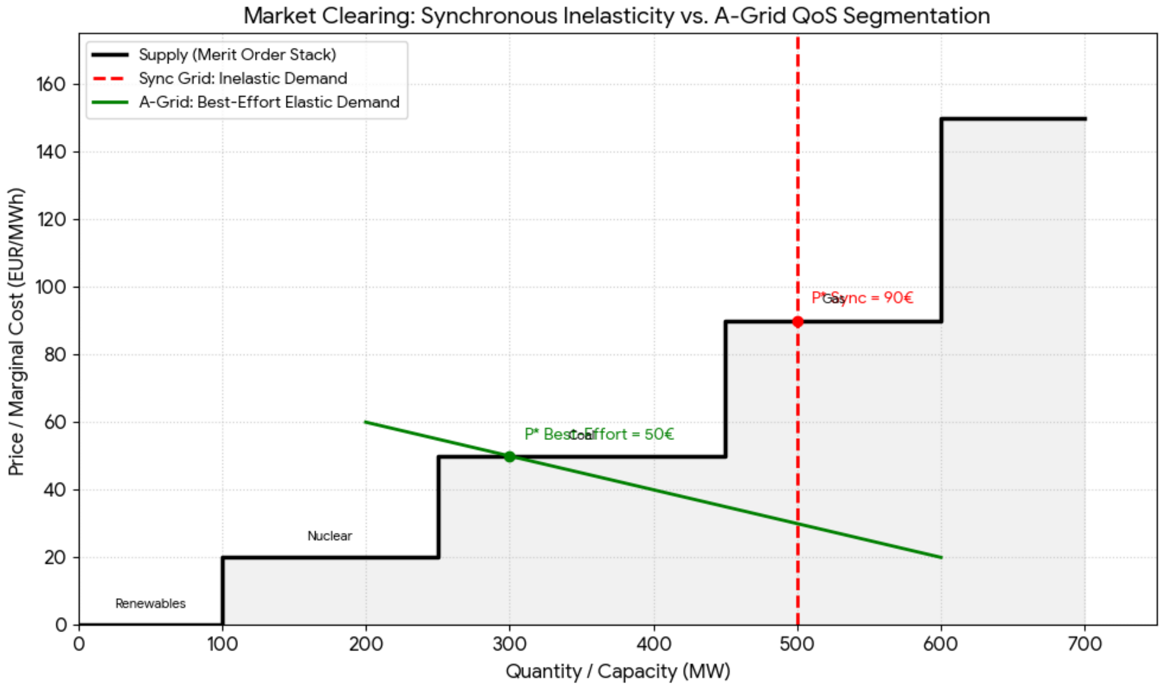
A "premium" tier, priced to reflect its scarcity rent, would suit consumers such as hospitals that require the highest reliability; a "standard" tier would suit general home heating and lighting; and a "basis" tier, priced closer to marginal cost, would suit flexible loads such as EV chargers or water heaters, whose delivery can be automatically adjusted according to weather, grid conditions, and price.

Because a basis tier is offered near marginal cost while a premium tier carries a scarcity rent, the grid can recover part of its fixed costs from those most willing and able to pay for premium reliability, without spreading that cost uniformly – and regressively – across all consumers.

Figure 4 compares market clearing under the two architectures for a 500 MW demand scenario.

In Figure 4 the inelastic demand in the case of the current centralized, synchronous grid is depicted with the dashed red line. To meet a fixed 500 MW demand, the market must engage expensive gas-fired plants, clearing at 90€/MWh. Physical congestion on the transmission

Figure 4: Quality of Service Pricing



Source: Author's compilation

lines leads to redispatching - ultimately increasing household grid fees.

In a SAFErGrid A-Grid, the demand for electricity can respond in real time to price signals, hence the demand curve becomes a downward sloping line - the solid green line in Figure 4. In this case, the A-grid's smart Energy Routers (a technology still to be developed) categorize loads using QoS pricing. Basis tier service appliances (e.g. EV chargers) are programmed to be price-sensitive.

Because the demand curve is now downward-sloping, the market can clear at a lower marginal step in the merit order. In this example, the flexible basis tier segment shifts consumption to clear at the coal price of 50€/MWh. Thus, by allowing households to choose a lower reliability tier for non-essential appliances, the wholesale cost drops significantly. Simultaneously, the use of local buffers to eliminate congestion means that regressive grid fees can be avoided.

In this system, a household's utility (U_i) is optimized by choosing a reliability level (θ_i) that fits their budget:

$$U_i = v_i(q_i, \theta_i) - p(\theta_i) \cdot q_i + \gamma_{Next} \tag{1}$$

While a hospital might choose $\theta = 1.0$ (premium service) and pay a premium, a low-income household can reduce the risk of energy poverty by selecting $\theta = 0.1$ (basis service) for certain appliances, accessing a much lower price $p(\theta)$ while benefiting from the overall resilience - the network externality - (γ_{Next}) - of the decentralized network.

Total consumer utility can even be higher in an A-grid, even if a small router fee is applied, because the overall reduction in redispatch lowers the base cost of electricity for the most vulnerable.

Finally, what the potential scenario discussed here implies, is that the reduction of grid fees should best be achieved through reducing wasted energy inherent in the low-quality housing and appliances typically occupied by low-income households - in other words, the accessibility and affordability of energy management systems for all households will be an important requirement for reducing energy poverty.

7 Discussion

The analysis in this paper identified two distinct channels through which SAFErGrid could reduce German energy poverty. The redispatch-elimination channel (Section 6.1) operates on the level of the average bill. Eliminating grid fees driven by redispatch could potentially lift roughly 650,000 households from energy poverty. The QoS-pricing channel (Section 6.2) operates on the structure of the bill, allowing low-income households to actively trade reliability for price on specific appliances. Its impact is targeted at the households most at risk, since it does not require abolishing grid fees altogether, but allow households to opt out of paying for quality (reliability) they do not need.

Three caveats NEED TO BE NOTED. First, the 650,000-household estimate assumes grid fees can be eliminated rather than merely reduced; in practice, some fixed network cost recovery will remain even under SAFErGrid.

Second, both channels depend on complementary household-level infrastructure – smart meters for dynamic pricing, and programmable appliances or a home energy management system for QoS tier selection. The uptake of these in Germany is however currently among the lowest in the EU (Kyllmann, 2024). W

Third, the transition path itself matters for distributional outcomes. If SAFErGrid components are rolled out gradually and unevenly across regions in future – as is likely, given that a phased integration with the existing synchronous grid would be necessary – there is a risk that early adopter regions or households capture disproportionate benefits, echoing the current geographic unevenness in German grid fees.

8 Concluding Remarks

Germany's experience shows that rising RES penetration and rising energy poverty are partly due to rising grid fees, driven by the cost of managing congestion and redispatch on the legacy synchronous grid. Current reforms, including for dynamic tariffs and time-variable grid fees, address the symptom of static pricing, without resolving this underlying structural driver.

SAFErGrid, a conceptual proposal for a possible future grid that is based on decentralization and asynchronicity - offers two specific channels for reducing energy poverty: eliminating the redispatch costs that drive grid fees in the first place, and introducing Quality-of-Service pricing that lets households trade reliability for price on flexible appliances - rather than paying uniformly for a reliability standard they may not need.

Taken together these channels could plausibly remove a meaningful share of German households from energy poverty in future – but only if the roll-out of a SAFErGrid is complemented by equitable household-level access to smart meters and energy management systems - and the innovations envisaged in the proposal is realized (see e.g. Naudé (2026c)).

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