Briefing for Climate Action Network Europe

Powering the future: Balancing Grid Investments and Consumer Protection in Europe's Energy Transition

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CAN Climate Action Network Europe

FÖS Forum Ökologisch-Soziale Marktwirtschaft

Content

This paper examines the financing and tariff structures necessary to modernize and expand Europe's electricity grids while ensuring fair cost distribution among consumers. It begins by analyzing the impact of rising grid tariffs on households across Europe, highlighting significant variations between countries, particularly the higher burden faced by lower-income households in Central and Eastern Europe.

The study then explores the investment needs of electricity grids, including transmission and distribution networks, and evaluates different financing options. These include national public financing, EU-level funding, private investments, and infrastructure funds, each with distinct advantages and challenges. The paper also assesses various grid tariff design options, such as volumetric pricing, capacity-based tariffs, and time-of-use tariffs, examining their effects on energy policy goals, revenue stability, and consumer fairness.

The findings emphasize the need for a diversified approach, integrating multiple financing mechanisms and tariff structures to balance affordability, efficiency, and sustainability.

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About CAN Europe

Climate Action Network (CAN) Europe is Europe's leading NGO coalition fighting dangerous climate change. We are a unique network, in which environmental and development organisations work together to issue joint lobby campaigns and maximise their impact. With over 200 member organisations active in 40 European countries, representing over 1,700 NGOs and more than 40 million citizens, CAN Europe promotes sustainable climate, energy and development policies throughout Europe.

CAN Europe members work to achieve this goal through joint actions, information exchange and the coordinated development of NGO strategy on international, regional, and national climate issues.

CAN Europe's vision is to protect the atmosphere while allowing for sustainable and equitable development worldwide.

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The Forum Ökologisch-Soziale Marktwirtschaft e.V (FÖS) is a non-partisan and independent political think tank. Since 1994, we have been advocating for the evolution of the social market economy into an ecological-social market economy. As both initiators and consensus builders, we engage with decision-makers and key stakeholders.

To this end, we conduct independent research, develop concrete policy concepts, and contribute to the debate on modern environmental policy through conferences, background discussions, and publications. FÖS is committed to a continuous ecological financial reform that strengthens both environmental sustainability and economic resilience.

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CAN CLIMATE ACTION NETWORK Europe

FÖS Forum Ökologisch-Soziale Marktwirtschaft

Powering the future: Balancing Grid Investments and Consumer Protection in Europe's Energy Transition

Contents

Abstract

The **modernization and expansion of Europe's electricity grid** are essential to ensuring energy security, integrating renewable energy, and meeting climate targets. Rising electricity demand from electrifying heating and transport further underscores the urgency of grid investments. Delaying these investments could result in bottlenecks, higher long-term costs, and missed opportunities to optimize grid efficiency. A robust, well-financed grid infrastructure is crucial to facilitating the energy transition while maintaining a stable and reliable power supply.

An analysis of Eurostat data reveals that grid fees already represent a **significant share of household electricity costs** across Europe, though the **burden varies by country**. Central and Eastern European (CEE) countries face particularly high grid cost burdens relative to household income. In Bulgaria, for instance, the proportion of income spent on grid fees is nearly five times higher than in Denmark. Since grid operators generally recover investment costs through consumer-paid tariffs, expanding grid infrastructure without financial reform risks exacerbating energy poverty and inequality.

To address these challenges, a mix of financing mechanisms is available to support grid investments while minimizing the financial burden on consumers. These include **national public financing, EU-level funding, private investments, and infrastructure funds**. While public financing offers lower-cost capital, private sector involvement can accelerate deployment and drive innovation. EU funding mechanisms, such as the Connecting Europe Facility and the Modernization Fund, provide additional opportunities, particularly for lower-income countries. However, each financing option comes with trade-offs, and their effectiveness depends on a country's regulatory framework, grid ownership structure, and economic conditions. A tailored approach is therefore necessary to ensure cost efficiency and affordability.

Beyond financing, grid tariff structures play a crucial role in balancing **cost recovery, system efficiency, and fairness.** While volumetric tariffs provide a predictable revenue stream, they do not reflect actual grid usage patterns or peak demand costs. Capacity-based tariffs align charges with peak consumption but may disproportionately impact low-income households. Time-of-use tariffs offer a promising solution for optimizing grid usage and integrating renewables, but their implementation depends on widespread smart meter adoption. Progressive tariffs, which charge higher rates for excessive consumption, can enhance affordability for low-income households but introduce administrative complexity. Given the strengths and limitations of each approach, no single tariff design can fully satisfy all policy goals. Instead, **a well-balanced combination of different tariff elements**—aligned with the specific circumstances of each country—is recommended.

Ultimately, securing the future of Europe's electricity grids requires a comprehensive strategy that integrates diversified financing options and well-designed tariff structures. Policymakers must carefully balance investment needs, affordability concerns, and incentives for efficient grid use. A coordinated effort among governments, regulators, and market participants will be key to achieving an energy transition that is both sustainable and equitable.

1 Background and Aim

The European Union (EU) has set an ambitious goal to achieve climate neutrality by 2050. Central to this objective is the widespread adoption and integration of renewable energy sources. This transition is critical for decarbonizing key sectors such as industry, heating, and mobility, which increasingly rely on electrification. As a result, electricity demand across Europe is expected to rise significantly in the coming decades (European Commission 2019).

This shift from centralized fossil fuel-based generation to decentralized and variable renewable energy generation, coupled with rising electricity demand, place unprecedented demands on the EU's electricity grid. To accommodate these changes, the grid must not only expand but also undergo significant modernization to become more robust, flexible, and digitally enabled.

The importance of this transformation is underscored in key strategic documents such as the *Grids Action Plan* (European Commission 2023) and the *Council Conclusions on Sustainable Energy Infrastructure* (Council of the European Union 2024). These initiatives highlight the need for a future-proof electricity network as a foundational pillar in achieving the EU's climate and energy targets. However, the scale of investment required to modernize and expand the grid is immense. Overall, total grid investment needs are projected at €584 billion by 2030, covering electricity transmission, distribution, and digital infrastructure (European Commission 2023).

By 2030, approximately €170 billion must be directed toward electricity networks, including €50 billion for cross-border interconnections and €120 billion for distribution systems critical to integrating renewable energy and new demand sources such as electric vehicles and heat pumps. Furthermore, adapting the grid for decentralized renewable energy integration to meet the EU's target of 1,000 GW of renewable energy capacity by 2030 requires an additional €150 billion (European Commission 2023).

Despite these pressing needs, how this financing will be secured and how costs will be distributed among stakeholder public authorities, private investors, and consumers—remains uncertain. At present, most grid-related costs incurred by operators are passed on to consumers through network tariffs. While this approach ensures immediate cost recovery, it has led to rising electricity prices, which disproportionately affect socio-economically vulnerable households (Dieler 2020).

Aim of the briefing

This briefing aims to provide a comprehensive analysis of the financing challenges and opportunities associated with modernizing and expanding Europe's electricity grid. Its overarching objective is to identify solutions that balance the urgent need for grid investments with the imperative to protect consumers, particularly the most vulnerable, from undue financial burden.

The paper is structured as follows:

1. **Impact of Rising Grid Tariffs on Consumers:**
   The first section examines the likely effects of increasing network tariffs on households, with a focus on socio-economic disparities. It addresses the challenge of financing grid modernization without exacerbating existing cost-of-living pressures, especially in light of political resistance to rising energy costs in some regions.
2. **Exploration of Alternative Financing Mechanisms:**
   The second section evaluates potential financing options for grid investments. This includes leveraging existing EU funds, mobilizing private investments, and exploring innovative funding mechanisms to support grid operators while minimizing cost impacts on households.
3. **Analysis of Grid Tariff Design:**
   The third section investigates the principles underpinning grid tariff structures and their role in advancing the energy transition. It assesses the implications of different tariff designs for equity, affordability, and the socio-economic wellbeing of households across the EU.

By addressing these dimensions, this briefing seeks to contribute to an equitable and sustainable pathway for financing Europe's energy transition, ensuring that grid modernization supports both climate goals and social cohesion.

2 The impact of rising grid tariffs on consumers

2.1 Social implications of rising grid tariffs

Energy costs, particularly grid tariffs, have profound social implications:

- **Energy poverty:** Central and Eastern European countries (CEE countries) face high levels of energy poverty due to low incomes, energy-inefficient housing, and limited access to renewable energy or energy efficiency measures. Rural households in these regions are disproportionately affected, often relying on solid fuels for heating and lacking access to modern energy solutions (European Parliament 2022).
- **Equity concerns:** In regions with high grid costs relative to income, rising tariffs exacerbate inequality, disproportionately impacting low-income households and undermining their ability to meet basic needs.

The need for grid modernization

Modernizing electricity grids is essential for enabling the energy transition and ensuring long-term affordability:

- **Reducing long-term costs:** Investment in smart grids and efficient infrastructure minimizes energy losses, enhances reliability, and reduces operational costs over time.
- **Facilitating renewable energy integration:** Smart grids support decentralized energy sources, energy communities, and demand-side flexibility, critical for decarbonizing the energy system.
- **Addressing energy poverty:** Upgraded grids, combined with targeted policies, can lower energy costs for vulnerable households and reduce reliance on inefficient, high-cost energy sources.

Balancing investment and consumer protection

Rising grid tariffs, while necessary for financing grid modernization, must be carefully managed to avoid undue financial strain on households (CAN Europe 2024).

2.2 Impact of grid tariffs on households across Europe

To assess the impact of grid tariffs on households in the different EU member states, we analyzed Eurostat data[1] for 2022 on electricity consumption per household and average grid tariffs per kWh. We set the total grid costs (as a product of electricity consumption and grid tariffs) in relation to income of households.

2.2.1 Electricity consumption

The average electricity consumption of households varies widely across EU Member States (see Figure 1) and depends, among other things, on the extent to which electricity is used for heating.

- **Lowest consumption** (< 2,500 kWh per year): CEE countries such as Romania, Latvia, Lithuania and Poland, but also Italy, consume less than 2,500 kWh per household and year.
- **Mid-range consumption** (2,500 – < 5,000 kWh per year): 19 of the 27 Member States, including the other CEE countries, have a consumption of between 2,500 and 4,999 kWh per household and year.
- **Highest consumption** (>5,000 kWh per year): Finland, Sweden Cyprus and France show a consumption of over 5,000 kWh per year. Sweden and Finland have a high proportion of heat pumps and e-cars. Electricity is also often used for heating in France. Air conditioners are widely used in Cyprus.

2.2.2 Grid tariffs

Grid costs for households vary widely across Europe, reflecting differences in grid infrastructure, investment strategies, and national energy policies. The following examples illustrate the different approaches:

- **Poland and Czechia:** Despite significant grid congestion and curtailment issues, grid tariffs have decreased by 9% in Czechia and 7% in Poland, between 2017 and 2022. However, this decline has coincided with reduced grid investments, jeopardizing infrastructure reliability and renewable energy goals (CAN Europe 2024).
- **Bulgaria:** In contrast, Bulgaria has significantly increased grid investments, aiming for a tenfold increase between 2022 and 2030 to support ambitious solar capacity expansion. This strategy aligns with its energy transition goals but raises concerns about affordability for households.

[1] https://ec.europa.eu/eurostat/de/web/main/home

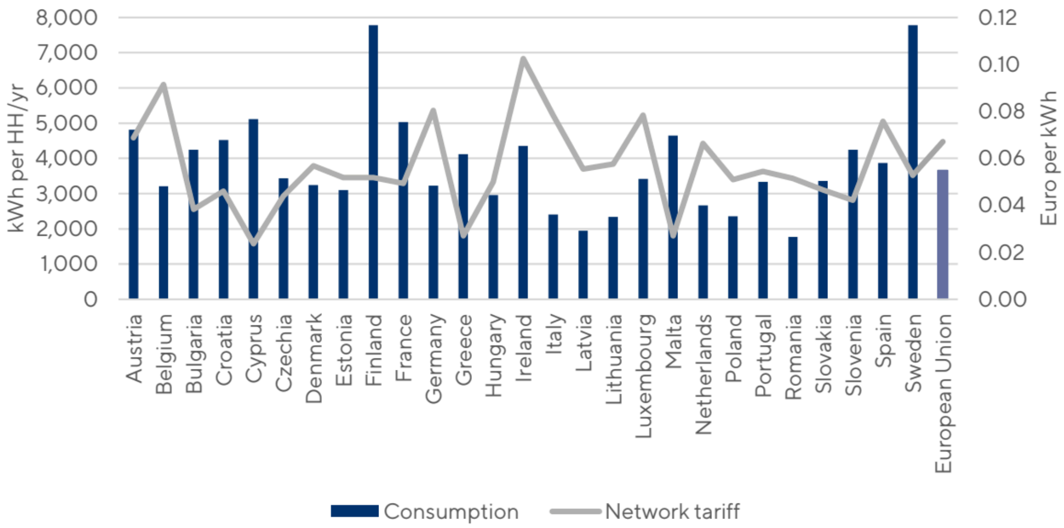
Between 2017 and 2022 grid tariffs increased by 65% (CAN Europe 2024; Eurostat 2024).

Figure 1 shows the different grid tariffs per kWh in 2022 according to Eurostat data (for the specific consuming bands):

- **Lowest costs (< €0.040/kWh):** Cyprus (€0.024/kWh), Malta (€0.027/kWh), Greece (€0.027/kWh), and Bulgaria (€0.038/kWh).
- **Mid-range costs (€ 0.04/kWh - < € 0.08/kWh):** 21 EU member states, e.g. Estonia (€0.052/kWh), Portugal (€0.054/kWh), Latvia (€0.055/kWh) and Lithuania (€0.058/kWh)
- **Highest costs (from €0.08/kWh):** Germany (€0.080/kWh), Belgium (€0.091/kWh) and Ireland (€0.102/kWh),

The average EU grid cost is €0.067/kWh. These figures highlight the disparities in electricity costs across the region, influenced by factors such as grid modernization levels, energy policy priorities, and economic conditions.

Figure 1: Consumption per Household (kWh per year) and Grid Tariff (€/kWh), 2022

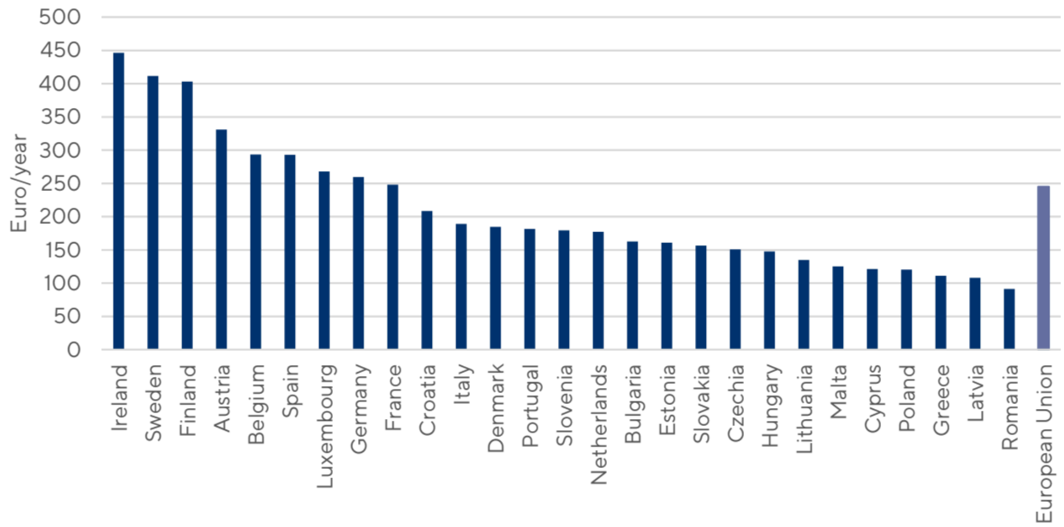


Source: own illustration. Data sources: Eurostat codes nrg_d_hhq, tps00001, nrg_pc_204_c

2.2.3 Total grid costs of households

The total annual expenditure for the average household results from electricity consumption and grid tariffs per kWh. Figure 2 shows the absolute burden in € per household and year. Households in Ireland face the highest costs (almost €450/year), with the high grid tariffs per kWh having a major impact, while the electricity consumption is average. In Sweden and Finland, on the other hand, high electricity consumption is the main determining factor for the total costs. Germany is in the upper midfield with costs of €259/year for grid tariffs. None of the CEE countries is above the EU average in terms of the absolute level of costs. Except for Croatia, all CEE countries have costs of less than €200/year for an average household. This is because both electricity consumption and grid costs per kWh are comparatively low.

Figure 2: Total grid tariff costs (€), 2022.



Source: own illustration

2.2.4 Share of grid costs on net income

However, in view of low household incomes in CEE countries, the relative burden (share of grid costs on net income) is usually higher compared to the EU average (1.13%). In Bulgaria and Croatia, the burden is over 2% of net income. The lowest burden occurs in high-income countries that have both moderate electricity consumption and grid tariffs (Denmark, Luxembourg, the Netherlands). Figure 3 shows results for all 27 EU member states.

- **Lowest burden** (< 0.75%): Denmark (0.49 %), Luxembourg (0.53%), Netherlands (0.56%), Cyprus (0.58%), Malta (0.59%),
- **Mid-range burden** (0.75% - < 1.5%): 17 member states such as Italy (0.89%), Latvia (0.90%), Germany (0.91%), France (0.95%), Estonia (0.95%), Czechia (1.11%), Poland (1.21%), Finland (1.36%), Sweden (1.41%) and Romania (1.49%)
- **Highest burden** (from 1.5%): Spain (1.53%), Slovakia (1.72%), Hungary (1.88%), Croatia (2.16%) and Bulgaria (2.38%).

2.2.5 Key takeaways

- **Grid tariffs vary widely across EU Member States:** They are over four times higher in Ireland than in Cyprus. The EU average is about €0.067/kWh, ranging from about €0.024/kWh to over €0.10/kWh.
- **The average electricity consumption of households also varies greatly:** The consumption depends, among other things, on the extent to which electricity is used for heating or cooling as well as for electromobility. Consumption in Finland and Sweden is more than four times higher than in Romania.
- **The absolute level of annual network costs of households also shows a widespread**: A household in Ireland pays almost five times as much as a household in Romania.
- **The relative burden in relation to income, i.e. the proportion of income spent on network costs, is particularly important**: Again, we find a large spread. Households in some CEE countries are

particularly affected due to low incomes. Spain also has a comparatively high burden. For households in Bulgaria, the relative share of costs in net income is 2.38%, almost five times as high as in Denmark (0.49%).

- **Grid tariffs are only one price component of the electricity price:** Depending on the country, the share of grid tariffs on total electricity price can vary greatly. In addition to procurement costs, other taxes and levies on electricity in particular play a key role in how high the overall electricity price is. Data on the absolute level of the electricity price is also available from Eurostat.
- **Energy is essential for safety, health, and economic well-being:** A modern and reliable electricity grid ensures uninterrupted access to power while supporting renewable energy integration and enhancing energy security. However, rising network tariffs—driven by the need for significant grid investments—present affordability challenges for households, particularly the most vulnerable.
- **Rising grid tariffs driven by the need for modernization and investment therefore affect households in the countries to varying degrees**: Even if grid tariffs per kWh were to rise equally in all member states, due to lower incomes, households in CEE are particularly burdened. Therefore, solutions must be found for the financing of investments / refinancing via grid tariffs in order not to burden these households disproportionately. Various options are presented in the next chapters.

3 Electricity grids in Europe – ownership and investment needs

Investments in the modernization, expansion, and management of electricity grids are approached differently across Europe. These differences stem from varying grid structures, ownership models, and regulatory frameworks in each country. The European electricity network consists of two interconnected layers: high-voltage transmission grids, responsible for transporting electricity over long distances, and medium-to-low-voltage distribution grids, which connect most end-users to the system. Transmission grids are interconnected across most neighboring European countries, allowing for cross-border electricity flows.

The European Union mandates that grid operators must function independently to ensure non-discriminatory access for all market participants. The regulatory framework introduced under the Third Energy Package in 2009 specifies ownership and operational requirements for transmission and distribution grids. However, each EU member state has its own regulatory approach to determining investment incentives and return structures for TSOs and DSOs. National regulators oversee the financial and operational frameworks that govern grid operators, influencing their ability to recover investment costs and maintain financial stability while expanding and modernizing the grid.

This chapter provides an overview of the current framework for electricity grids, with a specific focus on Germany and Poland.

3.1 Transmission Grid

The Third Energy Package of 2009 introduced strict unbundling rules for transmission system operators (TSOs), safeguarding that no market participants will face discriminatory grid access (European Commission 2024; European Parliament/European Council 2024).

The EU's unbundling rules for TSOs include three models:

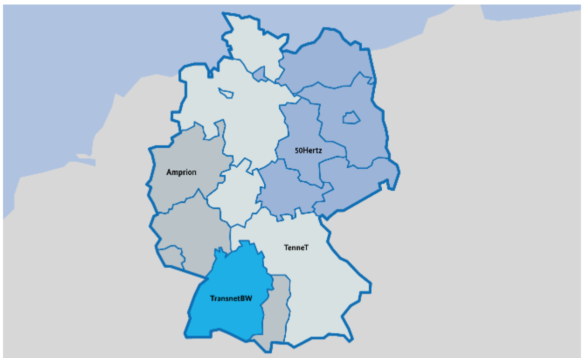
- Ownership Unbundling: Energy companies must divest their transmission networks entirely, preventing any supply or production company from holding a majority share or interfering in TSO's operations.
- Independent System Operator (ISO): Energy supply companies may retain ownership of transmission networks but must delegate operation, maintenance, and investment responsibilities to an independent company.
- Independent Transmission System Operator (ITO): Energy supply companies may own and operate transmission networks via subsidiaries, provided all critical decisions are made independently.

TSOs are subject to the oversight of national regulators to ensure compliance with these unbundling requirements (European Commission 2024; European Parliament/European Council 2024).

Many TSO's are fully or partially owned by the state. While many countries have one TSO, some countries, e.g., Germany, have multiple. In Germany there are four TSOs (see Figure 4).

- 50Hertz: The federal government holds a 20% stake through the state-owned KfW bank.
- TransnetBW: The federal government holds a 25% stake through KfW in this subsidiary of EnBW.
- Amprion: Privately owned by a consortium of investors, including infrastructure funds.
- TenneT: Owned by the Dutch government, with ongoing discussions about German government participation.

Figure 4: Four Transmissions System Operators in Germany



Source: (Bundesnetzagentur 2025a)

Poland has one state-owned TSO, Polskie Sieci Elektroenergetyczne (PSE). The Polish State Treasury entirely owns PSE.

3.2 Distribution Grid

Distribution system operators (DSOs) are subject to less stringent unbundling requirements (European Commission 2024; European Parliament/European Council 2024).:

- Legal Unbundling: DSOs must be separate legal entities from vertically integrated utilities.

- Functional Unbundling: DSOs must maintain independence in decision-making and organization.
- Accounting Unbundling: Separate financial records are required for distribution activities.

DSOs serving fewer than 100,000 customers are exempt from legal and functional unbundling requirements (European Commission 2024; European Parliament/European Council 2024).

Germany's distribution grid is highly fragmented, with 866 DSOs, some of which are municipal utilities, some are private energy companies, and some are public-private partnerships (Bundesnetzagentur 2023).

The Polish distribution grid is divided into 205 DSOs (Lighthief 2024). Poland's largest DSOs are legally unbundled but primarily owned by vertically integrated state-controlled companies:

- PGE Dystrybucja (owned by Polska Grupa Energetyczna).
- Tauron Dystrybucja (part of the Tauron Group).
- Energa Operator and Enea Operator are also state-controlled.

3.3 Investment needs

The energy transition poses significant challenges for grid infrastructure, necessitating large-scale investments to accommodate decentralized renewables, electrification, and digitalization.

The EU estimates multi-billion-euro investments are required annually to modernize and expand grids across Member States. The European Commission estimates an investment need of **€584 billion by 2030** (European Commission 2023):

- **€113 billion** for electricity transmission,
- **€294 billion** for electricity distribution,
- **€177 billion** for digital infrastructure.

The German ministry for Economic Affairs and Climate Action estimated an investment need **of €50 billion** for the expansion of the transmission grid by 2030 (BMWK 2023). Other studies estimate an investment need of **€651 billion** by 2045 for all investments into the power grid (Institut für Makroökonomie und Konjunkturforschung 2024).

Poland's grid investment needs are estimated at over **€110 billion** by 2040, including €28 billion for distribution networks by 2030 (CAN Europe 2024).

4 Financing and refinancing grid investments.

Investments in grid infrastructure are pivotal for supporting the energy transition, integrating renewable energy sources, and ensuring energy security. To modernize and expand the electricity grid, grid operators across Europe rely on a mix of public and private funding mechanisms. These mechanisms are designed to balance affordability for consumers with the financial needs of grid operators to enhance and sustain the grid.

While financing mechanisms ensure the availability of capital for grid expansion, affordability remains a key consideration. In many countries, e.g., in Germany, the majority of grid investment costs are recovered through consumer-paid network tariffs. Investment strategies, regulated returns on investment and interest costs incurred from loans and debts therefore have a direct effect on household electricity bills.

4.1 Strategic Investment Planning and Capital Allocation

Grid expansion and modernization begins with a thorough assessment of grid expansion needs, which are based on projected energy demand, grid stability requirements, and regulatory targets. Grid operators develop comprehensive investment plans to outline the necessary infrastructure upgrades and their financing strategies which have to be approved by the national regulatory authority (BMWK 2023; Bundesnetzagentur 2025b).

4.2 Unlocking private capital for grid investments

To meet investment needs, grid operators will often rely on private investments and loan capital. Private financing mechanisms include bond issuances, bank loans, and equity financing, which provide crucial funding for grid modernization and the integration of renewable energy (European Investment Bank 2023).

The return on equity is set by the national regulatory authority to balance investor incentives with consumer protection. A higher return increases investment profitability but also raises consumer costs through grid tariffs (tagesschau.de 2023). In Germany, for example, the current regulated return on equity stands at 7.23 % pre-tax. The rate has recently increased to attract more investment. However, the level of return on equity has been criticized as a driver for rising grid tariffs (Bundesnetzagentur 2024a; VZBV 2019).

Private financing introduces efficiency and innovation, as investors seek to optimize grid operations and adopt modern technologies. However, private capital generally is attached to higher interest rates than public financing, leading to higher overall investment costs. These costs are typically passed on to consumers through grid tariffs. Fully relying on private investments at high equity return rates will, in the long term, result in increased grid tariffs, placing a financial burden on households and businesses. Reducing the return on equity could lower consumer costs but may also discourage private sector participation, potentially leading to underinvestment in grid infrastructure (Institut für Makroökonomie und Konjunkturforschung 2025).

The cost of private financing also depends on the creditworthiness of grid operators and market conditions. Grid companies that take on high levels of debt may experience credit rating downgrades, which, in turn, increases borrowing costs. Some economists predict that due to the large volume of capital required for grid investments, the creditworthiness of some grid operators may decline, limiting access to affordable financing options (Dezernat Zukunft 2024).

Larger transmission system operators (TSOs) can issue bonds to access capital markets, while smaller distribution system operators (DSOs) often rely on bank loans, which can be more expensive. In a notable example of equity financing, National Grid (the UK's TSO) executed the largest rights issuance in the UK since 2009, raising £7 billion in 2024 to finance grid expansion. This illustrates how equity financing can be a viable alternative to debt for large-scale infrastructure projects (Bruegel 2025).

Policymakers must carefully balance private sector involvement to ensure that grid investments remain both attractive for investors and affordable for consumers. A diversified financing approach, combining private capital with public funding mechanisms, can help mitigate cost impacts while ensuring sufficient investment in the electricity grid.

4.3 The role of public financing

To reduce borrowing costs, and to ensure sufficient access to funding, national governments can leverage direct budget allocations, low-interest loans and public borrowing to finance grid investments.

Public financing offers strategic advantages, including lower borrowing costs compared to private entities, reducing the overall financial burden on consumers. Moreover, public funding enables centralized and strategic resource allocation, prioritizing critical infrastructure projects essential for the energy transition. Long-term public commitments foster a stable planning environment, which is crucial for large-scale grid investments. However, direct budget allocations from the government create political dependencies. Public financing is subject to changing political priorities and public support. In times of budgetary constraints, governments may struggle to allocate sufficient funds for grid investments, as competing demands for public resources can limit available financing. Additional public spending can require tax increases or budget reallocation, which may face political and social resistance.

4.3.1 EU-level financing: Opportunities and Challenges

At the EU level, grid investments can be supported through various funding mechanisms, including the European Investment Bank (EIB), the Connecting Europe Facility – Energy (CEF-E), the Cohesion Fund, and the Modernization Fund. These financing instruments aim to foster cross-border energy infrastructure, support low-carbon energy projects, and address regional disparities in grid development.

The EIB has played a significant role in financing energy infrastructure, with €4 billion invested in domestic electricity networks and €3.5 billion in cross-border electricity projects between 2010 and 2022, covering 40% of total project investment costs (EIB 2023). Additionally, the European Bank for Reconstruction and Development (EBRD) provides financial support for grid projects, particularly in the EU's newer member states and Greece.

The CEF-E, the EU's primary fund for energy infrastructure, has allocated €5.8 billion to the energy sector for the period 2021–2027. The Cohesion Fund provides financing for national electricity networks, focusing on reducing socio-economic disparities. Meanwhile, the Modernization Fund, which is financed through revenues from the EU Emissions Trading System (ETS), supports energy network investments in 13 lower-income EU countries.

While EU-level financing offers long-term, low-interest funding and de-risking measures for private investments, there are limitations. Available funds are restricted, and not all EU member states are eligible for every program. Additionally, application and approval processes can be highly bureaucratic and time-consuming, slowing down access to critical funding (Bruegel 2025).

Example: Germany – Failed attempt to nationalize Tennet

The challenges of state ownership were evident in the failed attempt by the German government to acquire TenneT's German transmission assets. Despite high profits, TenneT reinvested little equity into German grid expansion, financing most of its investments through debt and only implementing one-fifth of its planned projects by 2022. The proposed takeover was structured to avoid violating Germany's constitutional "debt brake," as the required loans would have been classified as a financial transaction rather than new public debt (Dezernat Zukunft 2024). However, the deal ultimately failed, with the government citing budgetary constraints and concerns over the fiscal impact of the acquisition. Additionally, Germany's finance ministry reportedly favored only a minority stake in TenneT rather than full nationalization, based on market-oriented principles (BR 24 2024).

4.3.2 vs. Market Efficiency

Gove**State Ownership: Strategic Control** rnments can also reduce financing costs and ensure strategic control over electricity grids through state ownership. A **majority public stake** in transmission and distribution operators can help overcome capital shortages by allowing direct equity contributions from the state. This approach lowers financing costs and enables grid operators to secure additional debt more easily (Institut für Makroökonomie und Konjunkturforschung 2025). Public ownership also ensures alignment with national policy objectives, including security of supply and affordability. However, state ownership carries risks, including potential inefficiencies due to bureaucratic decision-making, mismanagement, and political interference. Publicly owned companies may prioritize broader policy goals over cost efficiency, potentially leading to higher long-term costs (Dezernat Zukunft 2024; Haney/Politt 2010).

Alternatively, governments can hold **minority stakes** in grid operators, preserving private sector efficiency while retaining strategic influence. This model allows private investors to maintain operational efficiency and innovation, although the cost-reducing impact of state involvement is less pronounced compared to majority state ownership (Di Pillo et al. 2020). State ownership requires high upfront investment, which may face political opposition.

Example: Poland - Leveraging EU Funds for Transformation

Poland is the largest beneficiary of European investment funds, with nearly €66 billion from sources like the European Structural and Investment Funds (ESIF), the National Recovery and Resilience Plan (RRP), and the Modernization Fund allocated to climate action this decade. Of this, €10.5 billion is earmarked for grid investments and energy storage, primarily as loans:

- **ESIF (FEnIKS Programme):** €1.12 billion support for transmission and distribution networks, including the deployment of 221 smart grid management systems and 250 MWh of energy storage.
- **The National Recovery and Resilience Plan (RRP):** €8.69 billion fund for grid and storage projects, including 880 km of new rural distribution grid, large-scale battery systems, and hydroelectric storage modernization.
- **Modernisation Fund:** €666 million to finance smart energy infrastructure, electric vehicle grid development, and storage solutions for network stabilization.

4.3.3 Infrastructure Funds: Mobilizing Capital

Infrastructure funds can represent an alternative source of financing for the expansion of network infrastructures. The idea is that the government establishes a fund, whose shares are sold to private investors, or the fund is equipped with public funds. The capital of the fund is invested in infrastructure projects, generating market-level returns for the investors. Public infrastructure funds can be financed both with private capital and independently of the private sector. In Germany, where the constitutional "debt brake" restricts the level of government borrowing, infrastructure funds offer a way to mobilize additional investment while remaining outside these fiscal constraints. By structuring funds separately from the core government budget, investments in critical infrastructure, such as grid modernization, can proceed without conflicting with debt limitations (Deloitte et al. 2024).

The choice of shareholder structure brings different advantages and disadvantages:

An **infrastructure fund funded with public resources** invests in infrastructure projects independently of the private sector. The financial resources can be provided by the federal budget, through loans, or revenues (e.g., from the EU Emissions Trading

System). Due to a special credit authorization, the fund can take out loans at favorable conditions, independent of the debt restrictions. The financing costs are relatively low compared to others, as the state does not impose return expectations on the TSOs (frontier economics 2024).

In a **public-private infrastructure fund,** the state establishes a fund and sells shares to private investors. The state provides favorable conditions (e.g., default guarantees), creating a market-standard risk-return profile for private investments. This results in a high leverage effect for private investments with relatively low state involvement (frontier economics 2024). However, the fund must deliver a market-standard return, meaning there are no lower financing costs compared to private financing sources.

The infrastructure fund offers state-backed guarantees, which can lower financing costs and attract investors. The attracted private capital reduces the reliance on public funds and promotes long-term investments (Institut für Makroökonomie und Konjunkturforschung 2025).

The cost-efficiency, however, is not guaranteed since private investors may demand higher returns, increasing overall costs. All types of infrastructure funds require robust governance to prevent inefficiency or misuse.

4.4 Key takeaways

- **Balancing investment needs and affordability:** Expanding and modernizing electricity grids is essential for the energy transition. However, ensuring that investment costs remain affordable for consumers is a key challenge, as grid expansion is primarily financed through consumer-paid network tariffs in many countries.
- **Private investment and its trade-offs:** Private investment is an essential component of grid financing, helping to alleviate pressure on public budgets while introducing innovation and administrative efficiency. However, higher financing costs from private investors—especially when returns on equity are high—can increase grid tariffs for consumers. Policymakers must balance the need for private capital with measures to keep grid costs manageable.
- **Public financing as a cost-effective alternative:** National public financing offers a viable and cost-effective mechanism for funding grid investments, as governments benefit from lower borrowing costs than private entities. However, public budgets are often constrained, especially during economic downturns, limiting the ability to rely solely on government financing.
- **State ownership for strategic control:** Public ownership of transmission and distribution networks can enhance regulatory control and lower financing costs. However, the risk of bureaucratic inefficiencies and political interference must be carefully managed. The failed attempt by Germany to acquire TenneT highlights the complexities of state ownership in grid expansion.
- **Infrastructure funds as a flexible solution**: Infrastructure funds, particularly public-private partnerships, can provide flexibility and access to additional capital, reducing costs for consumers. These funds allow investment without adding to public debt constraints but require strong governance to prevent inefficiencies and ensure cost-effectiveness.
- **Need for a mixed approach:** No single financing model is sufficient to meet future grid investment needs. A diversified strategy—combining private investments, public funding, EU-level support, and innovative financing mechanisms like infrastructure funds—will be essential to balance cost efficiency, affordability, and long-term sustainability. Ultimately, a balanced mix of these financing mechanisms, tailored to the economic, political, and social contexts of each European country, will be critical in ensuring a resilient, sustainable, and modernized electricity grid.

Table 1: Overview of different financing mechanisms

	Advantage	Challenge/Disadvantage
Private capital and loans	• Private capital is utilised. • No burden on public budgets. • No dependency on political decisions.	• High interest rates and return on equity will drive up costs of the grid. • Creditworthiness can be limited if the volume of borrowed capital increases.
EU-level financing	• Low cost of borrowing. • Financial security and de-risking private investment.	• Limited funds. • Not all countries are eligible. • High level of bureaucracy.
State Ownership	• Lowering financial burden on consumers. • Ensuring strategic alignment of critical infrastructure.	• Risk of political interference and bureaucratic inefficiencies. • Burden on the federal budget.
Infrastructure Funds	• Insurance of the state while utilizing private capital. • Favorable borrowing conditions.	• Returns for investors can be high, burdening the consumers. • Risk of mismanagement and bureaucratic inefficiencies.

5 Grid tariff design principles to incentive flexibility and grid financing while ensuring the most vulnerable are protected.

In many countries, costs associated with maintaining, modernizing, and expanding the electricity grid are passed on to consumers through grid tariffs. In 2023, EU households paid an average of €0.29/kWh, with grid tariffs making up approximately 25% of the total electricity price. However, significant variations exist between countries (Heinrich Böll Stiftung/Green European Foundation 2024).

As demand for grid investments increases, these costs could rise further, leading to affordability and equity challenges.

To tackle these challenges, grid tariff design must evolve to achieve three key objectives: incentivizing system-friendly consumption, ensuring cost-reflectivity and financial stability, and protecting vulnerable consumers (eurelectric 2021; Stute/Klobasa 2024).

5.1 Key Principles for Grid Tariff Design

Incentivizing system-friendly consumption

Tariffs should encourage consumers to adopt system-friendly consumption patterns by providing price signals that reflect the grid's capacities and limitations. This approach can optimize grid utilization, reduce peak loads, and defer costly infrastructure expansion (eurelectric 2021).

Ensuring cost-reflectivity

Grid tariffs should accurately reflect the true costs of grid usage and provide a stable and predictable revenue stream to finance necessary investments. This requires balancing fixed and variable cost components to ensure fair cost allocation and financial sustainability (European Parliament/Council of the European Union 2024).

Protecting vulnerable households

Grid tariffs must also be designed in a way to protect vulnerable consumers who lack the means to shift their demand or invest in energy-efficient appliances. Fair cost allocation mechanisms are essential to maintain affordability and prevent excessive financial burdens on low-income households (Heinrich Böll Stiftung/Green European Foundation 2024).

5.2 Grid Tariffs in Germany

5.2.1 Standard Grid Tariff Structure

German household grid tariffs consist of two main components:

- **Base charge (€/year):** A flat fee that applies equally to all households, irrespective of their consumption.
- **Fixed volumetric charge (€/kWh):** A rate based on electricity consumption.

The variable charge per kWh consumed makes up much of the price, hence it is considered a volumetric system.

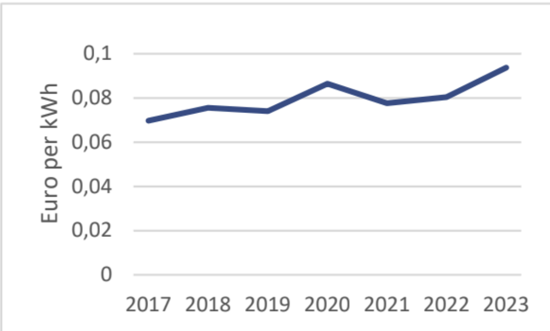
Industrial customers in Germany pay individually calculated grid tariffs, which consider factors such as maximum power demand, voltage level, and energy consumption (Stute/Klobasa 2024).

5.2.2 Development of Grid Tariffs

In 2023, grid tariffs in Germany amounted to approximately €22.6 billion. These tariffs are regulated by a revenue cap framework to ensure cost efficiency and fair returns for grid operators. The average household grid tariffs in 2024 were €0.1162/kWh, accounting for 28% of the total electricity price. Over the past years, grid tariffs in Germany increased from 0,07 Euro per kWh in 2017 to 0,09 Euro per kWh in 2023 (see Figure 5).

Until 2025 grid tariffs used to fluctuate significantly between regions, due to factors such as grid capacity, population density and amount of renewable energy generation (EnBW 2024). Starting from January 2025 regional differences will be equalized among regions (Bundesnetzagentur 2024b).

Figure 5: Development of grid tariffs in Germany (annual consumption 2 500 kWh – 4 999 kWh)



5.2.3 Introduction of Time-Variable Tariffs

From April 1, 2025, German consumers will have the option to select time-variable grid tariffs as an alternative to existing flat-rate grid charges. These tariffs include high, standard, and low tariff periods throughout the day, encouraging consumption shifts to low-tariff periods to reduce peak demand and optimize grid utilization. According to the regulations in § 14a of the Energy Industry Act (Energiewirtschaftsgesetz), grid operators have the authority to control these consumption devices in the event of grid overload, ensuring a stable and efficient power supply. Consumers can choose between a flat-rate reduction or a percentage reduction in their energy price, with additional time-variable tariffs becoming available from April 2025 to provide greater flexibility and cost savings (FfE 2024).

5.2.4 Impacts and Challenges

Germany's volumetric grid tariff model primarily incentivizes reducing overall consumption, supporting energy efficiency goals. However, the introduction of variable tariffs for electric vehicle charging marks a step toward incentivizing flexible consumption. Despite this progress, the current design has been criticized for its low cost-reflectiveness, as the mainly volumetric charge does not accurately reflect contributions to grid costs, which are predominantly driven by peak demand. Additionally, it presents equity challenges: The base charge disproportionately affects low-income households by applying a uniform fee while households with solar panels, which are often wealthier, are able to significantly reduce their contribution to the system, exacerbating social inequalities.

5.3 Grid Tariffs in Poland

5.3.1 Standard grid tariff design

Poland's household grid tariffs also consist of two primary components:

- Base charge (PLN/year): A fixed fee that applies regardless of consumption.
- Volumetric charge (PLN/kWh): A consumption-based fee.

Unlike Germany, Polish consumers can choose from various tariff groups to better suit their consumption patterns. The most popular option is the G11 tariff, which offers a fixed electricity price irrespective of the time of day or week (single-zone tariff). Other available tariff options include:

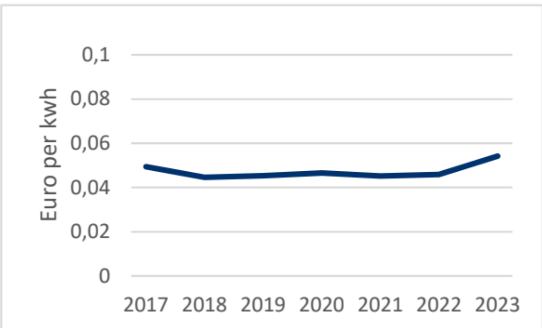
- G12: A two-zone tariff with lower rates at night and higher rates during the day.
- G12r: Similar to G12 but with additional reduced rates for premises and water heating.
- G12w: Provides lower electricity rates during nights and weekends.
- Special tariffs: Certain distribution system operators (DSOs), such as ENEA and TAURON, offer customized tariffs with varying time zones and rates tailored to specific consumer needs.

Additionally, larger consumers are subject to capacity-based elements that align costs with peak grid usage, ensuring a fair distribution of infrastructure expenses.

5.3.2 Developments of grid tariffs in Poland

Between 2022 and 2024, grid tariffs and retail electricity prices for household customers and small and medium enterprises in Poland were regulated by a price cap. From 2023 to 2024, distribution grid tariffs for end consumers increased by an average of 2.9% (URE 2023). However, due to the price cap, this adjustment primarily affected consumers who exceeded the consumption limits defined in the law of October 7, 2022. For those below the threshold, the lower distribution tariffs based on the 2022 tariffs remained in effect until June 2024. In 2023, the electricity price was frozen at the 2022 level of PLN0,412/kWh (net), with a partial unfreeze introduced in mid-2024 (ING 2024). The official tariff set by the Energy Regulatory Office (URE) for 2024 stands at PLN0,623/kWh, but the government imposed a cap of PLN0,500/kWh until the end of 2024 and suspended the capacity charge during this period. In December 2024, the Polish government extended these protective measures into 2025 to prevent retail prices from rising to the official tariff level of PLN0,623/kWh (see Figure 6).

Figure 6: Development of grid tariffs in Poland (2 500 kWh - 4 999 kWh)



5.3.3 Incentives for flexible use

In 2024, Poland introduced pilot programs for time-variable tariffs to incentivize off-peak consumption and reduce peak load strain. These tariffs include differentiated price periods throughout the day, encouraging consumers to shift demand to lower-cost hours.

5.3.4 Impacts

Poland's grid tariff system, like Germany's, primarily follows a volumetric pricing model, which encourages overall reductions in electricity consumption. This supports energy efficiency goals but does not sufficiently incentivize system-friendly consumption patterns or the efficient use of grid infrastructure. The introduction of dynamic price elements, which began in 2024, has the potential to improve flexibility in electricity demand, but its full impact remains to be seen.

Similar to the German model, Poland's volumetric tariff structure has been criticized for its low cost-reflectiveness. Since grid costs are largely driven by peak demand rather than overall electricity consumption, this model does not adequately align individual consumer contributions with their actual impact on grid infrastructure. As a result, consumers who reduce their total energy use but still rely on the grid during peak periods do not contribute proportionally to the cost of maintaining and expanding the network.

The Polish tariff system also presents equity challenges. Fixed charges can disproportionately burden low-income households, which typically have lower electricity consumption but pay the same base fee as wealthier households. As Poland moves towards greater tariff differentiation and the integration of dynamic pricing mechanisms, ensuring both cost-reflectiveness and social fairness will be critical to avoiding unintended distributional effects.

5.4 Evaluating Grid Tariff Design Options for Achieving Energy Policy Goals, Revenue Stability and Equity.

The design of grid tariffs plays a critical role in shaping energy consumption patterns, ensuring grid stability, and distributing costs fairly among consumers. This chapter explores various tariff design options, evaluating their potential to achieve the objectives laid out in chapter 5.1.

Generally, grid tariffs consist of two or more components, which are fixed charges (€/point of delivery), capacity-based charges (€/kW), and volumetric charges (€/kWh) (Lu/Price 2018).

5.4.1 Volumetric tariff design

Volumetric tariffs charge consumers based on the total amount of electricity consumed, making them the most common tariff structure across European grid systems. Their simplicity and predictability provide a stable revenue stream for grid operators, ensuring cost recovery for grid maintenance and expansion. Additionally, volumetric pricing encourages overall energy efficiency, as consumers have a direct financial incentive to reduce electricity consumption.

However, tariffs that are exclusively or largely volumetric do not accurately reflect the primary cost drivers of the grid. Grid expansion and maintenance costs are largely determined by peak demand rather than overall electricity consumption. Because volumetric tariffs apply a uniform price per kilowatt-hour regardless of when electricity is used, they do not provide incentives for consumers to shift demand away from peak times. This can result in inefficient grid use and an underinvestment in demand-side flexibility.

Furthermore, volumetric pricing can result in an unfair distribution of costs. Consumers with low overall electricity consumption but high peak demand may not contribute adequately to grid costs, while households with consistently high electricity use may face disproportionately high charges. This structure does not account for the flexibility potential of certain technologies, such as heat pumps and electric vehicles, which, if properly incentivized, could help reduce grid strain by shifting consumption to off-peak hours (eurelectric 2021). Additionally, households with solar PV systems can significantly lower their grid payments, even though they still rely on the grid during peak demand periods. This shifts the financial burden onto consumers without access to self-generation technologies, exacerbating social inequalities. (Azarova et al. 2018; Wang et al. 2022).

As energy systems evolve and peak demand becomes a more pressing concern, future tariff structures should integrate elements that better reflect grid usage patterns. This could include a combination of volumetric charges with capacity-based or time-of-use components to improve cost-reflectiveness, incentivize demand flexibility, and ensure a fair allocation of grid costs.

5.4.2 Capacity-Based Tariff Design

Capacity-based tariff components charge consumers based on their peak demand during a specified period, aligning grid costs with capacity requirements.

Capacity-based pricing effectively supports energy policy goals by encouraging demand reduction during peak times and improving grid efficiency. These tariffs generate stable and predictable revenues, as peak loads are a key driver of grid costs. However, they may disproportionately affect vulnerable households with limited flexibility to shift consumption, potentially increasing financial inequality if not accompanied by compensatory measures (Wang et al. 2022).

Capacity tariffs can lead to higher bills for certain consumers, such as public EV charging stations, which may have low utilization but require significant capacity (eurelectric 2021).

5.4.3 Time of Use tariffs

Time-of-Use (ToU) tariffs charge different prices for volumetric consumption at different times of the day, week, or year. They can be static (fixed periods based on historical data) or dynamic (adjusted in real-time based on grid demand)(Lu/Price 2018; Wang et al. 2022).

ToU tariffs are highly effective in integrating renewable energy and enhancing grid efficiency by encouraging consumers to align their usage with renewable generation peaks. Although they introduce revenue variability, well-designed pricing models can mitigate these challenges. Wealthier households, better equipped with automation technologies, may benefit more, potentially increasing inequalities. Nevertheless, indirect benefits such as lower system costs can offset some of these disparities (Agora Energiewende/Forschungsstelle für Energiewirtschaft e. V. 2023; Bergaentzlè et al. 2023; Stute/Klobasa 2024).

Strategic pricing models, such as critical peak pricing, can reduce grid reinforcement needs and help renewable integration. However, implementation requires substantial data availability and advanced metering infrastructure. Flexibility markets can complement static ToU tariffs to manage grid congestion effectively (eurelectric 2021; FÖS 2024).

A condition for any dynamic pricing model is the availability of smart meters. Smart meters are essential for implementing dynamic time-of-use tariffs, as they enable real-time data collection and communication between consumers, grid operators, and energy suppliers. Unlike traditional analog or digital meters, smart meters consist of a modern measuring device and a smart meter gateway, which transmits electricity consumption data securely and allows for remote monitoring and management. This capability is crucial for dynamic pricing, as it ensures that consumers are charged based on real-time grid conditions, encouraging demand shifts to off-peak periods. Without smart meters, it would be impossible to accurately track and apply varying electricity prices throughout the day. However, the rollout of smart meters across Europe varies significantly: while countries like Sweden and Spain have already achieved full smart meter deployment, adoption remains low in Germany (1%) and Poland (12%), highlighting a major barrier to the widespread introduction of dynamic tariffs (GridX 2024).

5.4.4 Progressive Tariffs

Progressive grid tariffs adjust electricity rates based on consumption levels or income brackets, aiming to alleviate financial burdens on low-income households while maintaining predictable revenue streams for grid operators. Two main models illustrate how such a system could be implemented.

In the first model, each household receives a baseline allocation of electricity at a lower rate, covering a percentage of the typical consumption for its household size. This could be structured as either fixed monetary credit or a specific energy allowance. Households consuming below their allocated baseline could potentially receive a rebate for unused electricity, which could also serve as an incentive for self-generation through solar PV systems. The second model introduces a tiered pricing system where households pay a lower base rate for essential consumption, with rates progressively increasing for additional usage. For example, a two-person household might receive 70% of the average consumption at a base rate of 20 ct/kWh, with higher rates of 50 ct/kWh and 80 ct/kWh applying beyond set thresholds, and consumption exceeding 140% classified as luxury use at 120 ct/kWh. Such an approach ensures basic needs are met affordably while discouraging excessive consumption (Konzeptwerk neue Ökonomie 2022).

A key advantage of progressive tariffs is that they subsidize essential electricity use while charging higher rates for increased consumption. This enables cross-subsidization, where higher-tier users contribute to reducing the cost burden on lower-tier consumers. Furthermore, individual household circumstances can be considered, ensuring a more tailored and equitable system. By guaranteeing affordable access to essential electricity, progressive tariffs could alleviate anxieties about rising energy costs and prevent political backlash that might otherwise favor continued fossil fuel investments. In addition, reducing overall electricity demand supports the energy transition by lowering infrastructure expansion costs and easing reliance on renewable energy sources, which remain limited in the short term. Importantly, progressive tariffs could be combined with capacity-based or time-of-use pricing, aligning social fairness objectives with incentives for system-friendly electricity consumption (Konzeptwerk neue Ökonomie 2022).

However, these models also present challenges. The second model, with its multiple pricing tiers, introduces significant complexity, making it difficult for consumers to predict and manage their energy bills. Even the first model, which applies subsidies broadly, risks being costly if not carefully designed, as it provides financial support to all households regardless of need. Another concern is that penalizing higher consumption could conflict with electrification goals. As households transition from fossil-fuel heating and combustion engines to electric alternatives such as heat pumps and electric vehicles, high electricity usage may not necessarily indicate inefficiency but rather sustainable energy use. Addressing this would require exemptions or additional allowances for electric vehicle charging, further complicating tariff structures.

Overall, progressive tariffs offer a promising mechanism for reducing the burden of grid costs on households, but their practicality and complexity must be carefully assessed. The direct impacts will depend on the specific design of the system, including the thresholds, cross-subsidization levels, and potential exemptions for electrification-related consumption. Further research is needed to explore how progressive elements could be effectively integrated with capacity-based or time-of-use tariffs to balance social fairness with system efficiency.

Nevertheless, direct financial support, such as subsidies or energy vouchers, is often recommended as a more effective solution for addressing energy poverty without influencing consumption behavior. Ensuring that financial transfers adequately meet the energy needs of vulnerable households is essential to achieving social and economic objectives while maintaining market efficiency (Dobbins et al. 2016; eurelectric 2021).

5.4.5 Key takeaways

- **Grid tariff design shapes consumer behavior and cost distribution:** The structure of grid tariffs significantly impacts energy consumption patterns, grid stability, and cost allocation among consumers. A well-designed tariff system should balance cost-reflectiveness, affordability, and incentives for efficient grid use.
- **Volumetric tariffs provide stability but lack Cost-reflectiveness:** Volumetric tariffs, the most widely used model, offer simplicity and predictable revenue streams. However, they do not reflect actual grid costs, which are driven by peak demand rather than total energy consumption. This can lead to inefficient grid use and an unfair distribution of costs, especially as consumers with low total usage but high peak demand may not contribute adequately to grid financing.
- **Capacity-based tariffs align costs with peak demand but raise equity concerns:** By charging based on maximum power usage, capacity-based tariffs encourage consumers to reduce peak demand, which supports grid stability. However, they can disproportionately impact low-income households and certain users, such as EV charging stations with low utilization but high capacity needs.
- **Time-of-use tariffs promote flexibility and renewable integration:** Time-variable tariffs, which adjust prices based on demand fluctuations, can incentivize consumers to shift usage to off-peak periods, improving grid efficiency and supporting renewable energy integration. However, they depend on smart meter adoption, which varies widely across Europe, with some countries nearing full deployment and others lagging behind.
- **Progressive tariffs enhance affordability but introduce complexity:** Progressive grid tariffs, which increase rates based on consumption levels or income brackets, can reduce financial burdens on low-income households and support equitable cost distribution. While they can provide security for basic electricity needs, they introduce administrative complexity and may conflict with electrification goals unless tailored exemptions are incorporated.
- **Multiple tariff elements should be combined:** No single tariff structure can address all challenges. A mix of volumetric, capacity-based, and time-of-use pricing—potentially combined with progressive elements—could balance fairness, cost-reflectiveness, and incentives for flexibility. However, careful design is required to avoid unnecessary complexity.
- **Direct financial support may be more effective for addressing energy poverty:** While progressive tariffs offer a means of redistributing costs, direct financial support such as targeted subsidies or

energy vouchers may be a more efficient way to protect vulnerable households without distorting consumption behavior. Ensuring that financial assistance meets the actual energy needs of low-income consumers remains a key priority for equitable tariff design.

Table 2: Overview of different tariff design options

	Incentivizing system-friendly consumption	Ensuring Cost-reflectivity	Protecting vulnerable households
Volumetric	Limited alignment with policy goals.	Insufficiently.	Generally fair, but potentially inequitable for non-PV households.
Capacity-based	Promotes efficient grid use and reduces peak demand.	Grid users are charged according to their burden on the grid.	May disproportionately burden inflexible households.
Time-variable	Supports renewable integration and grid efficiency.	Grid users are charged according to their burden on the grid.	Risks inequity unless safeguards are in place.
Progressive	Weak alignment with grid efficiency.	Cost-reflectivity could be achieved through combining progressive elements with capacity-based or time-variable design elements.	Highly equitable for low-income households.

6 Recommendations

A resilient, affordable, and modern electricity grid is essential for Europe's energy transition. Ensuring sustainable financing and fair cost distribution requires a balanced approach, combining multiple financing mechanisms and well-designed tariff structures. Policymakers must carefully navigate the trade-offs between investment needs, consumer affordability, and grid efficiency.

Grid tariffs vary significantly across EU Member States, reflecting differences in grid infrastructure, ownership models, and regulatory frameworks. While some countries maintain relatively low grid tariffs, others, particularly in Central and Eastern Europe (CEE), experience a higher financial burden due to lower average incomes. As grid expansion and modernization needs to increase, ensuring that investment costs remain affordable for consumers is critical. Without careful planning, rising grid tariffs could disproportionately impact vulnerable households, exacerbating energy poverty.

Grid financing strategies must strike a balance between attracting investment and maintaining affordability. Private capital is an essential component of grid financing, helping to alleviate pressure on public budgets while introducing innovation and administrative efficiency. However, reliance on private investment can increase consumer tariffs, particularly if returns on equity are high. Public financing offers a cost-effective alternative, leveraging lower government borrowing rates, but is often constrained by budgetary limitations. EU funding mechanisms provide an additional avenue for financing, though accessibility and eligibility requirements can pose challenges. Infrastructure funds, especially public-private partnerships, present a flexible solution that can combine public oversight with private sector efficiency.

Grid tariff design plays a central role in shaping energy consumption patterns, ensuring grid stability, and distributing costs fairly. No single tariff model can address all challenges. Volumetric tariffs are the most widely used, offering simplicity and revenue predictability. However, they fail to reflect the real cost drivers of the grid, which are largely determined by peak demand. Capacity-based tariffs align costs more closely with peak loads but may disproportionately affect certain consumer groups. Time-of-use tariffs incentivize flexible electricity consumption, supporting renewable energy integration, but require widespread smart meter adoption. Progressive tariffs offer a way to alleviate cost burdens on low-income households, but they introduce complexity and may conflict with electrification goals.

A well-balanced grid tariff system should mix and match different design aspects based on national circumstances, grid needs, and technological capabilities. The availability of smart meters is a crucial factor in determining whether time-of-use pricing can be implemented effectively. Additionally, social policies should complement tariff design to ensure energy affordability without distorting incentives for efficient electricity use.

Recommendations

1. Diversified Grid Financing Approach:

- A mix of public and private investments should be used to balance affordability with investment needs.
- Recommendations for financing models will vary depending on each country's specific circumstances, such as current grid ownership structures and regulatory frameworks. Policymakers must tailor their financing choices to national conditions to ensure the most effective and sustainable outcomes.

2. Fair and Efficient Grid Tariff Design:

- No single tariff design can fully achieve all policy goals. A balanced approach, combining volumetric, capacity-based, and time-of-use pricing elements, should be adopted according to national grid needs, smart meter availability, and country-specific conditions.
- Time-of-use and flexible tariff structures should be incorporated where feasible, as they will be critical for improving renewable energy integration in the long run.
- Smart meter rollout should be accelerated to enable dynamic pricing and enhance grid efficiency.

3. Targeted Financial Support for Vulnerable Consumers:

- Progressive tariffs should be considered and further analyzed as a potential tool to alleviate cost burdens on low-income households. However, their complexity and potential effects on electrification should be carefully evaluated.
- Our recommendation is to adjust and improve social policies to combat energy poverty, ensuring that financial assistance is well-targeted and adequately meets the energy needs of vulnerable

consumers without distorting consumption behavior.

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