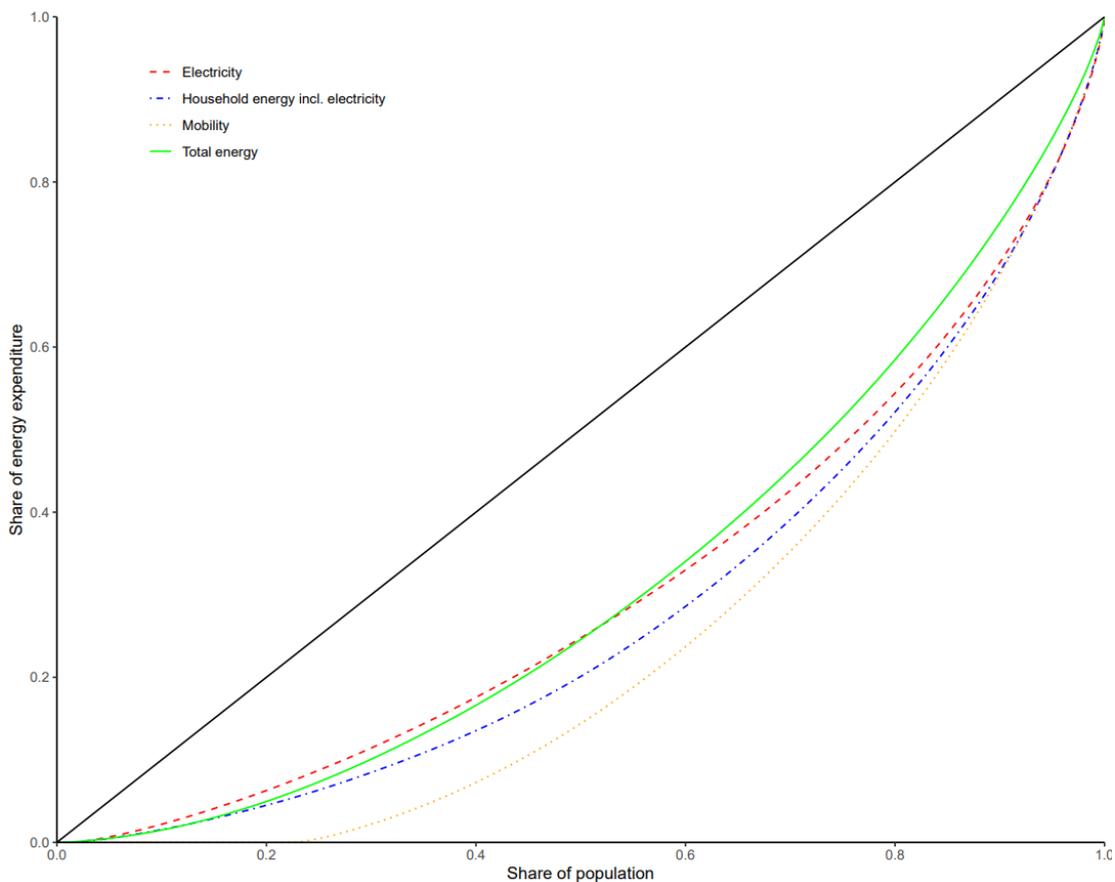




Interim report dated 01.12.2023

# Distribution of energy related living expenditures and likelihood of living in polluted areas: An analysis using European-wide household survey data



**Source:** Authors calculation. The Lorenz curves illustrate the energy expenditure inequalities for different energy categories. On the x axis households are ordered by energy expenditure levels from low to high. The y axis depicts the cumulative share of total energy expenditures in Switzerland. Therefore, the higher the degree of convexity, the higher the respective inequality. Total equality is represented by the 45 degree line.



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**The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.**



## Zusammenfassung

Im Verlauf des ersten Projektjahres haben wir uns eingehend mit der Verteilung der wohnbezogenen Energieausgaben in Haushalten befasst. Diese Analyse wurde mithilfe von Daten aus den Haushaltsbudgeterhebungen der Schweiz und weiterer europäischer Länder durchgeführt, wobei auch Informationen zu Energiepreisen und Schätzungen der Energiepreiselastizitäten einbezogen wurden. Unser Ziel besteht darin, die Auswirkungen der jüngsten Energiepreiserhöhungen auf die Verteilung der Energieausgaben in Haushalten unterschiedlicher Einkommensgruppen zu quantifizieren. Hierzu bedienen wir uns Energie-Gini-Koeffizienten und Lorenzkurven. Diese Berechnungen wurden für verschiedene europäische Länder durchgeführt, was einen länderübergreifenden Vergleich ermöglichte. Zudem setzten wir den Atkinson-Index und den Theil-Index ein, um die Robustheit unserer Ergebnisse bei verschiedenen Spezifikationen zu überprüfen.

Diese Vorgehensweise ermöglicht zu verdeutlichen, wie umweltpolitische Maßnahmen im Allgemeinen, insbesondere solche, die Kohlenstoff bepreisen und zu einer Erhöhung der Energiepreise führen, die Verteilung der Energieausgaben zwischen Haushalten beeinflussen können. Darüber hinaus quantifizieren wir die zeitliche Entwicklung des Anteils der Energieausgaben am verfügbaren Äquivalenzeinkommen für jede Einkommensquintile in den betrachteten Ländern.

Diese Forschungsarbeit trägt generell dazu bei, mithilfe von anerkannten Indizes zur Berechnung der Einkommensungleichheit, ein genaueres Bild über die Ungleichheit im Bereich der Energieausgaben von Haushalten in verschiedenen europäischen Ländern zu zeichnen. Die ersten Ergebnisse präsentierten wir im September 2023 auf der Jahrestagung des Vereins für Sozialpolitik.

Die Ergebnisse verdeutlichen, dass die Ungleichheit der Energieausgaben in Europa im Jahr 2020, gemessen am Gini-Index, zwischen 0,44 (Frankreich) und 0,25 (Slowakei) variierte. Der Gini-Index in Bezug auf Gesamtenergieausgaben für Wohnen und Mobilität lag in der Schweiz 2017 bei 0,37. Bei einem Vergleich des Schweizer Werts mit den Gini-Koeffizienten aller 19 betrachteten europäischen Länder wiesen lediglich vier Länder höhere Werte auf. Die Schweiz zählt somit gemessen am Gini-Koeffizienten für Gesamtenergieausgaben zu den Top 25% der Länder mit der ungleichsten Verteilung der Energieausgaben zwischen Haushalten verschiedener Einkommenskategorien. Der Median der Gini-Koeffizienten für Gesamtenergieausgaben betrug im Jahr 2020 0,326.

Eine Differenzierung der Gini-Koeffizienten für verschiedene Komponenten der Energieausgaben ergab einen Wert von 0,37 für Stromausgaben in der Schweiz im Jahr 2017, während die Verteilung der Mobilitätsausgaben generell etwas ungleicher ausfiel, dies aufgrund der Tatsache dass einige Haushalte kein Auto besitzen.

Unter den getroffenen Annahmen zeigen die jüngsten Erhöhungen der Energiepreise nur einen geringfügigen Anstieg der Ungleichheit der Wohnenergieausgaben in der Schweiz (von 0,43 im Jahr 2017 auf 0,45 im Jahr 2023). Dennoch lässt sich in allen betrachteten Ländern ein deutlicher Anstieg des Anteils der Energieausgaben am verfügbaren Einkommen über alle Einkommensquintile hinweg verzeichnen. In der Schweiz schätzen wir einen Anstieg auf 9,5% für das niedrigste Quintil (von 8,6% im Jahr 2017) und auf 3,1% für das höchste Quintil (von 2,6% im Jahr 2017). Der Mediananteil der Gesamtenergieausgaben am Einkommen betrug im Jahr 2023 23,6% für das niedrigste und 11% für das höchste Einkommensquintil. Damit liegt der Anteil der Energieausgaben am Einkommen für die ärmsten Schweizer Haushalte sogar unter dem Mediananteil für die reichsten Haushalte in den übrigen 19 europäischen Ländern.

## Résumé

Dans le cadre du projet, au cours de la première année de la durée du projet, nous avons examiné la répartition des dépenses énergétiques des ménages liées au logement. L'analyse a été réalisée à l'aide



de données provenant des enquêtes budgétaires des ménages suisses et européennes, ainsi que des informations sur les prix de l'énergie et des estimations des élasticités des prix de l'énergie. L'objectif de l'étude est de quantifier les effets des récentes augmentations des prix de l'énergie sur la répartition des dépenses énergétiques parmi les ménages de différents groupes de revenus à l'aide des coefficients de Gini de l'énergie et des courbes de Lorenz. Ces calculs sont effectués pour différents pays européens, permettant ainsi une comparaison de la situation entre les pays. Ces calculs sont également réalisés en utilisant différents indices tels que l'indice d'Atkinson et l'indice de Theil pour vérifier si les résultats restent robustes. Cette approche peut généralement être appliquée pour illustrer comment les politiques environnementales en général, qui tarifient le carbone et entraînent ainsi une augmentation des prix de l'énergie, influent sur la répartition des dépenses énergétiques entre les ménages. De plus, nous illustrons l'évolution temporelle de la part des dépenses énergétiques dans le revenu équivalent disponible pour chaque quintile de revenu dans les pays étudiés. En général, cette recherche contribue à fournir une image plus précise de l'inégalité des dépenses énergétiques des ménages dans différents pays européens en utilisant les indices d'inégalité des revenus reconnus dans la littérature. Les premiers résultats ont été présentés lors de la Réunion annuelle de l'Association allemande d'économie en septembre 2023. Les résultats montrent que l'inégalité des dépenses énergétiques en Europe, mesurée par l'indice de Gini, varie de 0,44 (France) à 0,251 (Slovaquie). En 2017, l'indice de Gini pour les dépenses énergétiques totales liées au logement et à la mobilité en Suisse était de 0,37. Lorsque l'on compare la valeur suisse aux coefficients de Gini de l'ensemble des 19 pays européens considérés, seuls 4 pays ont des valeurs plus élevées. Ainsi, la Suisse, en termes de coefficient de Gini lié aux dépenses énergétiques totales, fait partie des 25 % de pays présentant la répartition la plus inégale des dépenses énergétiques entre les ménages. Une différenciation des coefficients de Gini pour différentes composantes des dépenses énergétiques donne également une valeur de 0,37 pour les dépenses d'électricité en Suisse en 2017, tandis que la répartition des dépenses liées à la mobilité est généralement légèrement plus inégale dans les pays, principalement parce que certains ménages ne possèdent pas de voiture. Dans le cadre des hypothèses formulées, les récentes augmentations des prix de l'énergie n'ont entraîné qu'une légère augmentation de l'inégalité des dépenses énergétiques résidentielles en Suisse (passant de 0,43 en 2017 à 0,45 en 2023). Néanmoins, dans l'ensemble des pays examinés, on peut estimer une augmentation significative de la part des dépenses énergétiques par rapport au revenu disponible, quel que soit le quintile de revenus. En Suisse, nous estimons une augmentation à 9,5 % pour le quintile de revenus le plus bas (contre 8,6 % en 2017) et à 3,1 % pour le quintile de revenus le plus élevé (contre 2,6 % en 2017).

## Summary

During the first year of the project, our empirical investigation focused on the distribution of housing-related energy expenditures. We utilized data from the Swiss and European household budget surveys, incorporating information on energy prices and estimates of energy price elasticities. The primary objective was to quantify the impact of recent energy price increases on the distribution of energy expenditures among households across different income groups, employing energy Gini coefficients and Lorenz curves. This analysis spanned various European countries, enabling cross-country comparisons. Additionally, we computed the Atkinson Index and the Theil Index to test the robustness of our results under different specifications.

This approach also allowed us to illustrate how environmental policies, particularly those pricing carbon and resulting in increased energy prices, influence the distribution of energy expenditures among households. Moreover, we depicted the temporal evolution of the share of energy expenditures in disposable equivalent income for each income quintile in the countries under consideration.

The initial results, presented at the Annual Meeting of the German Economic Association in September 2023, highlighted that the inequality of energy expenditures in Europe, as measured by the Gini Index,



ranged from 0.44 (France) to 0.251 (Slovakia). When comparing Switzerland to the Gini coefficients for all 19 European countries, only four had higher values. Consequently, Switzerland ranks in the top 25% of countries with the most unequal distribution of energy expenditures between households in terms of the Gini coefficient for total energy expenditures, with a median Gini coefficient of 0.326 in 2020. Further differentiation of Gini coefficients for different components of energy expenditures revealed a value of 0.37 for electricity expenditures in Switzerland in 2017. The distribution of mobility expenditures tended to be slightly more unequal in countries, primarily due to some households not owning a car. Under the assumptions made, recent increases in energy prices resulted in only a marginal uptick in the inequality of residential energy expenditures in Switzerland, rising from 0.43 in 2017 to 0.45 in 2023. Nevertheless, across all examined countries, a substantial increase in the share of energy expenditures as a proportion of disposable income was observed for all income quintiles. In Switzerland, estimates indicate an increase to 9.5% for the lowest quintile (from 8.6% in 2017) and 3.1% for the highest quintile (from 2.6% in 2017). The median share of total energy expenditures in income amounted to 23.6% for the lowest income quintile and 11% for the highest income quintile in 2023. Consequently, the share of energy expenditures in income for the poorest Swiss households is even below the median share for the richest households in the remaining 19 European countries.



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# Abbreviations

Not yet applicable.

## 1 Introduction

### 1.1 Background information and current situation

Policymakers worldwide are currently prioritizing climate change mitigation and energy security. The aftermath of the pandemic, coupled with the geopolitical repercussions of the Ukraine-Russia conflict, has significantly impacted energy markets, resulting in notable price increases. The equity dimension of these rising energy prices is a crucial focus in climate change and the transition of modern energy systems to renewables. Policies aimed at addressing environmental externalities, such as carbon pricing, often lead to increased energy and downstream goods costs, raising concerns about their impact on individual welfare and the acceptance of such measures. The energy sector, in particular, faces scrutiny due to potential equity issues arising from escalating energy taxes and regulatory policies. These issues are not novel, as recent government policies globally, aimed at decarbonizing economic sectors, involve carbon or fuel taxes that ultimately elevate the cost of fossil energy sources. The significance of these concerns was evident in events like the 'gilets jaunes' uprising in France in November 2018.

Various strands of literature contribute evidence on the redistributive effects of climate and environmental policies and the transition to renewable energy. In the United States, studies by Burtraw et al. (2009), Hassett et al. (2009), and Fullerton et al. (2011) focus on climate policies, energy poverty, and the energy transition, revealing regressive effects. The OECD's meta study in 2021 also confirms regressive effects of environmental policies. Recent papers delve into energy inequality and the interplay between efficient energy provision (Menyhert et al. (2022), Kroeger et al. (2023)) and energy poverty, shedding light on the impact of energy expenditures on lower-income households (Drescher & Janzen (2021), D. Wu et al. (2017), Halkos & Gkampoura (2021)). Previous studies have computed inequality indices for energy expenditure in individual countries and specific years (Jacobson et al. (2005), Oswald et al. (2020), D. Wu et al. (2017)). However, our analysis fills a gap by computing these measures for multiple European countries, allowing for more comprehensive comparisons. Additionally, Gini energy expenditure inequality indices have not been calculated for Switzerland overall or its seven major statistical regions. Thus, our analysis contributes to understanding whether energy price increases significantly impact the inequality of household energy expenditures across income quintiles.

### 1.2 Purpose of the project

This project endeavors to offer insights into the inequality of households' energy expenditure, focusing on Switzerland and several major European economies for comparative analysis. The primary objective is to compute specific energy inequality indices and determine the percentage of income allocated to various types of household energy across income quintiles. This descriptive data aims to shed light on potential energy poverty and inequality, with a particular emphasis on the proportion of income spent on energy by the lowest income group, providing an indicator of potential energy poverty. Comparisons with other European countries enhance the understanding of the Swiss situation in context.

By utilizing energy price trends and energy demand price elasticities, we project energy consumption in 2023 based on the 2017 consumption levels. This approach enables the assessment of the impact of recent energy price increases on energy inequality and poverty. It also facilitates an examination of the



potential repercussions of heightened energy prices resulting from carbon pricing and the transition to renewable energy sources.

Furthermore, the project aims to illustrate the distribution of benefits arising from the energy transition, specifically in terms of environmental and air quality improvements among different income groups. This facet of inequality is frequently overlooked in the evaluation of the distributional impacts of environmental policies. Consequently, our endeavor is to contribute new evidence regarding the positive outcomes of the energy transition to the existing literature.

### 1.3 Objectives

Energy policies commonly aim to achieve multiple objectives, including emissions reduction, the promotion of renewable energy, and the enhancement of energy efficiency. However, the implementation of these diverse policies often encounters resistance, primarily due to concerns within the population regarding potential equity consequences. Therefore, this project is designed to gain a better understanding of how the costs associated with energy policies are distributed among the population.

To achieve this, we aim to quantify the distribution of living expenditures related to energy among households across various income quintiles. Additionally, for the Swiss context, we plan to examine this distribution based on different socio-demographic characteristics, such as retirement status, car ownership, and the language spoken in the household (French, German, Italian). This comprehensive analysis seeks to provide valuable insights into the social and economic implications of energy policy measures and address concerns related to equity and distributional impacts.

## 2 Description of facility

## 3 Procedures and methodology

We leverage data from the Swiss and European Household Budget Surveys (HBS), which offer insights into energy expenditures, income, and various socio-economic variables at the household level. To access this information, we secured permission from the Swiss Federal Office of Statistics for the Swiss HBS dataset and obtained the European HBS data from Eurostat. These cross-sectional surveys cover the years 2006-2017 for Switzerland and 2010, 2015, and 2020 for 19 European countries.

The initial months of 2023 were dedicated to cleaning and preparing the dataset. This process involved, among other tasks, excluding observations with negative expenditure and income values, as well as households with the share of income spent on energy falling below zero or exceeding one. As a result, we established a sample comprising 38,659 observations for Switzerland and 653,950 observations for the remaining 19 European countries.

To project energy expenditures for 2023, given that this data is not yet available, we utilized information on prices for different energy sources (electricity, gas, distance heating, gasoline, and diesel) for 2023. We also incorporated estimates for the price elasticity of energy demand for each energy source across income groups. Elasticities were assigned to observations in the latest available sample period based on net income relative to the distribution within the country. The price elasticity ( $\eta$ ) was approximated as the ratio of the percentage change in energy consumption to the percentage price change. By comparing the price for each energy source in 2023 with the price in 2020, and utilizing information on the price elasticity of demand and the quantity of energy consumed in 2020, we computed the change in



consumption for each energy source. This process allowed us to project the expenditures for each respective energy source (Q) in 2023.

$$\eta = \frac{\frac{dQ}{Q}}{\frac{dP}{P}}$$

$$Q_{2023} = Q_{2020} + \eta * \frac{(P_{2023} - P_{2020})}{P_{2020}} * Q_{2020}$$

However, this method has a drawback: the application of relatively high price elasticities and price increases can lead to an artificially high reduction in energy consumption. Consequently, for some households, this might imply negative expenditures, which is unrealistic. Every household requires a minimum level of subsistence energy consumption to meet basic needs such as lighting, cooking, and heating. While this issue does not arise when using Swiss data—where only households heating with gas may see a significant reduction in consumption due to recent price spikes—it does present a challenge for some European economies. To address this, we need to establish a calibrated minimum subsistence energy consumption level. Therefore, household energy consumption related to housing or electricity comprises two components: a subsistence (threshold) level that is entirely price inelastic and a second part that is price elastic. Incorporating these adjustments is the next step in our methodology. Currently, our projections should be considered a lower bound of true energy expenditures in 2023.

Utilizing survey data, we calculate the average share of income spent on energy (and different energy sources) by income quintile in each country. This analysis highlights variations between countries and income groups. Additionally, we compute the Gini, Atkinson, and Theil Inequality Indices for each country, year, and different energy sources. These indices range from zero to one, with one indicating total inequality and zero indicating total equality. The Gini coefficient tends to be higher for more unequal distributions, while the others are relatively higher for more equal distributions.

All inequality approximations are also calculated using the 2023 expenditure projections. Furthermore, for Switzerland, we compute the energy inequality indices and the shares of income spent on energy for the seven administrative and three language regions. We visually represent the results through Lorenz curves.

## 4 Activities and results

The table below provides calculations for Switzerland, showcasing the Gini index for various energy sources from 2006 to 2017, along with projections for 2023. In the second column, the figures for overall energy consumption (encompassing housing energy and mobility) exhibit only a nearly negligible reduction between 2006 and 2017, followed by a slight increase projected for 2023. Similar patterns emerge when focusing solely on electricity consumption. However, notably higher values are observed when examining housing energy and mobility separately.

*Table 1: Energy Gini coefficients for different energy sources in Switzerland (2006 - 2023)*

Year	Total energy	Housing energy	Electricity	Mobility
2006	0.39	0.49	0.38	0.50
2007	0.39	0.47	0.37	0.49
2008	0.40	0.49	0.38	0.50



2009	0.40	0.48	0.38	0.51
2010	0.39	0.47	0.37	0.51
2011	0.39	0.47	0.37	0.50
2012	0.38	0.48	0.37	0.49
2013	0.39	0.49	0.37	0.49
2014	0.36	0.44	0.38	0.50
2015	0.36	0.44	0.37	0.50
2016	0.36	0.43	0.38	0.50
2017	0.37	0.43	0.38	0.51
2023	0.38	0.45	0.38	0.52

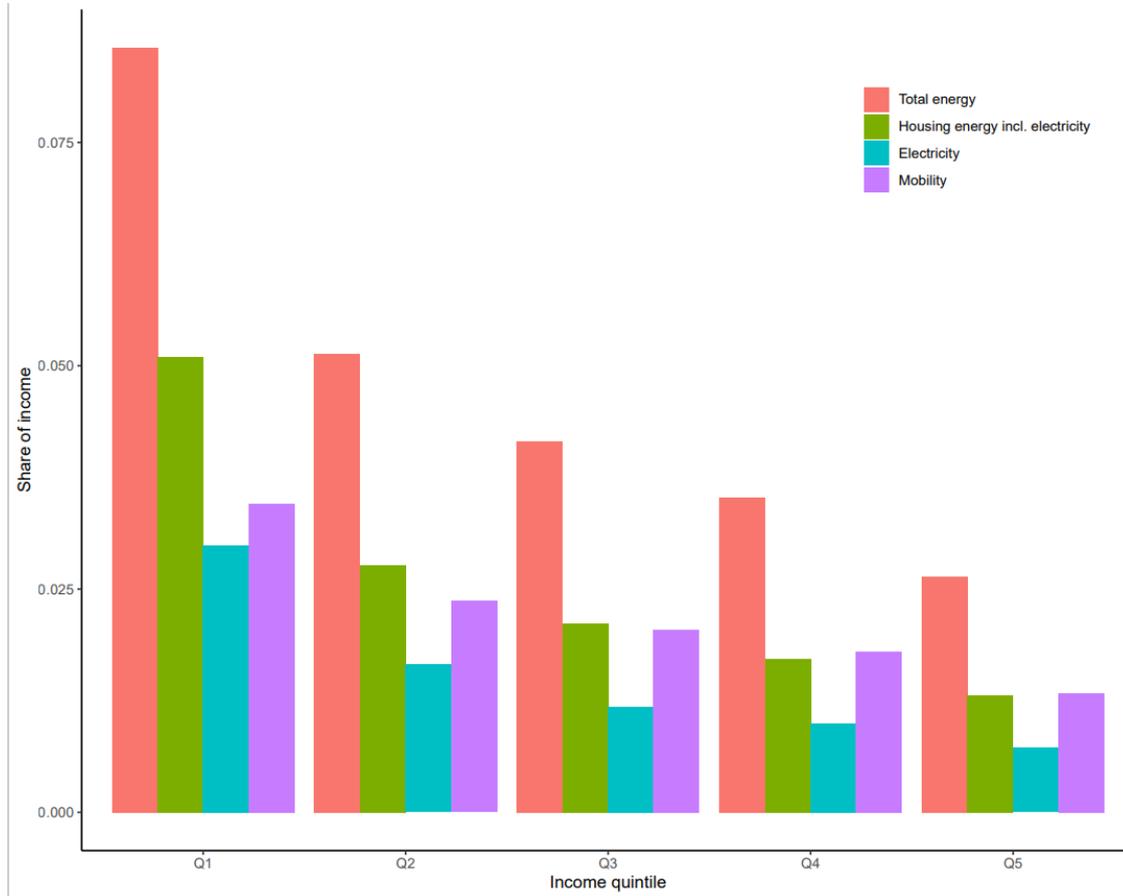
Source: Own calculation based on data from the Swiss Household Budget Survey provided by the Federal Statistics Office and price elasticity estimates for energy of various recent studies. The category total energy expenditures is the sum of housing energy expenditures and mobility (fuel expenditures), while electricity is one component of the housing energy.

We can also compare Switzerland's values with those of other European economies. The total energy inequality in Switzerland falls between the maximum and minimum values in the EU in 2020 (0.444 in France and 0.251 in Slovakia). Notably, only four out of the 19 other European countries analyzed exhibit higher values for the total energy Gini coefficients. This suggests that total energy expenditure inequality in Switzerland ranks among the top 25% of the highest inequality indices.

The figure below illustrates the shares of income spent on energy in Switzerland in 2017. A regressive effect is evident, as the share of income spent on energy is nearly three times larger for the poorest households compared to the richest ones. Projections for 2023 indicate an increase in all calculated shares, although these increases are moderate when compared to other European countries. For example, the share of total energy expenditures for the first income quintile in Switzerland increases from 8.6% to 9.4% between 2017 and 2023. However, in 2020, the share of income spent on energy for the lowest income quintile ranges between 30.1% (Croatia) and 7.5% (Luxembourg). Projected values for 2023 vary between 46.3% (Greece) and 10.4% for Luxembourg. The median share of total energy expenditures in income amounts to 23.6% for the lowest income quintile and 11% for the highest income quintile in 2023. Therefore, the share of energy expenditures in income for the poorest Swiss households is even below the median share for the richest households in the remaining 19 European countries.



Figure 1: Share of income spent on energy for different income quintiles in 2017



Source: Own illustration based on data from the Swiss Household Budget Survey provided by the Federal Statistics Office.

## 5 Evaluation of results to date

The initial findings indicate a relatively consistent energy expenditure inequality in Switzerland, with Gini coefficients falling within the top 25% of values among the analyzed European countries. This suggests a comparatively more unequal distribution of energy expenditures among households in Switzerland. However, concerning the share of income spent on energy, even the least affluent households in Switzerland exhibit lower shares compared to their wealthier counterparts in other European countries.

If we assume higher price elasticities of energy demand for the lowest income quintiles compared to the highest, the recent price surges imply a more pronounced reaction for the poorest households, leading to an increase in energy expenditure inequality. On the contrary, if we assume a specific level of subsistence energy consumption—thus a certain amount of energy or electricity to which all households are price insensitive, with price reactions only affecting the excess amount—then predominantly higher income groups will reduce their consumption. Meanwhile, the consumption for the lowest income decile will likely remain largely unchanged. In such a scenario, the inequality of energy expenditures would decrease, exacerbating energy poverty as low-income households spend a larger proportion of their income on energy, leaving less for other basic needs.



## 6 Next steps

- In the second year of our project, we have outlined several key objectives:

### **Data Update**

- We aim to update our dataset with the most recent survey waves, including information from Finland, Ireland, Poland, Portugal, and Sweden for the year 2020. As soon as these data become available, we will incorporate them into our analysis and calculate the inequality indices for these respective countries.
- We anticipate the release of the Swiss Household Budget Survey results for the 2018-2019 period in 2024, and we plan to update our calculations with this new dataset.

### **Minimum Subsistence Calibration:**

- We will calibrate a minimum subsistence level for energy or electricity consumption and use this assumption to project inequality indices for the year 2023.

### **Heating Energy Source Analysis:**

- The EUROSTAT dataset for the 19 European countries includes information on specific energy sources for heating. We will explore the impact of heating energy sources on the share of income spent on energy. Due to partial availability for Switzerland, we intend to investigate this effect through mean value comparison and Beta regressions.

### **Conference Presentations:**

- We plan to present the results of our project at various conferences and seminars to disseminate our findings and engage with the academic and research communities.

### **Commencement of Second Project Part:**

- Simultaneously, we will initiate the data preparation and analysis for the second part of our project. This phase involves examining the likelihood of households residing in neighborhoods affected by pollution. We already have access to the necessary survey data from the EU and Swiss Statistics on Income and Living Conditions (SILC)

## 7 National and international cooperation

Not applicable

## 8 Communication

The first findings of the project have been presented at the Annual Conference of the Verein für Socialpolitik in September 2023.

## 9 Publications

Not yet applicable



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## 9 Appendix

Not yet applicable