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Discussion paper:

What determinants of micro-enterprises influence their energy vulnerability?

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"What the concepts of vulnerability have in common is the structural aspect. It is important, when we talk about just transition, that we include micro-enterprises and small enterprises in all the policy responses." A. Brieger, SMEunited

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OBJECTIVE OF THE RESEARCH

Given the growing issue of climate change, environmental degradation, and the resulting inequalities (Schot & Kanger, 2018), the European Union (EU) through its European Green Deal (EGD), proposed a set of objectives, measures, and mechanisms to promote a just, efficient, and competitive transition to a climate-neutral EU by 2050. The realisation of the energy transition is one of the most important policy development objectives of the EU for the period up to 2030, and includes the goals of reducing greenhouse gas emissions, increasing energy efficiency, and enhancing the use of the renewable energy sources. Forty-plus years of research on the topic have focused on many aspects of the energy transition, in particular energy efficiency, showing its micro-level influences on disposable income or productivity, but also multiple-countries scenarios and technological developments changing courses of energy demand. Thoughtfully crafted policy interventions for energy efficiency improvement, as well as decarbonisation measures, consistently appear to contribute positively to economic welfare. (Saunders, 2021)

Looking at the same objectives from different perspective, energy transition and decarbonisation policies change import dependencies and global energy relations. (Yang & Qian, 2023) This fact became utterly important during the past two years and the threat to supply security through the Ukrainian war. Unstable prices of energy and unstable sources of imports have shown the burden that consumers endure even if they are not energy intensive. With that the burden to public funds dedicated to help the consumers, when trying to keep the economy stable. (UN Global Crisis Response Group (GCRG), 2022) Some countries are especially vulnerable to these circumstances, depending on their market composition (the lack of access to energy supply alternatives on infrastructural and market level), building ownership (affecting the possibility for interventions in the private-owned buildings), energy import dependences, macroeconomic indicators, and the capacities of the social protection systems.

Some consumer groups in those countries are, in particular, at risk of changes in energy prices. These consumer groups were until now mostly viewed as households vulnerable to energy poverty, and particular measures have been targeted towards them. The new European Social Climate Fund (SFC) and the reference to it in the Commission Recommendation on energy poverty, for the first time, mention the **vulnerability of micro-enterprises** in the same policy documents as energy poverty of households, putting small vulnerable consumers together, as a specific target group of the policies. (European Commission, 2023:b), (European Commission, 2023) Article 2 of the SCF Regulation outlines possible definitions for energy poverty, transport poverty, micro-enterprises, vulnerable households, and vulnerable transport users, but vulnerable micro-enterprises are still not well defined. **Therefore, this discussion paper focuses on the research needed to determine the indicators of energy vulnerability of micro-enterprises**.

In the following sections we:

- define the notion of micro-enterprises and develop the notion of their energy vulnerability.
- draft a list of indicators for the energy vulnerability of micro-enterprises and discuss challenges related to indicators composition.
- explore the link between the energy vulnerability of households and micro-business.

- discuss data availability and statistics relevant for indicators composition.
- develop policy implications, exploring at first transition policies which may enhance energy vulnerability. if not accompanied by specific measures.
- lay out the methodology for further research and discuss, how through case studies, sampling and statistical analysis the data context can be improved.
- finally develop discussion questions for experts discuss concepts, data and approach to measure energy vulnerability in micro-enterprise.

INTRODUCTION, CURRENT IMPLICATIONS AND KNOWLEDGE

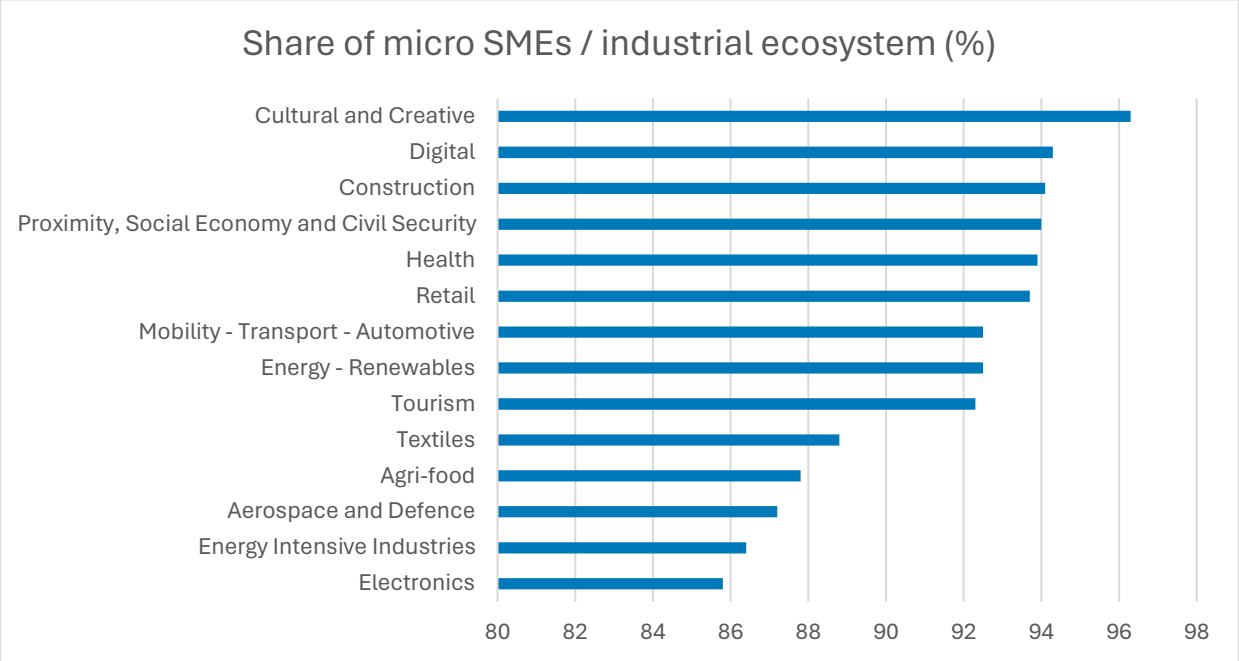
Looking into the energy transition of the business segment, the situation is more complex than in households for multiple reasons: current policies focus on larger consumers; barriers to implementing energy transition policies in all SMEs - and even more- micro-enterprises; and the novelty and lack of definition of vulnerability in the context of micro-enterprises.

The main information on enterprise needed to define it as an SME are staff headcount and either turnover or balance sheet total.

Table 1 Categories of SMEs, Source: (DG GROW, 2003)

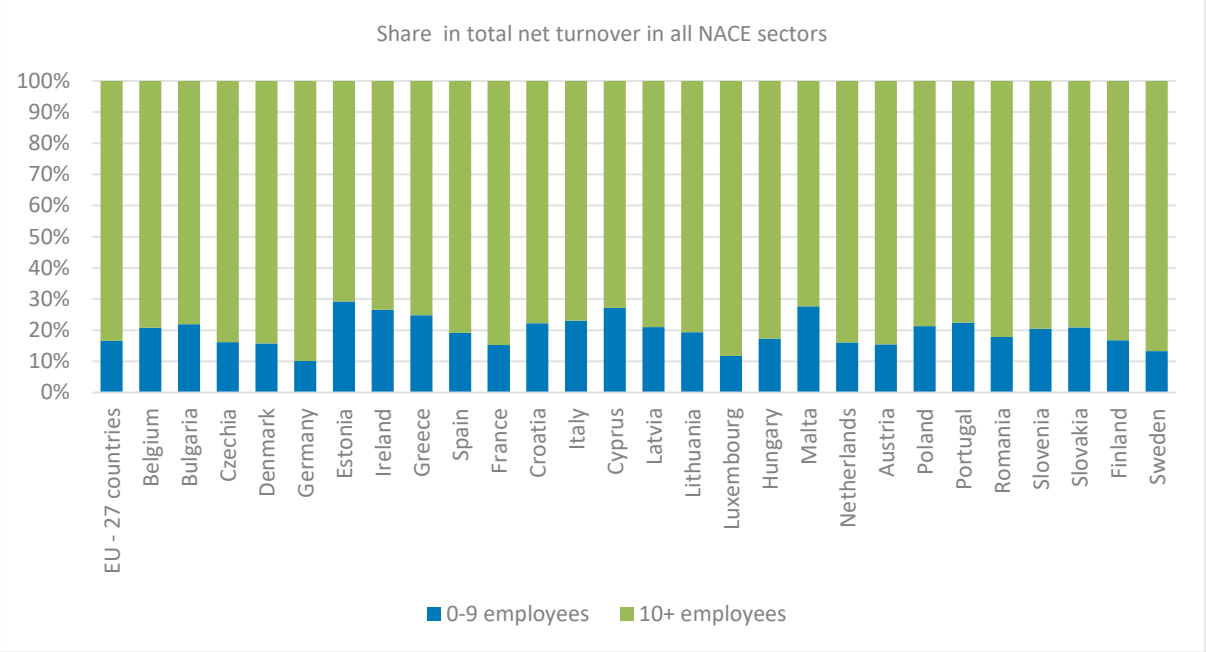
Company category	Staff headcount	Turnover or	Balance sheet total
Medium-sized	< 250	≤ € 50m	≤ € 43m
Small	< 50	≤ € 10m	≤ € 10m
Micro	< 10	≤ € 2m	≤ € 2m

Micro-enterprise is defined as an enterprise that employs fewer than 10 people and whose annual turnover or annual balance sheet does not exceed EUR 2 million, calculated in accordance with Articles 3 to 6 of Annex I to Commission Regulation (EU) No 651/2014 (27)). The importance of micro - SMEs is shown in Graph 1 and 2, developed by JRC from Eurostat data, where most European industries' ecosystems and value chains rely on the work and productivity of micro-enterprises. (Di Bella, et al., 2023)



Graph 1 Share of micro-enterprises in EU industries' ecosystems, Source (Di Bella, et al., 2023)

According to the Eurostat Structural Business Statistics, the share of total net turnover of micro-enterprises in Europe is significant: almost 17% on the EU level. (Eurostat, 2024) From these figures, it is clear that there are clear reasons to keep micro-enterprises strong and stable for the sustainability of local and national economies, while coping with the energy transition.



Graph 2 Share of total net turnover of micro-enterprises in the EU countries, Source: Eurostat SBS

There is no dedicated research on barriers to energy transition and in particular energy efficiency measures in micro-enterprises. They are in this part of the review seen as a subgroup of SMEs, facing the same though even more emphasized difficulties. They are confronted with numerous competing business priorities, other investments, such as internationalization, digitalization, "just-in time" organization, etc. At the EU level, there is a lack of specific quantitative objectives and mandatory requirements for SMEs, leading to being limited to voluntary involvement. At the national level, it remains unclear how policies can be aligned, and the assistance provided is primarily informative, lacking sufficient financial support. The review of the existing barriers has already been done in the paper by (Agrawal, et al., 2023):

Table 2 Barriers to implementation of energy efficiency projects in SMEs

Detailed barriers	**References**
LOW CAPITAL AND DIFFICULTY TO ACCESS FINANCING	
Large capital investment requirement for energy efficiency upgrades and small funds available to SMEs for investments; longer payback period for some of the potential energy saving investment opportunity; difficulties for securing loans from banks.	Catarino et al. (2015); Thiede et al. (2013); Prasad Painuly (2009); Nigohosyan et al. (2021); Viesi et al. (2017); Lee (1); Meath et al. (2016)
LACK OF HUMAN RESOURCES, KNOWLEDGE and AWARENESS	
The absence of internal knowledge to recognize and execute energy-saving measures, insufficient information regarding (a) energy expenses, (b) the significance and advantages of energy efficiency, and (c) outreach by technology providers to SMEs, presents a notable deficiency.	Fuchs et al. (2020); Rohdin et al. (2007); O'Keeffe et al. (2016); Kostka et al. (2013)

Detailed barriers	References
Small businesses do not have the resources to designate energy management responsibilities to any team member, let alone create a dedicated department or office for this purpose.	Eurochambres (2010); Sorrell et al. (2000); Henriques and Catarino (2016)
A lack of knowledge and awareness prevents SMEs from accessing any available financial schemes that support investments in energy efficiency.	Prashar (2017a); Hrovatin et al. (2021); Trianni et al. (2013); Fresner et al. (2017)
A shortage of time or an excess of other responsibilities among SME employees diminishes the priority placed on energy efficiency.	Paramonova and Thollander (2016); Henriques and Catarino (2016); Rohdin et al. (2007); Johansson (2015)

Source: (Agrawal, et al., 2023)

There was a long-term focus on decarbonisation and there are more policies focused on energy-intensive large industries in comparison to SMEs, particularly micro-enterprises. The number of SMEs (and especially micro-companies) is disproportionate to their energy consumption, which is one of the reasons why they have not yet been a priority for energy transition measures. (Reuter, et al., 2021) Therefore, the EU Commission has established or supported multiple networks, projects and programmes assisting SMEs, like Covenant of Companies (including advisory services for companies and intermediaries in energy transition; expertise and support materials; visibility, recognition and incentive schemes; effective monitoring, reporting and verification systems to verify company commitments; analysis of potential synergies between businesses and local authorities) or Enterprise Europe Network (world's largest support network for SMEs).

There is also undeniable impacts of energy transition measures on the businesses (micro-companies included) beyond the scope of basic energy (money) savings, counting in as total impacts of energy efficiency policies on SMEs. (Sangiorgio, et al., 2024) Assuming these, investments were put in place to increase energy efficiency of SMEs. An increase in income could also result from direct (increased workforce productivity) and indirect (positive perception of clients) effects of a series of multiple benefits integrated as part of the business model.

A significant existing discussion focuses on correlation between changes in energy expenses and company's profitability depending on its sector. Such changes can impact a company's expenditures due to the escalation of energy costs. Moreover, new expenses might constrain companies to maintain competitiveness, necessitating cost reductions, increased sales efforts, and/or price adjustments for their products. Holding all other factors constant, increased energy costs could lead to diminished profits for certain companies under specific conditions. If firms have not optimized the equilibrium between changes in revenue and production costs through price adjustments, they might need to explore alternative financing avenues to sustain their operations, such as seeking loans. Research shows that the size of the company affects these consequences, with smaller (and younger) companies being affected more significantly. (Herman, et al., 2023)

The major challenge in the assessment of influence of policies on vulnerable micro-enterprises is that their energy vulnerability has only recently been recognized and hence not properly addressed. Research on energy poverty and/or general vulnerability of the business sector to

energy, as it is mentioned in the newest EU regulation, is practically non-existent in the literature. A review of the literature shows one working paper from Greece, aiming to evaluate the extent of energy poverty in SMEs according to research findings. (Vatikiotis, 2021) In this research, the author uses a past survey of small and very small businesses and interviews 19 energy experts in the business sector. The indicator used is the same as for the residential sector, "arrears on paying utility bills ", where around 15% of small companies have such issues. Energy data are collected and sorted in three different consumption groups, self-employed doing dispersed work (can be interpreted as mostly service crafts, for example plumbers), using commercial buildings, but having minor energy consumption (for example, hairdressers) and manufacturing. The analysis is not followed up by any scientific method but does open the question of the major diversity among target groups in sector, sizes, and energy dependence. This also opens a research pre-condition, constituting the main research question: ***Which indicators should be employed to measure and analyse the energy vulnerability of micro-enterprises?*** *The significance of this research question is evident in the contemporary European policy, as it is one of the three aspects of the Social Climate Fund.* (European Commission, 2023:b)

Ecosystem and susceptibility of micro-enterprises to energy vulnerability

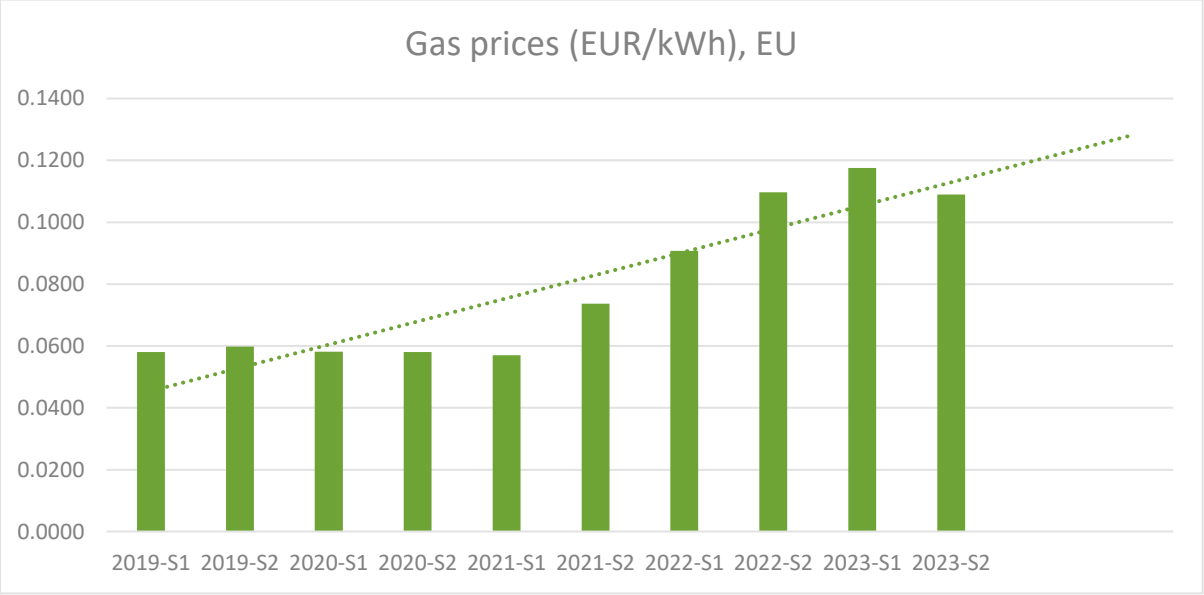
One of the definitions of the energy vulnerability of a system is "*the degree to which an energy system or entity is more likely to get exposed with adverse events or change, and risks to fall into traps in economic, social, environmental and governance terms*". (Gatto & Busato, 2019)

First, in the light of this general definition of energy vulnerability, we determine the energy – related threats that do happen to micro-businesses and that are the cause of disruptions:

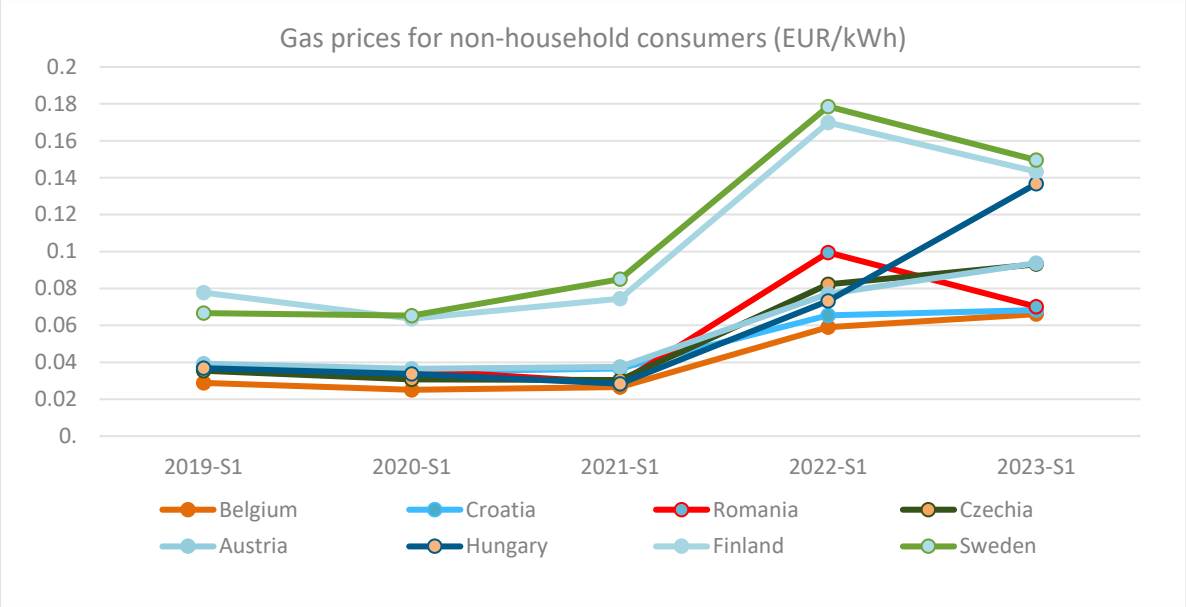
- Energy costs, as the smaller the company is, as stated in the introduction, the higher is the effect of price change (the higher the share of energy cost, higher the impact),
- Supply disruptions, linked to either infrastructure, energy efficiency, energy dependence or the access to renewable energy,
- Regulatory framework affecting the obligations or needs of small businesses,
- Access to finances to invest in energy efficiency.

We present further the analysis across European countries based on publicly available datasets of the wider socio-economic and technical trends that influence vulnerability of companies to energy prices change. The important part of it is the infrastructure, access to different networks, energy dependency, market development and energy prices and tariffs.

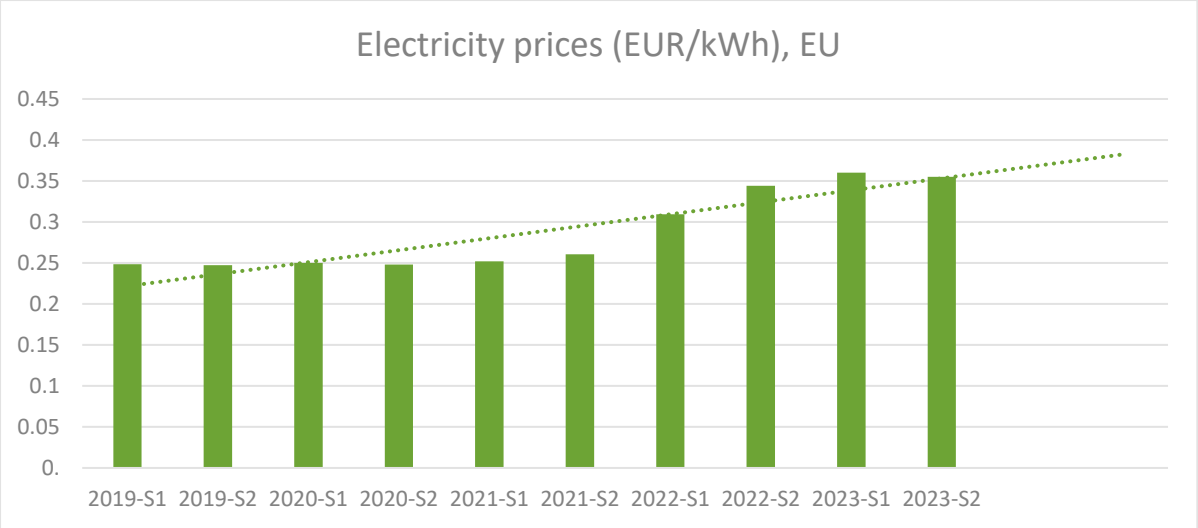
It is visible from the below graphs that the prices of gas and electricity have risen around 50% in the previous years, even relatively to 2019, where there was only a minor reduction in 2020, due to the COVID-19 crisis. Electricity prices refer to the lowest consumption bandwidth, so presumably includes most of the micro-enterprises (part of them that are not linked to households). In that segment the price has risen from 67% (Denmark) to 251% (Luxemburg) relatively to the price in 2019.



Graph 3 Gas price change since 2019 in the EU, for consumption less than 1 000 GJ - band I1, non-household consumers, all expenses included, linear progression added, Source: EUROSTAT [nrg_pc_205]

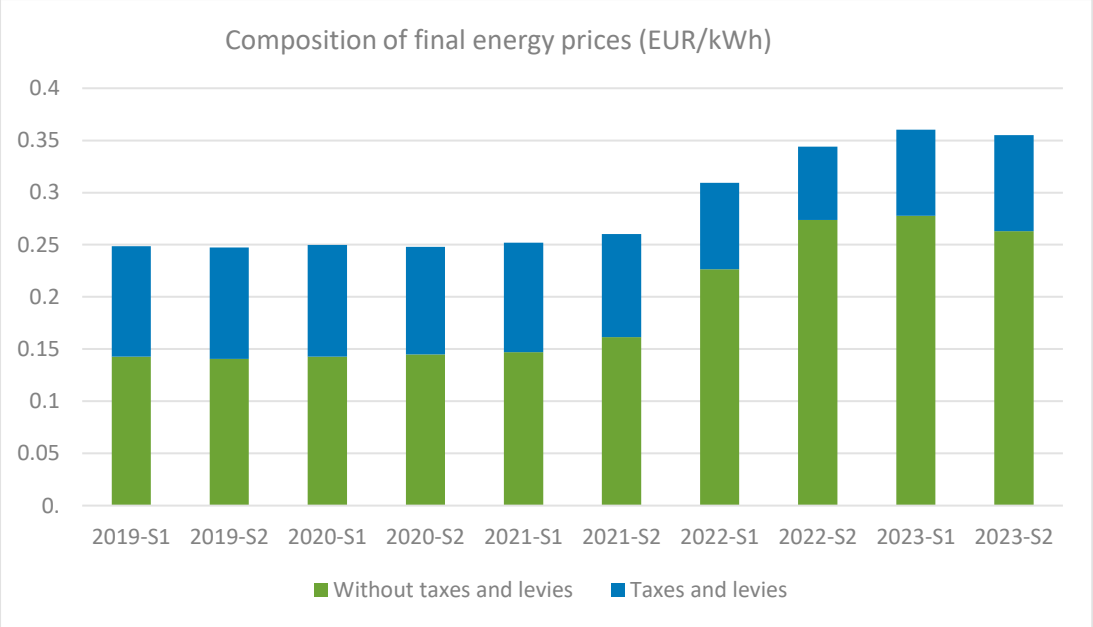


Graph 4 Gas prices for non-household consumers (EUR/kWh), same bandwidth as above, countries with highest, medium and lowest prices in the EU, source: EUROSTAT [nrg_pc_205]



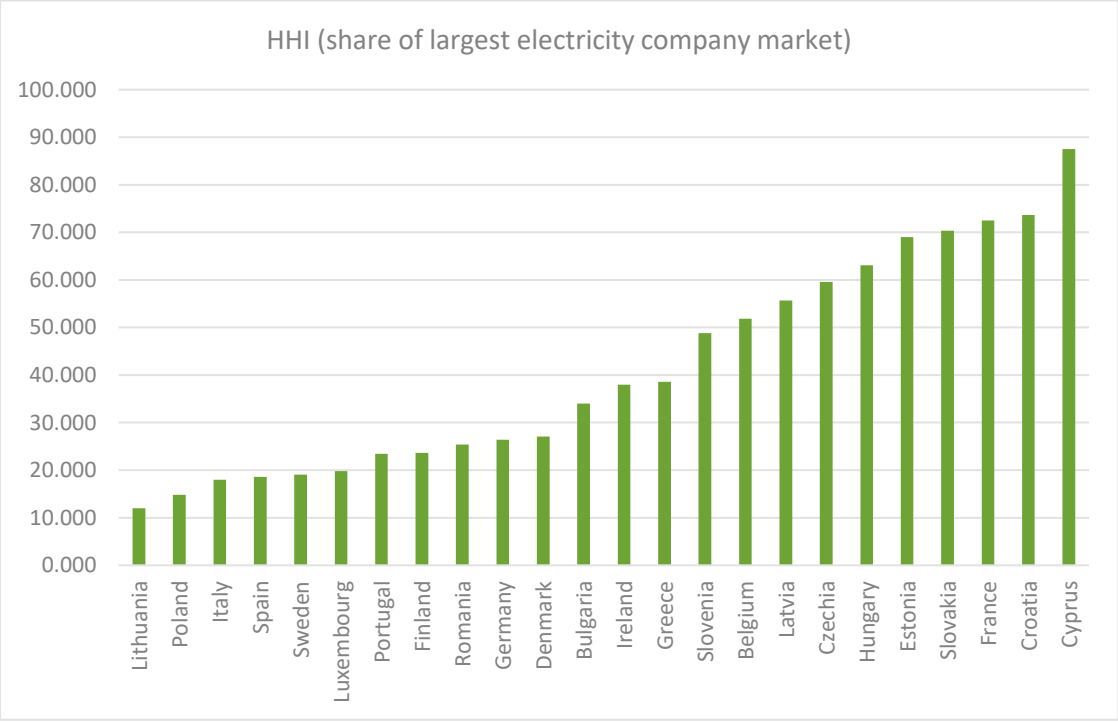
Graph 5 Electricity price change since 2019 in the EU, for consumption less than 20 MWh - band IA, non-household consumers, all expenses included, linear progression added, Source: EUROSTAT [nrg_pc_205]

Network charges and taxes compose a large part of the final electricity price. This is particularly pronounced in Denmark, Poland, Cyprus and Italy. The loading of non-tariff charges onto electricity prices has been shown as additional burden to the consumers.

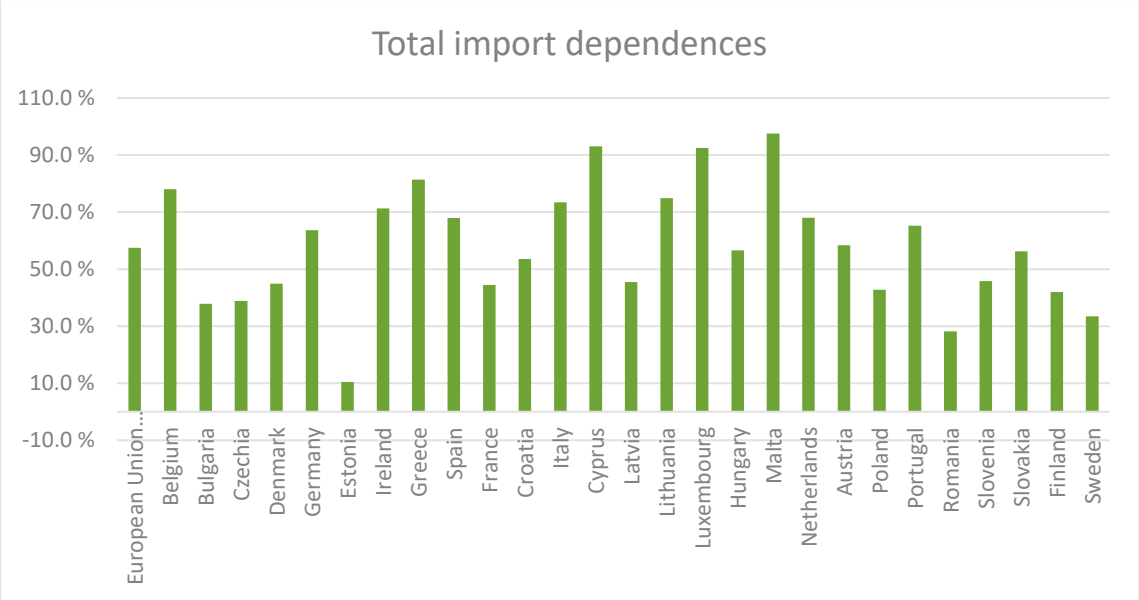


Graph 6 Composition of final electricity prices for small non-household consumers. Sources: Eurostat

Degree of market liberalization (HHI Index, Graph 7) shows the share of largest supplier in the electricity or gas market. The structure of electricity and gas retail markets has also been shown to influence consumer choice – which in theory should bring down prices through supplier switching – and broader possibilities for low-carbon transitions. This of course is not as straightforward as the market theory would assume but could be used as one of the possible indexes, especially in highly dense markets.

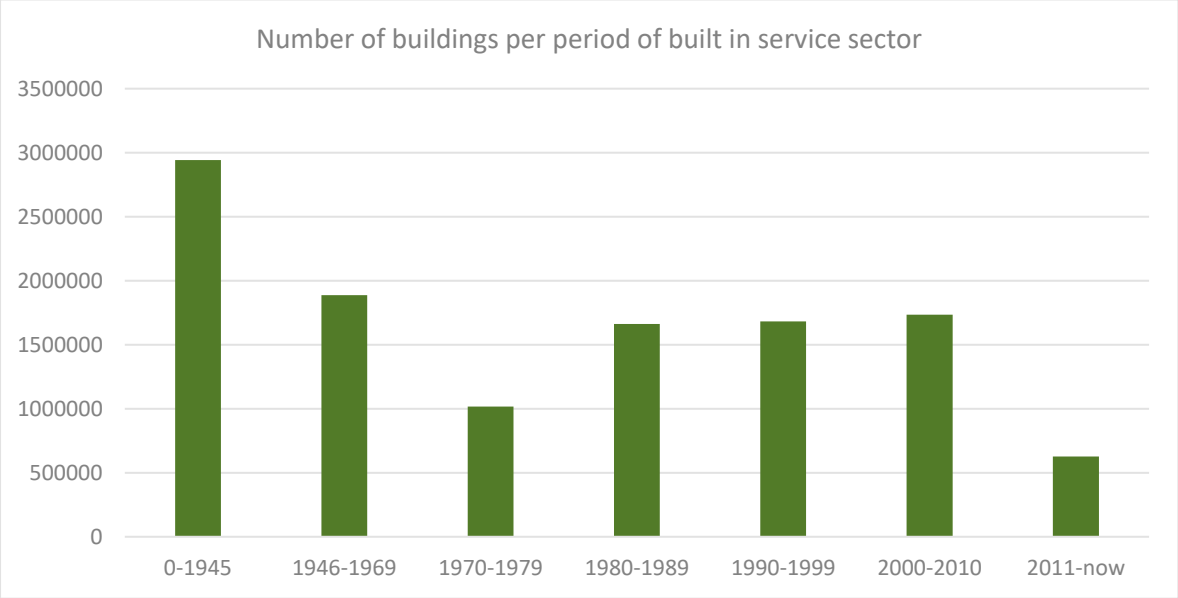


Graph 7 Degree of market liberalization (% Herfindahl Hirschmann Index) - Share of largest supplier in the electricity market. Source: Eurostat.



Graph 8 Energy import dependences across all energy carriers, EUROSTAT

As opposed to residential buildings, where there is a body of data we can use for evaluation of building stock quality, U-values, energy efficiency and refurbishment etc., the information is much less available for commercial buildings. For example, the EU Building Stock Observatory provides information on the age of buildings and tenancy (rent vs. ownership), which are both relevant for our work, but does not provide information of fuel distribution, meaning more literature review and data generation and consistency is needed in that area.



Graph 9 Service buildings per period, EU Building Stock Observatory

Regarding access to finances and assistance from all the governance levels, there are multiple initiatives to assist micro-enterprises, like financial subsidies (for example grants for energy efficiency measures (BMWi)) or technical assistance, but the common denominator is the accessibility and lack of capacities to efficiently use the provided assistance, as seen in Table 2.

Problem definition

To target energy vulnerable micro-enterprises, the definition of the energy vulnerability of businesses must first be investigated. A conceptual understanding of the definition of energy poverty in companies needs to be somehow operationalized using different metrics. For vulnerable households, it is easier to define energy vulnerability as it is directly linked to economic vulnerability and poverty and there are many more disaggregated data already collected. For micro-companies, we can argue that energy vulnerability is *the inability to afford adequate energy services to sustain business operations, which can impact their productivity, competitiveness, and overall viability/survival, but also have induced effects on the household of the owner (*which is discussed more later). This definition has many challenges later targeted but is a starting point of this research.

Learnings from indicators of energy poverty of households

In the research of energy poverty in households, indicators are grouped as follows:

- **Expenditure based** (where examination of the energy costs faced by households against absolute or relative thresholds provide a proxy for estimating the extent of domestic energy deprivation),
- **Consensual** (based on self-reported assessment of indoor housing conditions and the ability to attain specific basic necessities relative to the society in which the household resides),
- **Direct measurement** (where the level of energy services achieved in the home is compared to a set standard). (Thomson, et al., 2017)

In more details, the Energy Poverty Advisory Hub evaluates 21 indicators of the named categories, sorted as primary and secondary indicators. (Gouveia, et al., 2022)

Primary indicators and their respective drawbacks in the analysis are:

- Arrears on utility bills (data is available and disaggregated for households, however, does not cover special cases like on-purpose comfort loss, in-dept living, situations where social welfare programs cover expenses like in some people with disabilities, does not include energy without utility supplier – like wood heating),
- High share of energy expenditure in income (2M) (one problem is the "reason" that energy expenditure, could be due to a low quality dwelling, but could also be due to luxury - though in that case, income may also be high),
- Low absolute energy expenditure (M/2) (same as above, the problem is the "reason", are they a small household like employed couple or large with elderly and children),
- Inability to keep home adequately warm (lacks taking into account equipment, different habits or comfort needs).

Similar challenges with one indicator not being enough to determine vulnerability to energy poverty are recognizable in all secondary indicators, which are listed here: energy prices (fuel, biomass, coal, district heating, electricity, gas), comfort in dwelling (cool or warm), density of population, energy label, expenses per quintile, equipment ownership (air conditioning, heating), population of dwelling (number of rooms/person, person/room,

rent, ownership), presence of damp, leak, health consequences and excess mortality, poverty risk.

Some of the indicators (inability to keep warm, arrears on utility bills, total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor and rate of poverty risk), are also used to determine share of energy poverty in national energy and climate plans based on Article 8 of the Energy Efficiency Directive (EED). (European Commission, 2023)

Therefore, **composite indicators** (composition of several indicators) are used as determinants of energy poverty on different governance levels. (Siksnelyte-Butkiene, et al., 2021)

Inputs towards energy vulnerability of micro-enterprises

What was observed in the energy poverty research is a long process of indicator development and perfectioning, that is still ongoing, and the need for proper additions to data collection. Therefore, we are modest in assumptions, and using energy poverty in households' indicators as a starting point, developing a draft list of indications for the vulnerability of micro-enterprises.

Draft list of indicators for the energy vulnerability of micro-enterprises

This section presents a draft list of indicators for the energy vulnerability of micro-enterprises for further discussion. Some of the proposed indicators present risks of energy vulnerability, as opposed to already observed effects of energy vulnerability.

Table 3 Draft list of indicators for the energy vulnerability of micro-enterprises

	Indicator	Description
1. Expenditure based (where examination of the energy costs faced by a company against absolute or relative thresholds provides a proxy for estimating the extent of vulnerability):		
1.1	The proportion of energy (and transport) costs relative to:	*(Determining the risk of being energy vulnerable)*
	A) total operating costs	*The share of energy in total expenditures is more than x% of the total costs.*
	B) sectoral median	*The share of energy in total expenditures is more than x% of the median – this indicator will depend on the total number of targeted micro-companies it covers and is sector – adjusted, relative threshold*
1.2	Energy prices (fuel, biomass, coal, district heating, electricity, gas)	*Tariffs available to the companies*
1.3	Companies "in arrears on paying utility bills "	*According to national data, companies not paying the bills*
1.4	Lack of ability to react to high price shocks	*Total net income of the company (energy cost/net income) or (% of net income reduction)*
2. Consensual (based on self-reported assessment of risk to energy poverty):		
2.1	Limited access to capital	*Limited access to financial resources, making it difficult to invest in energy-efficient technologies or renewable energy sources*
2.2	Limited perceived flexibility to adapt processes	*Process are perceived as not easily adaptable to energy-efficient practices and knowledge on the options to improve the energy efficiency of processes is limited*
2.3	Composition of the market	*Percieved loss in competitiveness towards larger companies due to energy expenditure share*
2.4	Perception of energy prices imposing	

	business risk	
3. Direct measurement (where the level of energy services achieved is compared to a set standard):		
3.1	Energy consumption patterns	*Energy and transport intensity (measured for example in terms of kWh/EUR company income) and peak demand (measured in kW)*
3.2	Energy efficiency of a commercial building or a production site	*as determined through energy audit*
3.3	Ownership of a commercial building	*Own vs rent*
3.4	Split incentive	*What can company vs owner vs employees gain from the investment?*

Challenges related to indicators composition

Link between the household and micro-business

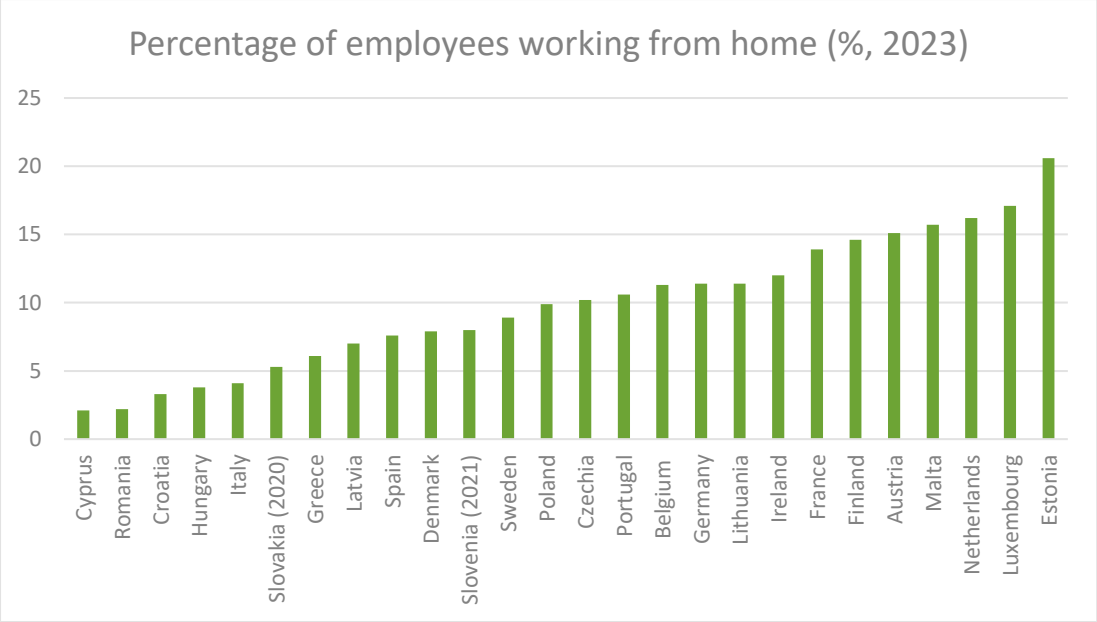
Is the family company, consultancy and craft activity an extension of the household or an enterprise in own locations?

In the case of households, the most used comfort indicator is the inability to keep the household adequately warm and the health of inhabitants, where in businesses it is how energy influences competitiveness and health of the company. In the case of homeworkers, it can be both.

Table 4 Types of working from home, various sources

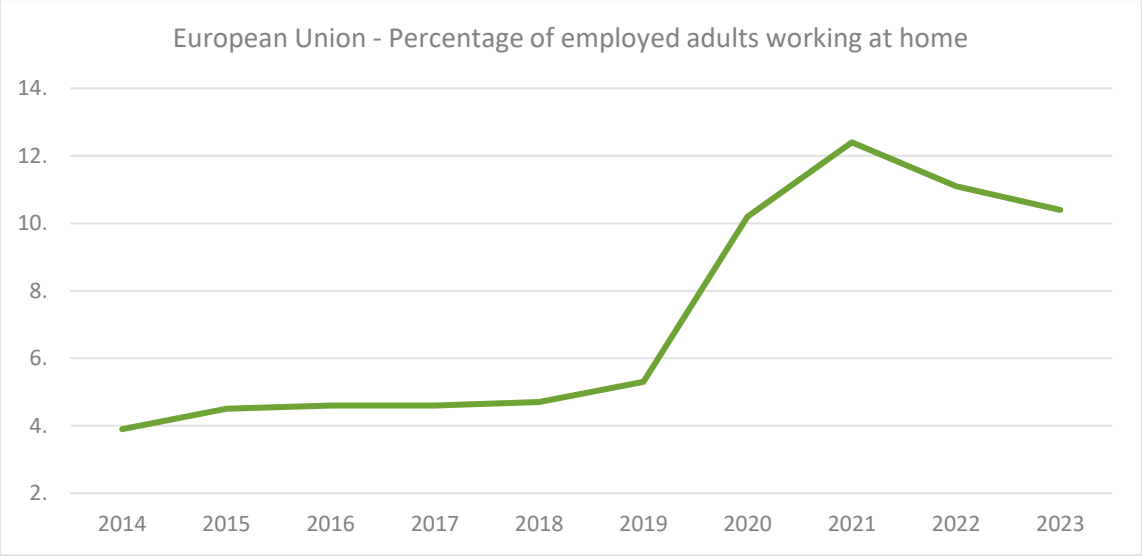
Individual homeworkers	Family businesses
Remote employment – having an employer somewhere else than at home, where you do work (example: analysist, programmers, accountants, IEECP)	Home – based family business – operated from family members in home (catering, crafts, online stores)
Freelancers and gig workers, B2B – self – employment offering services (ex. designers, consultants, task-based)	Small family enterprise, small service – regular business operated by family but including employees, can share dwelling with the household (restaurant, store, small manufacture)
Entrepreneurs – running own business from home (ex. craft makers)	

There is more disaggregation of these categories existing, based on regularity of home – work and availability of other options, but this information cannot be easily adapted to the present evaluation. (Eurofound, 2020)



Graph 10 Percentage of employees working from home, Source: EUROSTAT

A paper on ethnography of home working discusses the under-researched aspect of working from home within social scientific energy research, emphasising the importance of incorporating practice, theory and the notion of affect to analyse energy demand and consumption patterns. It also describes how characteristics of the practice, such as comfort, control, and flexibility, influence energy consumption behaviours and challenge traditional assumptions about energy conservation and demand shifting in the context of home-based work environments. This research highlights the potential for net energy and emissions savings through understanding of home workers' behaviours and practices, important for policymakers, regulators, and employers in shaping future energy management strategies. (Hampton, 2017)



Graph 11 Evolution of number of employees working from home, Source: EUROSTAT

There are many interesting aspects of this setting in relation to policies targeting energy efficiency and energy poverty. The International Labour Association (data from Delphi

questionnaires) claims that 12-13% of workers from home are probably low income. (International Labour Organisation, 2020)

Regarding the economic and financial disadvantages, one research shows that home working leads to higher costs associated with increased electricity and gas usage, as well as expenses for necessary digital technologies (such as a personal computer, internet connection, licenses for instant communication platforms, and cloud storage). On average, workers experienced a monthly increase of 20 EUR in their electricity bill, 25 EUR in their gas bill (with heating costs significantly contributing to this rise), and 11 EUR for digital technology costs. Only 3% of the sample did not report any increase in costs. (Battisti, et al., 2022)

More interesting aspects to investigate include:

- Division of bills and utility obligations: Some countries already assign certain amount to be tax-deductible meaning assigned as energy used for micro-company or homeworking. Example: (Revenue, Irish tax and custums, 2024)
- "Double" type of poverty: Being a low-income household with expenditure change influencing both net income of the household and net income of the company/ business.
- Split incentive of savings and investment that is both private and business: Would the investment be assigned towards the business or the household? How will it influence the poverty of the household and the vulnerability of business.

Further expert discussion should focus on where to "put" this consumer group in the context of energy poverty and how to use and adjust the indicators?

The role of energy poverty of owners/employees and their households

In the case of micro-enterprises, the complexity comes from the links between the micro-enterprise and quasi employed/ owner in energy poverty, where it is not easy to differentiate the household from the owner. Business researchers argue that a crisis related to high energy prices impacts businesses at the entrepreneur level, affecting not only their financial situation but also their psychological and social well-being. The financial effects on entrepreneurs involve changes in their wealth and income. (Newman, et al., 2022) This is a straightforward conclusion, and we can argue that it is the same for all employees everywhere and is not considered energy poverty, but in this specific case, effects of a change in net income of the entrepreneurship translate to effects on the owner and with that on the household (*income side of energy poverty*).

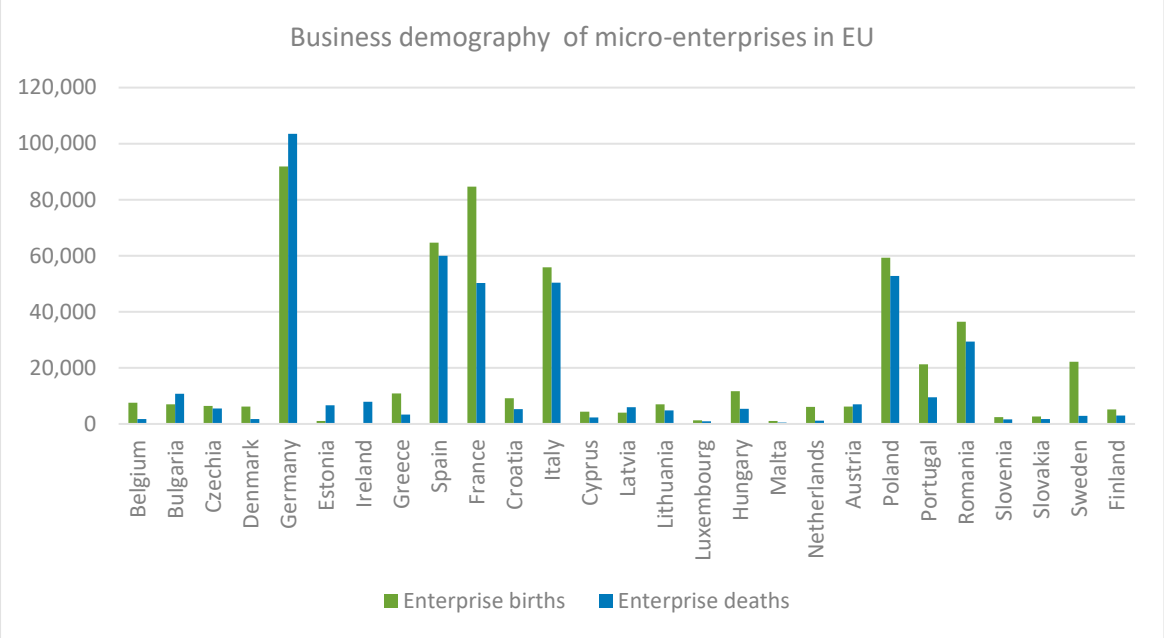
Further expert discussion could be if this is to be taken into account as induced effect of business poverty to household poverty?

Data availability and statistics relevant for indicators composition

A lot of experimental statistics has been dedicated to the living conditions of the households, which serves as perfect data source for research on energy poverty. Researchers testify that exemplary data from EU-SILC (EUROSTAT, 2023) seems to be real improvement in comparison to previous datasets with more reliability, response rates and geographical coverage. (Clemenceau & Museux, 2007)

In order to understand where to move on to improve data collection and establish future data needs, we start from what data is available. Interesting data to evaluate the national level of business survival is available from EUROSTAT Structural Business Statistics, which is generally

the most relevant data source for business information. It includes also the sectoral disaggregation of business survival. Business survival is an indicator of the general economic status of micro-enterprises in the country. (EUROSTAT, 2023)



Graph 12 Business demography of micro-enterprises (1-4 employees): annual creation and death of micro-enterprises EUROSTAT SBS, 2021

The most relevant problem linked to this research is the disaggregation of data in micro-enterprises and lack of research on consistent datasets on energy in micro-enterprises. SMEs' economic statistics are well-documented as stated above in EUROSTAT SBS and other business statistics. However, there is a notable **absence of energy-related data** for SMEs at both European and national levels. The quality of existing energy-related data for SMEs is inadequate to provide robust, scientifically based support for the policy-making process. (Herce, et al., 2024). In the frame of the present paper, the authors develop an own methodology for data assumptions; however, more work would be needed to both disaggregate data per size of the companies but also per sector.

> Further expert discussion: data availability on national level and the need for disaggregated data collection.

To be able to determine whether the energy demand of the micro-company is considered normal for the sector or not, the disaggregation of data is needed. Practically, the energy demand of micro-companies can differ from 5% of total expenditure (for example consulting) to levels of 40% of total expenditure (for example car washing service).

Expert information on processes, consumption patterns and efficiency are part of energy audits. This opens the question of the need of energy audits as a prerequisite for any type of support towards energy vulnerability in micro-companies. Obligatory energy audits for micro-companies are not cost effective at this moment, but a walk-trough audit could be considered.

Policy implications

Definition of energy vulnerability as part of the business risk

In business, vulnerability refers to a weakness or gap in a companies' defences. It can exist in various aspects, such as system infrastructure, databases, software, processes, controls, or implementation. Social aspects of a company (e.g. lack of access to qualified staff or age structure in the company) may also give rise to vulnerability. In our case, it is the weakness of the company to respond to the threats linked to energy price changes or similar. Risk represents the potential for loss or damage when a threat exploits a vulnerability. Some of our previously presented indicators present risk as opposed to vulnerabilities and should be further evaluated.

> Further expert discussion: how to differentiate risk from energy vulnerabilities in business?

Role of micro-enterprise in ETS2/SCF and other price signal policies

The "ETS2" (Revised ETS Directive) (European Comission, 2023) is a carbon pricing mechanism for the building and road transport sectors starting in 2027. It covers CO_2-emissions from fuel combustion in buildings, road transport and additional sectors (mainly small industry not covered by the existing EU ETS). Under this system, energy suppliers must purchase and sell emissions allowances, with costs expected to be passed on to consumers through higher prices for fossil fuels like natural gas, coal, petrol, and diesel. Unlike ETS1, which covers electricity consumed by households and micro-enterprises and offers free allowances to electricity generators and large industrial sources, ETS2 provides no free allowances. Revenues from ETS2 are split between the SCF and national auctioning revenues to EU Member States, with a cap set at 5.3 billion allowances from 2027 to 2032.

The implementation of ETS2 would for sure influence energy and transport poverty, particularly among low and lower-middle income households and micro-enterprises. This concern stems from the regressive impact of carbon pricing. To address this issue, the SCF Regulation defines energy and transport poverty and requires Member States to develop Social Climate Plans (SCPs) tailored to their specific contexts.

The SCF aims to support vulnerable households and micro- businesses during the transition to climate neutrality. Member States must submit Social Climate Plans (SCPs) by mid-2025 to access SCF funds, detailing the definitions, indicators, and support measures for vulnerable groups in the buildings and transport sectors. The allocation of SCF funds is based on a formula favouring Member States with higher numbers of affected households and businesses. Given differences in definitions and indicators across countries, context-specific SCPs are necessary, along with harmonization and monitoring mechanisms. Energy and transport poverty are also significant considerations in other EU policies, such as the EED (European Commission, 2023) and the Energy Performance of Buildings Directive (EPBD) ((European Commission, 2024). The 2023 Energy Poverty Recommendation (European Commission, 2023) thoroughly examined definitions and identification of energy poverty.

The currently used indicator for the determination of the impacts of ETS2 on vulnerable households is welfare loss for disposable income reduction (compensation variation). It is important to see what indicators of energy vulnerability of micro-enterprises would show

adequately the impact of ETS2 on micro-enterprise. Potential indicators may include the policy induced increase in the share of energy cost in total cost of micro-enterprises.

Energy poverty policies and "thin" border between micro-enterprise and household

The question that is already discussed is where the energy poverty of home- enterprises should be accounted.

METHODOLOGY OF RESEARCH

As these indicators have not been previously researched or applied in the European context, appropriate additional research is planned or ongoing.

Shaping the concept of energy vulnerability of micro-companies

A systematic literature review to research and analyse the concept of vulnerability to energy poverty of businesses, with the objectives to review the following aspects:

- *Concept of energy risk, vulnerability etc. in businesses: describing adequately such risks and how they are defined until now*,
- *Understanding the definition of energy poverty and business risk in the same context*,
- *Analyse situations where the household and micro-enterprise overlap.*

This part will be complemented by research on expert opinions on the topic and a focus group discussion.

EU level available statistics and national available statistics

For the definition of vulnerable micro-enterprises, a statistical data collection is needed from the perspective of size, income, employment etc. Structural business statistics (SBS) of Eurostat will be used as the starting point, complemented with other available data (including on national level). A second step is to determine their macroeconomic role in Europe and try to gather as much disaggregated data as possible. This would include sorting by NACE, type of employment and, what is most important, type of ownership. A descriptive statistic will be used to describe all relevant data that is available and what is the data status.

A combination of data collection via surveys and semi-structured interviews will be exploited in case study countries. The research will include questions on:

- *data availability regarding disaggregation of energy statistics per size of company*,
- *sectoral structures in micro – enterprises*,
- *ownership distribution and employment distribution (to detect quasi-employment as a double risk to energy poverty)*,
- *differentiation of type of building (commercial, residential)*,
- *differentiation of utility bills for businesses that are in the same house /building as household*,
- *enterprises who have asked for energy assistance during energy crises (type, NACE, size of companies)*,
- *whether actions already been undertaken in terms of assistance towards vulnerable*,
- *other questions that come up during expert workshops and discussions.*

Case study, sampling and statistical analysis

We go one step back to check what determinants of a company would influence its objective and subjective vulnerability. In the situation where datasets are scarce, a first step is to carry out sample case study. To answer the question of determinants, we need to put in relation companies' vulnerabilities and resulting risk and, for that, define a set of objective and subjective data needs which need to be collected. We present here only partial data that are to be collected in the frame of such case studies.

Data on the determinants of energy vulnerability

- Companies' ownership, size and income status,
- Number of employees, link of the employees to (same) household,
- Sectoral information (NACE code/detailed sector status) – composition of the market to be derived,
- Available data on energy prices (general) and specific energy price data (micro-company), types of fuels and consumption,
- Consumption pattern (working time, production time…),
- Information on building/facilities (ownership, residential/commercial),
- Implemented energy audit (of a building or a process), implemented measures of energy efficiency (if, when, what),
- What processes (if any) are included in the companies' production (in case of physical production),
- Own- evaluation on the knowledge of the processes.

Data on the perceived and direct energy vulnerability (objective/subjective)

- Inability to pay bills and affordability issues due to private or business financial reasons,
- Whether the change in energy prices is recognised as a business risk to company,
- Limited access to capital,
- Perception of own vulnerability (household vulnerability) in the context of company vulnerability.

The objective is for the analysis to show the statistical relevance of different determinants of vulnerability to the objective and subjective status of vulnerability.

Starting from possible indicators drafted having energy poverty of households in mind, status of companies, data availability, national information and all other data collected will be taken into consideration for the re-evaluation and development of a possible first version of indicators for the energy vulnerability of micro-enterprise, and the composition of the indicator set.

The definition of such an indicator set will be supported by detailed description of type, data needs, influences, and policy use.

Discussion questions for experts

- *Where to "put" homeworkers and family companies' group in the context of energy poverty and how to use and adjust the indicators?*
- *What are induced effects of business poverty to household poverty?*
- *Data availability on national level and the need for disaggregated data collection*
- *How to differentiate risk from energy vulnerabilities in business?*
- *Importance to determine which companies are most vulnerable to policy changes, especially if that means expenditure change*
- *Current policies are omitting targeting small and vulnerable companies*
- *Primary determinants of self – perceived vulnerability to energy poverty of companies*
- *Available measures to assist micro-companies in energy bills, existing and research- based best options*
- *Prioritisation of sectors*

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