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Exploring health impacts of living in energy poverty: Case study Sisak-Moslavina County, Croatia

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1. Introduction

Energy poverty (also known as fuel poverty) manifests either as a complete lack of access to modern energy sources [1–3] or as the inability to bear the energy-related costs that are necessary for acceptable living conditions in terms of health, society and culture [4–9]. Worldwide, more than a billion people still lack access to electricity, and almost three billion still depend on fuelwood and other sources of traditional biomass for cooking and heating [10]. In the EU, more than 9% of the population reports the inability to keep their homes adequately warm, 5.5% consider their dwellings too dark and more than 15% report living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in the window frames or floor [11]. Based on the existing literature and lack of an official definition in Croatia, for the purpose of this research, energy poverty is observed as a household's inability to access and/or afford basic energy services: cooking, indoor lighting, heating (cooling) and water heating, cooking and washing, and to use these services in a socially and culturally acceptable level without adverse impacts on the residents' health.

1.1. Background

The continuous increase of energy costs coupled with the poor energy efficiency (EE) of the dwelling and appliances within poses a significant social and political issue across the EU [12,13], and it is especially evident in post-socialist economies in south eastern Europe [14–18]. Likewise, the continuous increase of energy prices in Croatia is leaving more than 29% households with arrears on their utility bills [19]. Limited household budgets are forcing families to live in inadequate conditions, giving up on their energy comfort and often forcing them to decrease their living space in the winter months [19–21]. Although it has long been acknowledged that the continuous increase of energy costs drives many families into energy poverty, there have been only limited efforts to implement protection systems for the vulnerable. There is no universal definition of energy poverty [22], no EU level definition [9,23,24] and no official definition in Croatia. There is also no clear definition of energy-vulnerable consumers [23,25–27]; thus, there are no comparable statistics either on how many people are vulnerable or how many are energy poor. Defining both energy poverty and energy vulnerability is needed to give this topic political significance leading to effective policies. While waiting for definitions and strong policies, the energy poor are left without real protection and must endure adverse conditions.

1.2. What is energy poverty—What do we know?

Some definitions state that energy poverty is a lack of access to modern energy services – electricity and clean cooking sources [1,2,28,29]. Other definitions focus more on the affordability aspect of using an adequate quality of services when the services are available, that is, keeping the home adequately warm, cool or lit or being able to use any type of energy services in a way perceived as the cultural norm or keeping a minimum health requirement [9,14,16,30–35].

Defining energy poverty so that it could be measured and monitored is a challenging task requiring extensive research [4]. Buzar defines energy poverty as the inability to keep a home at a socially and materially necessitated level [4]. In its lack of measura-

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bility, this definition contrasts the one given by Boardman, which states that a household is energy (fuel) poor if it needs to spend more than 10% of its income on the energy costs needed to keep the home adequately warm [5]. Another well-known measurable definition is given by the low income high costs (LIHC) method that considers a household to be energy (fuel) poor if it has energy costs above average and if the remaining household's income after paying for energy costs pushes the household bellow official poverty threshold [6]. More research is needed to assess the real implications that different energy poverty definitions could have in the Croatian context. Thus, for the purpose of our research, energy poverty is observed through a descriptive definition as the inability to access and/or afford modern energy services without adverse impacts on health, and to use them in a socially and culturally acceptable level without adverse impacts on health.

1.3. Consumer vulnerability and energy poverty in the Croatian policy context

Vulnerable consumers of energy are those who, according to the socio-demographic and energy indictors linked to their households, have a higher probability of becoming energy poor than the general population. For example, socially vulnerable households have a significantly higher chance of being energy poor than the average household, single-parent households are also significantly more likely to be energy poor than families with both parents and pensioners are more likely to be energy poor than employed persons [36–38]. A careful definition of vulnerable consumers is a key to the success of policies aimed at tackling energy poverty. The European Commission has formed a working group for vulnerable consumers that has come to the conclusion that 'It is not possible to have a unified definition of vulnerable consumers which would apply to the entire EU' [23]. Each country is left to decide on its own definition of energy vulnerability and energy poverty.

Energy poverty has officially entered the EU legal framework for the first time via the 'Third Energy Package' when through the EU Internal Market in Electricity (2009/72/EZ) and Natural Gas (2009/73/EZ) Directives, member states were called on to define energy poverty and protect vulnerable energy consumers. The EU has emphasised even more on the need to tackle energy poverty through the 'Clean Energy For All' package, which states 'through Energy Union Governance process, Member States will have to monitor and report on energy poverty while the Commission will facilitate the exchange of best practices' [12].

Although there is a (very narrow and limited) definition of vulnerable energy consumers in Croatia, there is no program specifically aimed at energy poor households. Vulnerable consumers are those who are recipients of a guaranteed minimum compensation (social welfare) or disability support. There is a regulation in place (OG 102/15) which defines that the amount of compensation for a vulnerable customer is set to an amount not exceeding 200.00 HRK per month (26 EUR). Vulnerable consumers thus have direct financial help for their electricity expenses. The Energy Act (OG 120/12, 14/14) states that vulnerable consumers have the right to receive energy under specific conditions.

The Social Welfare Act (OG 157/13, 152/14, 99/15, 52/16, 16/17) states that all recipients of a guaranteed minimum compensation have the right to financial aid for housing expenses and related bills and heating. Article 43 states that eligible households that use wood heating are entitled to either $3m^3$ of wood for heating or an approved monetary amount to ease this expense. Both support systems in place are limited to only recipients of social welfare and to a specific fuel type: electricity and/or biomass.

Overall, the current Croatian policy context framing the issue of energy poverty is scarce and poorly defined; it also has questionable effects when it comes to providing protection for vulnerable energy consumers.

1.4. Framing the context of energy poverty in Croatia

There have been only a few attempts to investigate the factors describing energy poverty in Croatia. A phone survey on the state of EE awareness in Croatia was undertaken in 2013, and it included a section on energy poverty [20,39]. The results of the phone survey analysis show that the largest number of respondents spent from 500–800 HRK (66–105 EUR) monthly on their energy bills. Considering that the monthly average equivalent income for the same year (2011) was 3776 HRK (495 EUR) [40], the average household was spending between 13% and 21% of its income on energy costs in the winter months.

Energy poverty has also been analysed in a dissertation on the efficiency of district heating system models and energy poverty [41].

Using Croatia as a case study, recent research on energy poverty in the Western Balkans assesses possible policy adjustments, arguing that investing in EE is a cost-effective policy mechanism compared to the policies currently in place, which offer direct financial support for vulnerable groups [42,43]. In addition to the scarce research dedicated specifically to energy poverty in Croatia (or the Western Balkans as a region), data are available through two main sources on the EU level: the European Union Statistics on Income and Living Conditions (EU SILC) and Household Budget Survey [44]. According to EU SILC's results for 2015, 10.9% of the Croatian population was living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floor, and those issues were faced by 21% of those living below 60% of the median equalised income (MEI). In the survey, 9.9% were unable to keep their homes warm, and 23.7% of those were below 60% MEI. It is important to take into consideration that the stated results are in relation to all Croatia. It is likely that the mountainous areas, together with central, northern and eastern Croatia, will have greater difficulties in the winter months because of a greater need for energy to heat the household [41]. Another important indicator of the critical situation in Croatia is that 28.7% of its citizens have arrears on their utility bills (compared to the 9.1% EU28 average), with 40.5% of those living below 60% MEI having arrears on their utility bills (21% EU28) [11]. Croatia has a worryingly high 20% at risk of poverty with 29.1% of people at risk of poverty or social exclusion, with single-female households being the most vulnerable group at 41.1%. Another group with a strikingly high at risk of poverty rate are single households 65 years of age or older, coming in at 40.4%, followed by single parents at 33.1%. For the total Croatian population, 62% has a heavy financial burden for their total housing costs, energy included [19].

Total energy use in households in Croatia in 2012 was 30,215,680 MWh, of which 71% was spent on heating [45], which, together with aforementioned inability to keep the house warm, indicates that heating-related expenses are likely directly contributing to energy poverty in Croatia. Energy and housing costs make 16.1% of personal consumption expenditures, energy costs at 10.5% [46]. A disadvantage of the existing databases is a lack of data regarding individual groups of indicators, for example, the level of the buildings' EE, the EE of household appliances and the health of inhabitants, being shown in a way that for each household, all the data and the representativeness of the sample can be followed. In the current study, to provide a basis for a more comprehensive understanding of energy poverty in Croatia and to assess the levels of the EE of dwellings, appliances and health of inhabitants, a survey was undertaken in Sisak-Moslavina County, Croatia.

2. Materials and methods

A total of 394 households were visited in Sisak-Moslavina County, out of which complete data were collected for 375 households. The survey sample was chosen with the help of the local authorities and different local actors (NGOs and social workers). Selected households were either recipients for support for vulnerable consumers, per the Croatian legislation, or they are receiving some type of direct support from local NGOs.

In the literature, there are numerous indicators linked to energy poverty [32], and regardless of the complexity of the various approaches, they can generally be divided into four groups: "(1) Subjective qualitative assessments by the affected persons; (2) Subjective qualitative assessments by others; (3) Objective non-expenditure-based indicators; (4) Expenditure-based indicators" [47]. An increasing number of studies show that different combinations of these indicators should have a role in the evaluation of energy poverty and understanding of the concept well-being [16,32,36,48,49]. All four groups are taken into consideration in our study.

Semi-structured interviews were used to gain a subjective qualitative assessment from the relevant stakeholders—local social workers, NGO representatives and local authority representatives who are acquainted with the living conditions of the assessed vulnerable households (N = 10). Based on results of the semi-structured interviews, the subjective part of the survey was designed. A questionnaire survey on energy poverty and the needs of users[1] was conducted to assess objective indicators through a quantitative approach (N = 375). The objective indicators assessed include data on incidence of mould and draught in dwellings, energy consumption and costs data, data on household appliances, efficiency of windows and doors, information on heating systems and information of the household's income. Data on electricity consumption were collected through energy bills; however, in cases when the respondents did not have bills available, a calculation was made based on the price of the monthly bill they reported. Also, if the information on the tariff model was missing, it was assumed that the average electricity price was 0.78 HRK/kWh (ca. 10 eurocents/kWh,total price, including VAT and other charges). For heating, because most of the households used fuelwood, the consumption was reported in space meters. Heat consumption was calculated based on the assumption that 1 srm = 1.575 kWh, and the average price was calculated as 280 HRK/srm. All field visits were done by volunteers who have undergone basic training on undertaking surveys. Volunteers were trained on basics of simple energy audits and were able to collect needed technical data. Due to time constraints and limits of the skills of volunteers only descriptive data on insulation was assessed (i.e. volunteers have made visual inspection of the building and noted whether there was any or no thermal insulation visible).

In the subjective part of the questionnaire, questions were designed to cover the health-related behaviours of the participants, their health status and self-assessment of their personal health. There are general approaches that can be used when measuring personal health status. One way relates to the medical exploration of the presence or absence of disease that affects the individual state or his or her quality of life in general. Another way measurement methods relates to individual health assessments and then the individual's perception of his or her health. It should be stated that a person could have a particular objective health problem that causes a certain physical pathology, but what a person feels and how he or she behaves is for that matter subjective dimensions which is equally important for science and for health practitioners. Some researchers are convinced that health is only a subjective category and that the only valid measure of health is the individual assessment of his or her health status [50,51]. In this research, health indicators related to the self-assessment of the physical and mental condition, chronic disease, personal well-being and general health were assessed.[2] The questionnaire also enabled the collection of socio-demographic data, and for the analysis, the following indicators were used:

Indicators of self-assessment of psychological and physical health (ISPPH). This consisted of a battery of six questions in which respondents were asked to estimate during the past four weeks how often: a) have they had difficulties in business or household activities because of health problems; b) their health problems limited their usual social activities with family or friends; c) have they experienced a physical pain; d) have they felt unhappy or depressed; e) have they lost confidence in themselves; f) have they had a sense that they can overcome their problems. For all six questions, the same scale of 1 to 5 was used (1-never, 2-rarely, 3-sometimes, 4-frequently and 5-very often).

Indicator of illness (II). Through this indicator, the respondents were asked to indicate if they were suffering from a long-term disease, chronic illness or disability; here, it was possible to respond with 1-yes and 2-no.

Indicator of personal well-being (IPW). As a measure of personal well-being, respondents were asked to answer the question, 'Thinking in general about your life today, how happy are you in general?' Answers were set up on a 7-point Likert type scale: 1-completely happy, 2-very happy, 3-quite happy, 4-neither happy nor unhappy, 5-unhappy, 6-very unhappy and 7-completely unhappy.

Indicator of general self-assessment of health (IGSH). As part of this indicator, a frequently asked question is used: 'In general, would you say that your health is…'. The answers were 1-low, 2-fair, 3-good, 4-very good and 5-excellent.

For an easier comparison, three indexes were constructed: an *index of the self-rated mental health (ISMH)* and the *index of the self-rated physical health (ISPH)* (range from 3 to 15 in both indices, where the lower values indicate a better state of health). Both of those indexes were combined into one *index of self-rated general health (ISGH)* (range from 6 to 31).

The first part of the field survey, which was done through field visits, was conducted from April to August 2015. The second round of field visits was carried out from November 2015 to February 2016. In the second round of field visits, all households were provided with and implemented simple EE measures with average investment of 40 EUR (LED lightbulbs, reflective foils for radiators, timers for electrical boilers, draft proofing for doors and windows and water aerators). Through these inexpensive measures, the goal was to improve the quality of life of the participants and reduce energy consumption. All participants were advised on the efficient use of energy by the field workers and through brochures and leaflets. This segment of the research was used to assess the im-

[1] For objective part of the survey existing template available from project Achieve was used [70]. Same questionnaire was conducted in Bulgaria, Slovenia and Macedonia within the project REACH [71], however only in Croatia subjective part of the survey was developed.

[2] Indicators of a health condition used in this survey were the standard health indicators used in the *International Social Survey Programme,* which is a cross-national collaboration programme that conducts annual surveys on diverse topics relevant to the social sciences. One of those surveys is the module *Health and Health Care* from 2011. Replication of the indicators enables the comparison of the data from the present paper with the general population of adult citizens in Croatia (*ISSP Research Group (2015): International Social Survey Programme: Health and Health Care – ISSP 2011. GESIS Data Archive, Cologne. ZA5800 Data file Version 3.0.0,* doi:10.4232/1.12252).

Table 1
General characteristics of the respondents.

		Respondents (%)	National population
Sex	Male	34.4	47.4
	Female	65.6	52.6
Age	18–34	13.6	27.1
	35–54	46.1	32.7
	55+	40.3	38.5
Marital status	Married (and living together)	46.4	59.2
	Married (living separated)	0.5	2.9
	Civil partnership	6.1	NA
	Divorced	15.2	4.8
	Widowed	19.7	12
	Never married	12	24
Education	No formal education	15.2	1.8
	Primary level	33.9	17.4
	Secondary level	47.5	54.8
	Tertiary level	3.5	17.6
Work status	Unemployed (looking for job)	54.1	8.2
	In formal education system (not paid by employer)	0.3	3.5
	Permanently sick or disabled	3.7	6.5
	Retired	25.9	31.4
	Domestic work, caring for children or other persons	12.5	6.3
	Other	3.2	0.1
		M	
Income	Respondent's monthly income (€)	163.87	–
	Household's monthly income (€)	311.99	924
	Household's monthly income per capita (€)	108.89	–
Household members		3.56	2.8

pacts of small EE improvements and energy-saving advice on the overall quality of life. Four months after the second visit a phone survey was conducted to assess overall satisfaction level with measures and advices provided (N = 60). Respondents were chosen randomly from the list of visited household subject to availability of their phone number and their willingness to participate in the phone survey.

All respondents from quantitative and qualitative research sections were asked to give an informed consent to participate in the research, and their identities were anonymised; data are presented on an aggregate level.

3. Results and discussion

Sisak-Moslavina County is situated in eastern central Croatia and has seven towns and 12 municipalities. According to the last census, it has a population of 179,078. From the characteristics of the surveyed respondents (Table 1), especially compared to the average population in Croatia, it is clear that there is a slight overrepresentation of those groups that are more likely to be vulnerable. When compared to national averages [52], the surveyed sample from this research is slightly skewed in terms of having more elderly, more widowed, more people with a lower educational level and more women. The most significant difference is that there is no officially employed respondents because all the respondents were either energy vulnerable or socially vulnerable (according to the current Croatian legislation).

In 2015, on a national level, the average disposable monthly income per household was 924 EUR, while in the surveyed households, the average households monthly income was 312 € and per capita income was 109 EUR [19]. In 2015, the median equalised income was 457 EUR [53] monthly, so the surveyed sample falls below 60% of the national equalised income, meaning they are in the group of people at risk of poverty or social exclusion.[3]

3.1. Household conditions

Most (55%) of the visited households (N = 375) had three or more household members, and they were living primarily in family houses (89%) mostly built before 1990 (84%). The average living space was 72 m^2, out of which 56 m^2 was heated. In the study, 78% of the visited households used individual fuelwood heating stoves, with 15% having fuelwood fired central heating and 7% being connected to the local district heating network. Most dwellings (93%) had no building insulation whatsoever. The windows and doors were also inefficient, with single-glazing or old type of double widows without insulation (Table 2). Eleven of the visited households were not connected to the electricity grid. They either had no electricity at all or occasionally used electricity from a neighbour.

It is important to note that for the living space, only the estimates provided by household members have been used; the dwellings were not measured. The difference between overall living space area and the areas heated in the winter months occurred because many households were forced to reduce their living space in the winter. They either had no heating systems available in some rooms or were unable to pay for the needed heat. Similar results were shown by research undertaken in 2012/13 on a sample of 1722 respondents who were randomly chosen via phone survey across all Croatia [20,39]; in that survey, 22% of households reported they reduce their living space in the winter months, primarily as result of an inability to afford the needed energy (55%) and because of a lack of heating systems in certain rooms (22%).

The average consumption of electricity for one of the studied households amounted to 4.427 kWh/annum, which is more than national average in 2012 at 3.766 kWh/annum for all Croatia and 3.766 kWh/annum for Sisak-Moslavina County (calculated from [52,54]). The average heat consumption for the studied dwellings was 25.220 kWh/annum, double the national average in

[3] The at risk of poverty threshold is determined by calculating the equivalised income per household member for all households. After that, the middle value (median) of the income distribution is determined, and 60% of the median is determined as the risk of poverty threshold. Persons with an income below the threshold are at a higher risk of poverty than others but do not necessarily live in deprivation [19].

Table 2
Information regarding the dwellings participating in the study.

		%
Type of dwelling	House	89.3
	Apartment	10.7
Year of construction	1991–2010	16.5
	1981–1990	18.1
	1956–1980	46.1
	<1955	19.2
Insulation of the dwelling[a]	Walls and roof	3.7
	Walls	2.9
	Partially insulated	0.8
	No insulation	92.5
Window isolation	Single-window glazing	34.1
	Double-window glazing without insulation	44.5
	Double-window glazing with insulation	21.3

[a] Insulation level was assessed based on visual appearance and based on inputs of household members. "Partially insulated" means parts of walls have insulation.

Table 3
Information regarding the health conditions of the survey participants.

		Never	Seldom	Sometimes	Often	Very often		
		%						
ISPPH	Health problems limit usual social activities with family and friends	56.1	14.6	12.2	9.8	7.3		
	Difficulty with work or household activities due to health problems	29.9	12.6	17.6	19.5	20.3		
	Have bodily aches or pains	27.2	10.7	19.7	21.3	21.1		
	Feeling unhappy and depressed	26.5	12.9	28.7	18.5	13.4		
	Losing confidence in yourself	60.6	9.2	14.9	9.0	6.3		
	Feeling you could not overcome your difficulties	41.5	13.7	22.4	14.6	7.8		
		Yes	No					
II	Long-term disease, chronic illness or disability	53.3	46.7					
		Completely happy	Very happy	Quite happy	Neither happy nor unhappy	Unhappy	Very unhappy	Completely unhappy
IPW	How happy in general	10.0	16.3	29.8	30.1	8.9	3.5	1.4
		Low	Fair	Good	Very good	Excellent		
IGSH	In general, would you say that your health is…	21.3	32.0	25.6	13.1	8.0		

2012, which was 10.889 kWh/annum, but similar to the average for Sisak-Moslavina County in the same year, 23.209 kWh/annum. Completely uninsulated dwellings combined with old and inefficient household appliances are the likely reasons for these high energy consumption rates [18,55]. Another important finding is that almost all the households faced some continuous draught through windows, doors or both (89%) and more than half (57%) had visible mould in their homes.

3.2. Health conditions

Many respondents, over 50%, were suffering from a long-term illness or chronic illness or had certain disabilities (Table 3). It can be assumed that this high rate of chronic health problems is present because of the sample bias (vulnerable energy consumers, per Croatian legislation, and recipients of direct support from local NGOs), but if the percentage of those suffering from long-term illness, chronic illness or disabilities is compared with the 22% of the general population [56], then it is obvious that the personal health of the respondents living in inadequate household conditions is significantly more detrimental. In accordance with this information are the current study's percentages of the general self-assessment of health, according to which over 50% of the respondents' health in general was rated as poor or mediocre (Table 3). On the national level, this is the case with 30% of the population [56].

A significant number of respondents (57%) stated that in the last four weeks (by the time of the survey), they had difficulty carrying out work or household activities due to their health problems; around 60% had bodily aches or pain, and around 60% felt unhappy and depressed. Around 30% of the respondents claimed that they were unable to participate in social activities due to their health problems. Opportunities to participate in community activities represent one of the key parameters for the overall assessment of the participants' quality of life and are a focus of energy poverty research.

A comparison between the general population and the respondents in our research clearly shows that the respondents have poorer mental and physical health (Fig. 1). Overall, their general health status is significantly more vulnerable than the general population.

3.3. Household conditions as determinants of health conditions

In exploring energy poverty, special attention is being paid to exploring the connection between energy poverty and health in terms of mediating the role that poor housing conditions have on personal health [4,55,57–61]. To explore to what extent the personal health of respondents is impacted by the household conditions, a linear regression analysis was employed (Table 4). The characteristics of the dwelling are set as predictor variables while the ISMH, ISPH and ISGH are modelled as criterion variables.

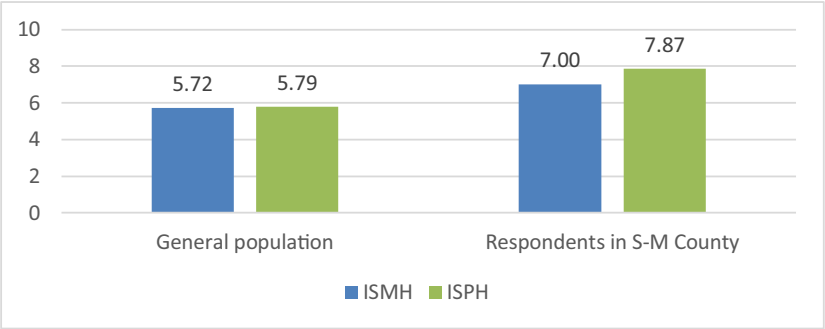

Fig. 1. Indexes of the self-assessment of mental (ISMH) and physical health (ISPH)—a comparison between the general population and S-M County respondents.

Table 4
Linear regression models—household conditions as determinants of health conditions.

	ISMH		ISPH		ISGH	
	Beta Coeff.	Sig.	Beta Coeff.	Sig	Beta Coeff.	Sig
Type of dwelling	−0.093	0.073	−0.012	0.811	−0.066	0.204
Year of construction	0.043	0.421	0.118	**0.025**	0.095	0.077
Isolation of the dwelling	0.104	**0.047**	0.129	**0.013**	0.135	**0.010**
Window isolation	−0.123	**0.021**	−0.009	0.866	−0.071	0.179
F-ratio	3.799		3.233		3.911	
F-Sig.	0.005		0.013		0.004	
R-squared	0.040		0.034		0.042	
Adjusted R-squared	0.030		0.024		0.031	

Items in bold show statistical significance, when $p < 0.05$

Although the models presented in Table 4 are not robust because personal health has many more significant predictors, the results indicate that dwelling conditions are important when speaking of the determinants of health. In all three models presented, isolating the dwelling stems as a statistically significant predictor of the indexes of personal health. The poorer the isolation of the dwelling is, the poorer the personal health is. As mentioned, in the surveyed households, there is a significant presence of mould, with 54% of the dwellings having visible mould. Therefore, the difference between the households in which the mould is visible and those in which it is not in respect to self-reported general health was assessed (because ISGH as a composite measure contains more information on personal health). Nonparametric statistics were conducted to test the difference between households experiencing problems with mould and those without, and the results imply a statistically significant difference (Mann–Whitney $U = 112.412{,}00$; $p < .021$). In dwellings with a visible presence of mould, the respondents tended to have poorer overall health.

3.4. Impact of the simple energy efficiency measures and energy advices

The phone survey results indicated that concept of providing vulnerable households with simple energy efficiency measures significantly improves overall living comfort. Overall 77% of respondents reported their general living comfort has improved. When asked more specific (it was possible to provide multiple answers in this question). 42% of respondents reported that their general comfort has improved a lot, although for some few problems with cold, humidity and draught remain. 19% of respondents stated their overall comfort has improved after the second visit but they still sometimes feel cold with 9% stating they still feel some draught even ater being provided with draught proofing on their windows and doors. Overall 17% report they still had problems with humidity regardless of the devices provided. Another important finding is that 87% of the phone survey respondents (a total of 52 households) reported at least some improvement in quality of life as direct result of EE measures and energy advices provided.

The average calculated energy saving per household was 68 kWh of electricity and 599 kWh of heat annually. These energy savings resulted in estimated total cost savings of 55 EUR/year. Compared to investment cost of mere 40 EUR it is evident that the simple EE measures have a very short payback period and provide immediate improvement in quality of life.

Testing of simple and low-cost EE measures has indicated potential for improving the overall quality of life. It is likely that greater EE investments would result in better overall satisfaction and impact, however, more research is needed to test this hypothesis.

4. Discussion—What can we learn from the data?

The results of the field survey conducted in Sisak-Moslavina County indicate that most vulnerable energy consumers in Croatia do not have adequate basic energy services. Moreover, some are facing a complete lack of access to specific services. Eleven (almost 3%) of the visited households were not connected to the electricity grid. Many households have no heating in more than one room, and most have inadequate indoor lighting. Furthermore, visited households had household appliances—refrigerators, freezers, washing machines, electrical boilers and so forth—older than 30 years, and most of these dwellings had no thermal insulation. Individual fuelwood stoves and inefficient old central heating systems without the ability to regulate temperature or distribute heat evenly across rooms in dwellings without thermal insulation result in high energy requirements. The inhabitants of such households are exposed to the continuous flow of cold air through uninsulated windows and doors, which create high levels of humidity that result in mould. The results clearly indicate that living in such conditions has adverse impacts on one's health. The overall assessment of physical and mental health was lower than for the general population, and the respondents exposed to mould reported hav-

ing poorer health conditions. Similar results have been found in previous research in France and the UK [62–64].

Energy poverty has a greater impact on the health and overall well-being of household members than some other forms of poverty [58,65]. Inadequate indoor temperatures and high levels of humidity, creating evident mould, increase the risk of many diseases [63,64]. This research shows this is the case of the respondents exposed to mould. Despite the fact that living in energy poverty has an adverse impact on health and poses serious threats in the long term, the public policies currently in place in Croatia only provide financial support for a part of the energy expenses [21,42]. Although this approach eases the financial burden of the energy costs, it does not offer a solution to the inefficiency of the buildings or appliances, and it does not improve the overall living and health conditions. Furthermore, this approach does not support the rational use of energy, and as such, it does not have any positive impact on the environment or on a household's budget. On the other hand, EE has long been recognised as a central pillar of Croatia's energy strategy; however, the actual implementation of EE measures has been slow, mainly due to a lack 'of a serious and forceful political commitment to adopt and to implement energy efficiency policies' [66]. EE, together with the improvement of heating systems, improves indoor air quality, temperature and humidity and thus removes numerous adverse impacts on health [15,16,31,62,67].

Improving EE in vulnerable households in Croatia is likely to have positive impacts on the health of the inhabitants while also helping ease the burden the state's continuous financial support [68] to cover the ever-increasing energy costs and health care costs arising from the increased incidences of certain health conditions.

Potential of EE measures was researched through provision of simple and low-cost EE measures to the visited households during the second round of field visits. As shown in the Results and discussion even those very basic measures already contribute to improving the overall quality of life and decreasing prevalence of indoor cold and draught. It was found that the implementation of simple, low-cost EE measures can result in a significant improvement in the general comfort level of the households although a few problems with cold, humidity or draught still remain for some [42]. Testing the impact of implementing a wider range of EE measures is needed on a national level with wider range of EE measures. This would show the actual scale of health and well-being impacts while contributing to efforts in fighting climate change through reduced energy use while enabling a shift toward using the state budget as an investment rather than continuous expenditure [69]. Because there is a lack of strong political will to invest in EE in Croatia [66], shifting the focus from energy savings to improvement of health, well-being and living conditions for the vulnerable could trigger greater interest of different political and social actors to speed up the EE implementation process.

Providing a traditionally technical topic such as EE within a strong social context could increase its visibility on the political agenda. Strong political commitment and proven success stories is the best way to start the talk on EE [66], and we believe that starting a national pilot with different levels of EE investments in energy-vulnerable households will speed up the development and implementation of adequate policies for energy poverty while opening the door for an overall increase in EE.

5. Conclusions and policy implications

Energy poverty is a multidimensional problem that is likely to affect a significant share of Croatian citizens. Further research is needed to assess the scope and intensity of energy poverty in Croatia and to analyse possible definitions. This study has analysed one segment of energy poverty in a specific region on a specific group of people: the impacts of living in energy poverty in Sisak-Moslavina County on residents' health and well-being. The current study has shown that those who are affected by energy poverty are living in inadequate conditions and face adverse impacts on their health.

A lack of data, lack of a systematic approach and a total lack of an all-encompassing definition of energy poverty and energy vulnerability has led to the inefficient administration of resources and produced the long-term health consequences for the affected population. To enact a quality solution to the problem of energy poverty in Croatia, it is necessary to design and implement policies that would focus on eliminating both the causes and consequences of energy poverty.

The research presented in this paper focused primarily on energy-vulnerable consumers, per the current Croatian legislation's definition. Although the results of the research indicate severe deprivations of basic energy services and adverse impacts on health, this research only focused on one segment of the energy poor in Croatia. For gaining more insight into the causes and consequences of energy poverty and testing benefits and assessing limitations of EE improvements in Croatia, further research is needed.

Though the legislative framework is lacking, the implementation of EE measures should serve as the first step. Though the attempt to make a first step in tackling energy poverty has been taken in Croatia by introducing the solidarity tariff and support for fuelwood purchase, this type of measure is questionable in the long term. Direct subsidising of energy bills does not improve living conditions and thus does not remove the adverse impacts on health; in the way it is designed, the current policy poses a threat to push more people into energy poverty because the solidarity fee is charged for every kWh of electricity used. Additionally, this mechanism exclusively focuses on one of the consequences (inability to pay for electricity bills and fuelwood), without addressing the source of the problem. It is further limited by focusing only on a very narrow group of vulnerable citizens and only two types of fuel. As energy poor live in inefficient and deteriorated buildings with inefficient appliances EE is a measure that can improve living conditions while decreasing energy costs and it decreases the long-term burden on the state budget that arises from the continuous provision of direct financial support and health costs of those affected by living in inadequate conditions.

To root out energy poverty, there is a need to define the energy and social policies that would enable an improvement in the population's living and health conditions while easing the financial burden of energy needs for both households and the state. Shifting the focus from energy savings to health benefits could contribute to the creation of much needed political will, enabling the immediate start of the implementation of a wide range of EE measures—from lower cost to the full retrofitting of building envelopes.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.enbuild.2018.03.080.

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