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Investigating the Regional and Individual Drivers of the Support for Renewable Energy Transition: The Role of Severe Material Deprivation

Efthymios Altsitsiadis | Micha Kaiser | Anastasios Tsakas | Anastasios Kyriakidis | Angelos Stamosris

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Highlights

- Regional factors can influence public support for renewable energy.
- Severe material deprivation negatively affects support for renewable energy – both hydrogen and biomethane technologies.
- Policies promoting support for renewable energy should address regional makeup, as its effects are not visible at national or individual levels.
- European regions with higher severe material deprivation rates could be transitioning slower, while increases in (energy) poverty might be associated with further decreases.

Abstract

Clean energy transition underpins the European Energy strategy with ambitious objectives for Renewable Energy Technologies (RET) deployment. Yet, social support remains a significant barrier to accelerating the energy transition. Existing studies have examined wide-ranging social-psychological factors that can affect support for RETs but have failed to address key local barriers. This study aims to illuminate regional characteristics that can influence social support for energy alternatives by assessing public support for two emerging renewables, hydrogen and biomethane, in three different EU countries, the Netherlands, Spain and Greece. We combine our micro-data with EU regional indicators to extend our model beyond known individual-level factors and test the effects of higher-scale antecedents covering regional development, poverty and social exclusion statistics. Our multilevel regression analysis reveals that severe material deprivation plays a key role in social support for RETs. In particular, our results suggest that people living in regions with elevated poverty levels are less likely to support such energy systems. This finding is consistent for both the renewables examined in the three EU countries studied. Our research offers significant and timely insights for accelerating the clean energy transition, while highlighting the need for better strategies to gain and increase social support for RETs.

Keywords: Renewable energy acceptance, just transition, energy poverty, regional factors

1. Introduction

Today, with global warming so clearly evident, urgent action is required (Atwoli et al., 2021) to shift energy production away from conventional fossil fuels. The concept of *clean energy transition* (Tagliapietra et al., 2019) is at the core of the European energy strategy, which highlights the development and deployment of Renewable Energy Technologies or RETs as primary components (Commission & Energy, 2019). In the revised Renewable Energy Directive (Official Journal of the European Union, 2018), which is the legal framework for developing renewable energy across all sectors of the EU economy, the European Union set the overarching renewable energy target of 32% and included rules to ensure the uptake of renewables, while calling for further accelerated deployment. However, the energy transition seems to be stagnating as the energy crisis (Hussain et al., 2023), the increased building costs for new RET infrastructure (Dominković et al., 2018) and political aspects (Hewitt et al., 2017), together with several other barriers (Popescu et al., 2022), are hindering its acceleration.

Social support for renewable energies is a key moderator for the success and speed of the energy transition. In fact, social support is considered one the greatest non-technical barrier (Mancini & Raggi, 2022), with some research even indicating that social and technological dimensions are of equal significance (Fournis & Fortin, 2017). Scientific evidence consistently shows that social factors significantly impact on the adoption and implementation of RETs (Wüstenhagen et al., 2007). As this influence spans all types of RETs, not wind and solar energy exclusively, social acceptance issues are highlighted as prevalent regardless of the maturity level or specific category of a technology (Cousse, 2021; Ellis & Ferraro, 2017). Research from various fields has illustrated the complexity of social factors in renewable energy adoption. Therefore, identifying and understanding the drivers for public support are crucial for enhancing and ultimately achieving a more effective energy transition (Segreto et al., 2020).

Literature has acknowledged several drivers for social support. First, socio-psychological factors, including demographic characteristics, have been shown to influence public support for RETs (Dessi et al., 2022; Huijts et al., 2012). Research has also shown that the ***perceived benefits and costs*** of RETs can play an important role in social support for such energy systems (Baxter et al., 2013; Emodi et al., 2021; Haggett et al., 2011; Liebe & Dobers, 2019; Strazzera et al., 2012; Huijts et al., 2014; Perlaviciute & Steg, 2014). For instance, Soland et al. (2013) found that perceived benefits and costs of biogas plants are strongly correlated with social support for such renewable energy systems, underlining that increased perceived costs in particular negatively impact on support for biogas plants. ***Trust*** is another key influencing factor (Aitken, 2010). Indeed, scholars have found that people with ***trust in technology*** are more likely to support RETs (Achterberg et al., 2010; Hall et al., 2013). In addition, ***trust in various stakeholders*** (Baur et al., 2022; Emmerich et al., 2020) who are responsible for planning, decision-making and implementing renewable energy projects, strongly influences support, as members of the public perceive them as technical experts, especially when a technology is relatively known. ***Perceived risks*** relating to the safety of RETs and uncertainty about financial costs, such as maintenance and repair costs, also seem to influence social support (Emmerich et al., 2020; Huijts et al., 2012).

Several studies have examined ***attitudes*** from a social-psychological perspective as a key determinant of public support for RETs (Carlisle et al., 2015; Guo et al., 2015; Liebe & Dobers, 2019). In particular, attitudes are a factor, defined as a positive or negative evaluation of a certain type of alternative energy system, that strongly influences public support. In other words, people with a more positive attitude towards RETs are more likely to adopt such energy projects. Researchers have also studied the impact of ***personal values*** on support for renewables (Bidwell, 2013). In short, personal values are described as general guiding principles for an individual's life (Bouman et al., 2018). Biospheric, altruistic, hedonistic and egoistic values are of great interest with regard to environmental research and their effect on sustainable energy transition (Perlaviciute & Steg, 2014). ***Sociodemographic characteristics*** such as age, education and gender appear to play a role in support for energy alternatives (Schönauer & Glanz, 2022). Findings suggest that young male individuals with higher levels of education are more likely to support renewables than older, less-educated females (Azarova et al., 2019; Bertsch et al., 2016).

Regional characteristics can potentially comprise another important set of key factors that drive the energy transition. Literature have shown that energy consumption can be influenced by regional characteristics in NUTS 2 levels such as disposable income per habitat and severe material deprivation (Borozan, 2018). Yet, a few studies have examined key determinants ***at regional level*** that can influence RET adoption. Jenniches' (2018) literature review on the potential economic impacts of RETs and their assessment at regional level concluded that regional characteristics are crucial for RET deployment. Horbach and Rammer (2018) found that regional factors such as proximity to RET facilities and the regional green orientation correlate strongly with the diffusion of renewable energy innovation.

While prior research has provided extensive insights into the dynamics of social support for RETs, a comprehensive understanding of how regional characteristics and social-psychological factors intertwine to influence this support remains less explored. Our study aims to bridge this gap in the literature by examining the interplay between individual-level social-psychological attributes and regional factors in shaping social support for emerging RETs – specifically hydrogen and biomethane – to uncover the multidimensional drivers for social support. Our ultimate goal is to contribute towards a more effective and inclusive energy transition strategy.

Over the past few years, ***hydrogen*** and ***biomethane*** have become two promising RETs for decarbonising the energy system in the EU. This is reflected mainly in the EU Hydrogen Strategy (European Commission, 2020), which charts a course for large-scale deployment of renewable hydrogen from 2030. Similarly, the targets of the REPowerEU plan (European Commission, 2022) aim for biomethane production of 35 bcm[1] by 2030, thus paving the way for EU energy independence. Hydrogen is usually produced by water electrolysis with zero greenhouse gas emissions (GHG) depending on the electricity source used (Shiva Kumar & Himabindu, 2019). Hydrogen has several main advantages: its high energy density, light weight, and facile electrochemical conversion (Oliveira et al., 2021). It can be used as a feedstock for the chemical industry, for heat generation, as a reagent for producing synthetic fuel, and for electricity generation via fuel cells, to name but a few applications. Biomethane, on the other hand, is a purified and upgraded form of biogas produced by anaerobic digestion of organic matter. It can be used for heating and electricity generation, transportation fuel or as a natural gas substitute in the grid (Khan et al., 2021). The advantages of using biomethane lie in its environmental and economic sustainability, as it combines sustainable waste management and green energy production with reduced GHG emissions (D'Adamo et al., 2023).

In the present study, empirical micro-level data were collected from three EU countries, specifically the Netherlands, Spain, and Greece, and comprehensively analysed, drawing on recent research (Scheepers et al., 2022; Brey, 2021; Calero et al., 2023). Exogenous regional data were also incorporated to examine the effect of regional determinants on social support for the two selected RETs under consideration. To the best of our knowledge, this research appears to be the first to explore the relationship between regional characteristics and the drivers of social support for RETs, taking into account the impact of individual socio-psychological characteristics. Using robust multilevel regression analysis that could account for nesting effects, a significant finding emerged: severe material deprivation has a notable impact on social support for both hydrogen and biomethane. This consistent association underscores the importance of regional socio-economic contexts in influencing public attitudes towards emerging RETs.

The rest of this paper is organised as follows: Section 2 outlines the materials and method used in our study. Section 3 reports the results of the multilevel regression analysis. In Section 4, we discuss the main study findings. And finally, Section 5 presents the main conclusions of this work.

[1] Billion cubic metres.

2. Data and methods

2.1. Data collection

To facilitate the present study, an online survey based on scale items derived from prior research was deployed from November to December 2022 through two panel data companies, across three countries – Greece, Spain and the Netherlands. The research sample consisted of 3,055 responses in total, with a roughly equal distribution of participants per country.

2.2. Measurements

2.2.1. Personal characteristics

Data collection on personal characteristics encompassed several key variables: respondents' support for RETs, basic knowledge on the technologies, perceived benefits, perceived costs, trust in technology, trust in utility companies, energy industries and governmental authorities, perceived risks, and personal values.

A questionnaire devised by Achterberg et al. (2010) was used to measure respondents' support (*SUP_IN_EN*). Participants were asked to indicate their agreement with nine statements, such as *"I think using hydrogen/biomethane as a fuel is a very good idea"* and *"I think using hydrogen/biomethane as a fuel for me personally is acceptable".* To determine the attitudes towards using power from hydrogen and bio-methane *(ATT_TOW_EN)*, participants were asked to indicate their agreement with five statements based on an adapted measure, previously used by Kardooni, Yusoff and Kari (2016).

To evaluate participants' fundamental understanding of each technology, they were presented with a series of self-assessment questions designed to indicate their awareness and knowledge of each technology. For hydrogen (*KNOWL_HYDRO*), a set of questions previously used by Ono and Tsunemi (2017) was employed, while for biomethane (*KNOWL_BIO*), a set of questions validated by Mazzanti, Modica and Rampa (2021) was used.

The perception of the benefits associated with biomethane and hydrogen technologies (*PERC_BEN*) was assessed using a questionnaire adapted from Kim et al. (2014). Respondents were asked to indicate their agreement with several statements such as *"employing hydrogen/biomethane technology gives us environmental and social benefits"* and *"overall, I feel that employing hydrogen/biomethane technology is beneficial for our society*". Based on the same study, the perceived costs *(ECON_COST)* related to hydrogen and biomethane technologies were assessed on a similar scale.

To measure trust in hydrogen and biomethane technologies (*TRUST_TECH*), participants were asked to state their agreement with three statements based on Kim et al. (2014), specifically "*hydrogen/biomethane technology is more reliable than other energy technologies", "hydrogen/biomethane technology is more* *trustworthy than other energy technologies"* and "*hydrogen/biomethane technology is more secure than other energy technologies*". Trust in utility companies (*TRUST_UTIL*) was evaluated using a measure previously validated by Chen, Xu, and Arpan (2017), with questions such as *"I trust my utility company overall"* and *"I trust my utility company provides good service"*. Trust in governmental authorities (*TRUST_AUTH*) was measured with a set of items taken from a study by Baur et al. (2022), for example "*I trust that the governmental authorities will ensure that safe technology plants will be built"* and *"I trust that the governmental authorities have the relevant expertise to successfully build a safe technology plant*". Likewise, trust in the energy industry (*TRUST_IND*) was measured through a set of three items based on the same study.

To measure the perceived risks of hydrogen and biomethane usage (*PER_RISK*), items from Wang et al. (2019) were utilised, i.e. *"I am concerned about the safety of hydrogen/biomethane infrastructure"* or *"The operation of hydrogen/biomethane infrastructures constitutes a continuous threat to human health and the environment"*.

Personal values were measured using a scale developed by Bouman, Steg and Kiers (2018) to assess respondents' biospheric (or pro-environmental) behaviour (*BIO_VAL*), altruistic behaviour (*ALTR_VAL*) indicating a value placed on the welfare and well-being of other human beings, egoistic values (*EGO_VAL*) focusing on valuing personal resources, and hedonic values (*HED_VAL*) emphasising the importance of pleasure and comfort. We also collected information on each participant's age, sex, education and net annual household income. A detailed description of these variables and their levels of measurement is provided in Table A in the Appendix.

2.2.2 Regional Characteristics

A range of representative economic and social indicators (Appendix - Table A1) at regional level were selected to examine the influence of regional attributes on social support for hydrogen and biomethane. These indicators, i.e. the most recent data available for the countries in the analysis, were sourced from the Eurostat platform[2]. Our selection process aimed to incorporate a balanced mix of metrics. Some indicators were chosen for their economic relevance, reflecting the financial aspects of regions that could impact on attitudes towards energy innovations. Others were included for their social implications, providing insight into the societal dynamics that might influence public support. A few indicators also served as control variables, helping to ensure the robustness of our analysis by accounting for potential confounding factors. This thorough approach allowed us to develop a deeper understanding of the various factors that shape regional support for hydrogen and biomethane technologies.

[2] https://ec.europa.eu/eurostat

Specifically, the following indicators were used: the *Cooling Degree Days (CDD)* and the *Heating Degree Days (HDD)* indicators at NUTS3 level (2022), the *Regional Innovation Scoreboard (RIS)* indicator for NUTS2 level regions (2021), the *Regional Gross Domestic Product indicator* expressed in Purchasing Power Standards per inhabitant for NUTS2 level regions (2021), the *Severe Material Deprivation Rate* for NUTS2 level regions (2020), and the *Gross Value Added* at basic prices indicator for the primary and secondary sectors at NUTS 3 level (2020). The regional level, i.e. the NUTS[3] classification system, is very important for policymaking within the European Union (EU). In brief, this classification system divides the EU economic territory into regions at three different levels: NUTS 1, NUTS 2 and NUTS 3 and enables comparisons of regional statistics between these levels. For example, material deprivation, a key regional characteristic, has been found to drive energy consumption at NUTS 2 level in several EU regions (Borozan, 2018).

Heating degree days (HDD) and *cooling degree days (CDD)* are weather-based technical indicators designed to describe the energy requirements of buildings in terms of heating HDD or cooling, respectively (Spinoni et al., 2018). HDDs reflect the energy requirement – for instance, of a heating system in a building – over a day or an extended period, to elevate the indoor temperature to a predetermined base level (e.g., 15.5°C) in colder climates. Conversely, CDDs measure the energy necessity – for example, of a cooling system in a building – over a similar timeframe, to lower the indoor temperature to a set base level (e.g., 22°C) in hotter climates. The conceptual framework for calculating heating and cooling degree days can vary based on the nature and objectives of a study (e.g., Schoenau and Kehrig, 1990).

The *Regional Innovation Scoreboard (RIS)* is a regional extension of the European innovation scoreboard (EIS), for assessing and comparing the performance of innovation systems in European regions. As of 2023, the RIS provides a comparative assessment across 239 regions from 22 EU countries, as well as other European regions. The RIS is part of a broader set of scoreboards and initiatives aimed to promote and measure innovation in Europe. The *Regional Gross Domestic Product* indicator expressed in Purchasing Power Standards per inhabitant is a measure used to compare economic performance and living standards across different regions. This measure adjusts for differing price levels between countries, providing a more accurate comparison of economic output and living standards. RGDP per inhabitant in PPS is the key variable for determining the eligibility of NUTS 2 regions within the framework of the European Union's structural policy.

The *Severe Material Deprivation Rate* covers indicators related to financial strain, basic amenities, housing quality and environmental conditions. Individuals who are severely materially deprived face significant

[3] Nomenclature of Territorial Units for Statistics.

restrictions in their living conditions due to limited resources. They suffer from at least four out of nine types of deprivation: inability to i) afford rent or utility bills, ii) adequately heat their home, iii) handle unexpected expenses, iv) consume meat, fish, or a protein substitute every other day, v) take a one-week vacation away from home, vi) own a car, vii) own a washing machine, viii) own a colour television, and ix) have a telephone. *Gross Value Added (GVA)* at basic prices is a significant economic metric used to measure the value added by different sectors of the economy, including the primary (agriculture, fishing, forestry) and secondary (manufacturing, construction) sectors. The index is defined as the value of output less the value of intermediate consumption. Output is valued at basic prices, GVA is valued at basic prices and intermediate consumption is valued at purchasers' prices.

2.3. (Multi-level) Regression with random intercept

Subsequently, we introduce and utilise a linear regression model and carry out a multilevel mixed-effects linear regression.[4]

Our model rests upon the variable y_{ijk}, which captures the support of the respective renewable energy (biomethane and hydrogen) from an individual i residing in NUTS3 region j nested within NUTS2 region k. The model's hierarchical framework is outlined in Equations 1 to 3. Equation 1 defines the relationship between the n_1 individual level predictors, detailed in the previous section, and the outcome variable. Equation 2 illustrates the association between the n_2 predictors measured at NUTS3 level and the individual-specific intercept α_{0jk}. Finally, Equation 3 exhibits the connection between the n_3 predictors evaluated at NUTS2 level and the NUTS3-specific intercept β_{0k}.

Level 1
$$y_{ijk} = \alpha_{0jk} + \sum_{p=1}^{n_1} \alpha_p x_{p,ijk} + \varepsilon_{ijk} \quad \varepsilon_{ijk} \sim N(0, \sigma_1^2) \tag{1}$$

Level 2
$$\alpha_{0jk} = \beta_{0k} + \sum_{p=n_1+1}^{n_1+n_2} \beta_p x_{p,jk} + \mu_{jk} \quad \mu_{jk} \sim N(0, \sigma_2^2) \tag{2}$$

Level 3
$$\beta_{0k} = \gamma_0 + \sum_{p=n_1+n_2+1}^{n_1+n_2+n_3} \gamma_p x_{p,k} + \rho_k \quad \rho_k \sim N(0, \sigma_3^2) \tag{3}$$

[4] For a detailed description of multilevel modelling, see, for instance, Garson (2013).

To summarise, Equations 1 to 3 demonstrate that we are estimating a multilevel model with random intercepts. We deliberately avoid modelling random slopes, as such a model structure appears too complex for clear interpretation and therefore numerical optimisation is extremely challenging, if not impossible.[5]

The level 3 equation contains our main variable of interest, the material deprivation rate measured at NUTS2 level. Despite our model incorporating a comprehensive set of individual and regional covariates, potential selection effects remain due to unknown regional characteristics that could systematically attract individuals with particular attitudes towards renewable energy support. While we consider this influence to be minimal, we acknowledge and discuss it as a potential bias later in the limitation section.

Finally, we use a likelihood ratio test to check whether the multilevel model offers a better fit than a simple linear model structure without random intercepts.

3. Results

3.1 Descriptive results

Before the results of our model are discussed, some descriptive findings should be presented as they comprise the foundation for our analysis. As illustrated in Table 1, our study encompasses two distinct samples – focusing on biomethane and hydrogen – with each comprising approximately 1,500 participants. A noteworthy observation is the slight difference in support levels between the two energy sources; biomethane receives a lower average rating of 3.63 on a 1 to 5 scale, compared to hydrogen's 3.84. This preliminary finding hints at variances in public perception and acceptance of different renewable energies (Paravantis et al., 2018; Cousse, 2021).

In terms of potential factors influencing support for renewable energies, such as attitudes towards energy, trust in technology, providers, the industry and authorities, both samples display similar values. For example, trust in technology scores are 4.44 for biomethane and 4.67 for hydrogen. However, it is important to note that these scores are not entirely directly comparable due to slight variations in question wording, as detailed in the previous section discussing measurement instruments.

An analysis of sociodemographic variables further underscores the samples' comparability. The average age of respondents in both groups is around 48 years, with the most common income bracket being €15,001 to €25,000 per year. Approximately 32% of participants hold a bachelor's degree, and about 20% possess a master's or advanced degree. This indicates a skew towards well-educated individuals in our sample, suggesting it may not be fully representative in terms of educational attainment. Additionally, the

[5] Note that two additional levels (NUTS1 and NUTS0) could easily be included. However, as we lack direct measurements at these levels, we have chosen not to incorporate them.

proportion of female participants, at approximately 48%, is slightly lower than anticipated when compared to the target countries' populations, being around 5.2% points below the average of the three countries and 3.1% points below the EU average[6].

– Table 1 around here –

While most regional measures do not lend themselves to straightforward interpretation, our main variable of interest, the Severe Material Deprivation Rate, registers at 7.43%. This figure is relatively low, especially considering that some European regions[7] exhibit deprivation rates exceeding 30%, highlighting the diversity of economic conditions within the geographical scope of the study.

The (descriptive) relationship between the Severe Material Deprivation Rate and support for biomethane and hydrogen is depicted in Figure 1, which presents kernel density plots that differentiate support levels for both energy sources in regions with SMDR values below and above the median. Despite some overlap between the estimated density functions, evidently support for both biomethane and hydrogen in areas with higher deprivation levels tends to be more dispersed, indicating a larger variance—and hence, less stable levels—of support for renewable energies among populations experiencing material deprivation.

– Figure 1 around here –

This trend is similarly reflected in the box plots in Figure 2, further illustrating that regions with SMDR values above the median tend to show more variability, as indicated by the wider whiskers of the box plot. This variability suggests a broader range of energy support levels, further emphasizing the complex relationship between material deprivation and support for these energy sources. Notably, more deprived regions slightly exhibit greater support for renewable energies on average, with a more noticeable effect observed for biomethane than for hydrogen. However, these figures are primarily descriptive and do not account for individual or regional characteristics. Therefore, in the next section, we delve into the modelling results to provide a more comprehensive analysis.

– Figure 2 around here –

3.2 Model estimates

This section, featuring our estimation results, begins by contrasting the linear model with the multilevel model with random intercepts. Using the full control set (column 7) in Table 2 and Table 3, the estimated variances for NUTS2 and NUTS3 levels approach 0, indicating minimal variation between NUTS levels. This is corroborated by a likelihood ratio test (Chi2 value near 0) suggesting no significant difference

[6] https://ec.europa.eu/eurostat/web/interactive-publications/demography-2023

[7] See https://ec.europa.eu/eurostat/databrowser/view/tgs00104/default/table

between the multilevel model and a standard regression lacking group-level random effects. Given the extensive set of covariates, this outcome is expected. Despite the pronounced variance at the NUTS2 level of the parsimonious model, which contradicts the null hypothesis of the likelihood ratio test and implies inter-regional variations in support for both energy types, this variation diminishes as more covariates are incorporated. Put simply, any unexplained variance in the final model stems from individual-specific variation rather than any unobserved regional differences.

–Table 2 around here –

– Table 3 around here –

In contrast to the descriptive figures previously shown, our main variable of interest, the Severe Material Deprivation Rate, exhibits a negative and statistically significant influence on support for biomethane and hydrogen across all model specifications, with the sole exception of the parsimonious model, which does not take additional influential factors into account (see Tables 2 and 3).

A closer look at Table A3 and Table A4 in the Appendix reveals the effect sizes of various covariates. Our findings align with existing research, as described in the discussion section, demonstrating a positive and significant relationship between support for biomethane and attitudes towards biomethane, perceived benefits of biomethane, trust in biomethane technology, and trust in the biomethane energy industry. We noted a statistically significant negative association with the perceived risk of biomethane (albeit within a 90% confidence interval), heating degree days, and Regional Gross Domestic Product.

Similarly, for hydrogen, our findings corroborate those in the existing literature (see discussion), identifying a positive and significant association between support for hydrogen and attitudes towards hydrogen, perceived benefits of hydrogen, trust in hydrogen technology, trust in the hydrogen energy industry, altruistic values, previous knowledge of hydrogen, and age (also within a 90% confidence interval). On the other hand, a negative correlation exists between the perceived risk of hydrogen, heating degree days and support for hydrogen.

To examine the impact of material deprivation in greater detail, we computed conditional predictions using our main model specification (including all controls), with all covariates fixed at their sample mean values. As illustrated in Figure 3, our findings indicate that each one percentage point increase in material deprivation corresponds to a 0.37% decrease in support for biomethane. This relationship highlights a significant disparity in support: ceteris paribus the most materially deprived area, with a deprivation rate of 27.4, exhibits approximately 10% less support for biomethane than the least deprived area, which has a rate of 0.5. The pattern for hydrogen is analogous but milder; a one percentage point increase in material deprivation results in a 0.18% decrease in support, translating into a 5% difference in support between the most and least deprived areas. An increase in material deprivation of one standard deviation would lead to an estimated 2% decrease in support for biomethane and a 1% decrease in support for hydrogen.

Although the negative impact of material deprivation on support for biomethane and hydrogen might appear modest at first glance, its significance becomes more apparent when contrasted with other variables within our model, such as trust. For instance, to counterbalance the effect of a one standard deviation increase in material deprivation, which leads to a reduction in support for renewable energies, we would need to (ceteris paribus) also enhance trust by one standard deviation. This comparison underscores the substantial influence that material deprivation has on public support and highlights how increased trust could potentially mitigate these negative effects.

4. Discussion

In our study, we analysed panel data from Greece, the Netherlands and Spain to investigate the individual socio-psychological and regional characteristics of social support for two specific RETs: biomethane and hydrogen. To our knowledge, ours is the first research to simultaneously examine regional characteristics and individual-level socio-psychological characteristics of social support for RETs. This dual focus enables a deeper understanding not only of the presence of support but also its varying degrees and dimensions in different contexts. To thoroughly assess these combined effects, we employed a multi-level regression analysis, a powerful tool account for the nested structure within our dataset (Lang et al., 2014). This offers a more detailed understanding of the factors influencing social support for renewable energy technologies. The results revealed some interesting findings at both individual and regional levels.

At individual level, our study identified several key factors influencing social support for biomethane and hydrogen. For biomethane, the principal drivers included a positive attitude towards the technology, recognition of its benefits, and trust in both the technology and the biomethane industry. With hydrogen, similar factors play a role, such as positive attitudes, perceived benefits, and trust in the technology and industry. Altruistic values, prior knowledge of hydrogen, and the age of the individual are also significant factors. These findings not only confirm existing research on general acceptance and support for renewable energy technologies (as discussed in studies by Baxter et al., 2013; Emodi et al., 2021; Haggett, 2011; Liebe & Dobers, 2019; Strazzera et al., 2012; Huijts et al., 2014; Perlaviciute & Steg, 2014), but also expand this body of literature, particularly regarding research focused on biomethane and hydrogen. Our study stands out as one of the first to comprehensively map the socio-psychological factors driving support for these particular technologies, and therefore offers new in-depth insights into public support in the field of renewable energy.

In the context of regional drivers, our main finding is the direct link between an individual's support for RETs, and poverty at regional level, as measured by the severe material deprivation rate. Residents in areas with increased severe material deprivation rates demonstrate less support for the two RETs featured in our study. While much of the research on support for RETs has been concentrated at national and local levels, our study reveals that regional characteristics are crucial in influencing individual attitudes, independent of these levels. This impact persists even when various regional attributes, such as climate conditions and economic structure, are accounted for, suggesting that these specific regional traits are not the drivers of the effect. Our nested model also considers potential influences from national or NUTS-level variations, establishing material deprivation as a consistent significant factor across different geographical areas, not limited to the specific cultural or political subtleties of a territory. This phenomenon was observed with both biomethane and hydrogen technologies, indicating broader applicability for our findings. Intriguingly, even after controlling for personal income, the poverty rate in an individual's region continues to significantly influence their support for RETs, underscoring the impact of regional economic conditions on individual preferences for renewable energy beyond the individual's own economic condition.

RET literature has explored the relationship between poverty and adoption, with studies suggesting that people experiencing severe material deprivation might resist adopting RETs for multiple reasons. Energy poverty in rural areas has been associated with financial, societal and political barriers (Batool et al., 2022), which, in turn, can hinder RET adoption. In the EU, individuals with severe material deprivation are disproportionately burdened by the costs of renewable energy technologies (Haar et al., 2020), as the regressive pricing structure of renewable electricity penalises low-consuming households. The problem is particularly prevalent in Eastern, Central and Southern Europe, where energy poverty is widespread (Bouzarovski et al., 2014). EU support schemes for renewable energy, while aiming to reduce greenhouse gas emissions and promote technological development, may not adequately address the needs of these vulnerable populations (Lorenzoni, 2010) while it is known that economic feasibility is a key factor in social acceptance (Moula et al., 2013). From these findings we can partially infer that people living in deprived regions – and regardless of their own financial situation, can be generally less supportive of RETs because the economic fit or urgency for RETs in the region is low.

Our study has several implications for policy and practice aiming to boost the adoption of RETs. At individual level our findings support previous research in highlighting the importance of attitudinal and perceptual factors. It should be noted that these factors are multidimensional, covering multiple aspects from the entire triple bottom line (e.g. economic investment, social impact, environmental benefits). Actions aimed at enhancing social support for RETs can therefore be more successful if they focus on promoting the key benefits that adopting these technologies could actually bring; apparently these matter to the public and can positively shape support. They should also address and dispel risk perception related to the RETs (e.g. public concerns for safety, threats, and accidents). Similarly, and consistently with previous research, trust, is an important determinant of adoption. Trust is itself a multifaceted construct and we show that actions promoting RETs should focus more on boosting trust in the technology and in the energy industry and less on trust in utility companies and authorities. Notably, our study found that while largely similar, there are still considerable differences between the two RETs. This suggests that a careful tailoring of interventions is necessary while a one-size-fits-all approach in boosting RETs adoption might be less effective.

Traversing beyond the individual level factors, our finding on material deprivation can have far reaching implications for RETs adoption. Firstly, it points to the so-far-unknown effect of severe material deprivation on RETs adoption. This is important because it adds more urgency to the ongoing debate and calls for addressing poverty. Our study shows that a reduction of severe material deprivation at regional level would have a significant positive effect on RETs support. Therefore, policies that aim to alleviate such poverty will also have a beneficial spillover in the support for the energy transition. It also, however, means that if left untreated or if the situation regresses, these deprived regions might suffer further due to the lack of support for the transition, which would in turn widen the gap with regions with less material deprivation. Secondly, it creates a new perspective for campaigns aimed at RETs adoption, suggesting that the regional make-up is an important condition that can influence the efficiency of such promotional actions. Based on our results, it should be expected by both practitioners and policy makers, that in areas with higher levels of material deprivation, the baseline support will be less, suggesting that additional or better tailored efforts will need to be foreseen to increase general support for RETs.

5. Conclusions

This study set out to map social support for renewable energy technologies across subnational regions, and to test the importance of higher-scale factors, particularly poverty, on individual social support. Our findings reveal a previously unseen connection between social sustainability and the green transition. Poverty – at higher aggregations than micro level – can impede social support for RETs, and this finding transcends factors such as the countries, regions and renewable technologies covered in this study. While this finding is robust, more research is necessary to replicate beyond these countries and RETs and, more importantly, to understand why this correlational connection exists. Researchers who study social support of RETs could look for insights in the social sustainability literature and in particular (energy) poverty. As this study shows, poverty can influence key energy transition aspects in ways that are both wide-ranging and hard to predict.

In conclusion, social support is a multidimensional construct shaped by factors that overlap at individual but also higher levels. Therefore, in order to fully understand social support, a wider integration of approaches and theories would be more appropriate. We focused on a combination of individual-level endogenous and regional-level exogenous factors, and illustrate how those regional factors support this integration narrative. This could pave the way for researchers to explore the importance of other sub-national characteristics within the regional studies literature on social support of RETs. It also indicates a potentially novel pathway for intervention. Practitioners and policy makers should start by considering the socio-economic conditions in the region where they seek to promote RETs and tailor their campaigns accordingly.

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Tables and Figures

Table 1. Descriptive statistics

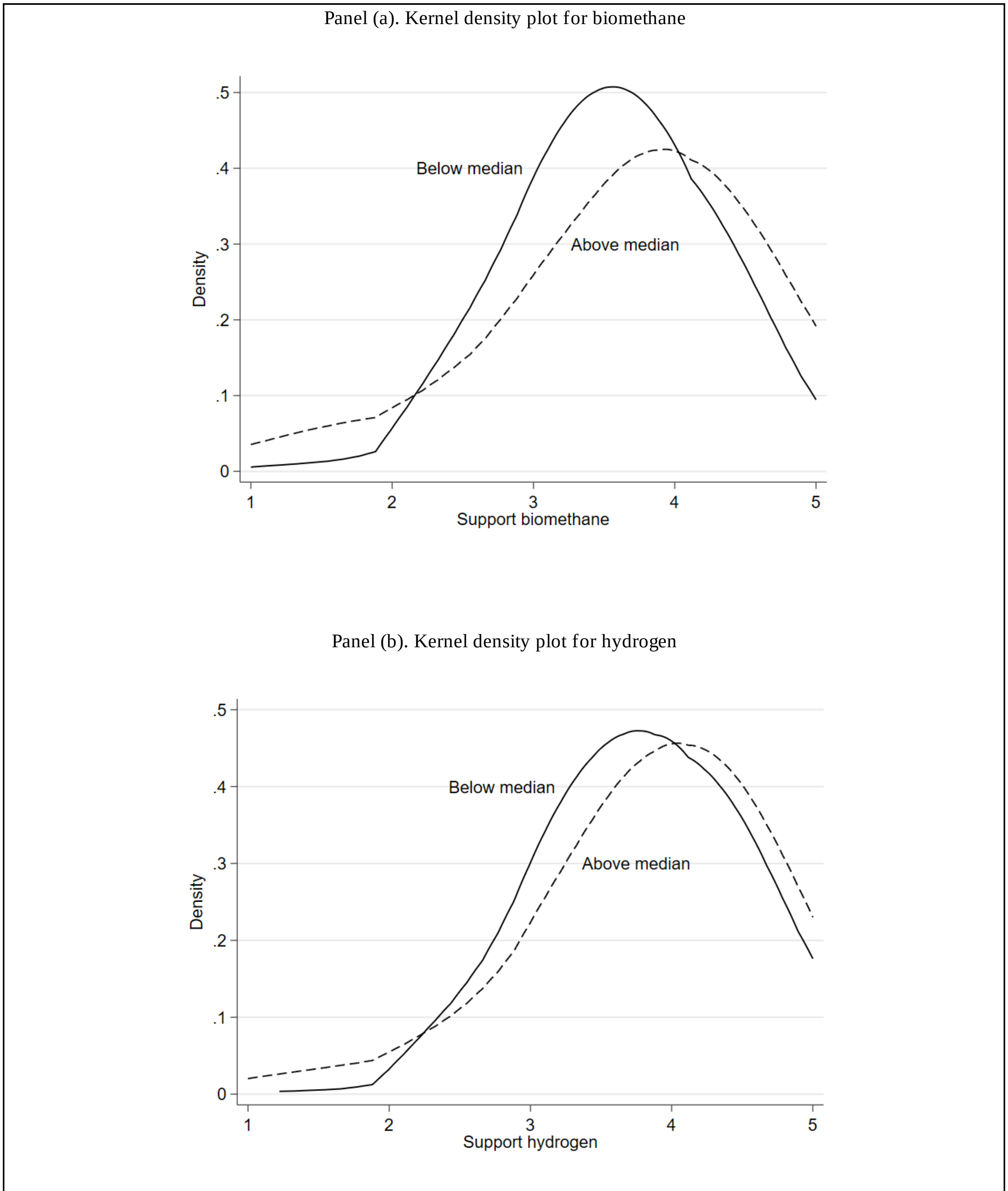
Variable	Mean/%	SD	N
Sample I (Biomethane)			
SUP_IN_EN	3.63	0.79	1527
ATT_TOW_EN	3.41	0.67	1527
PERC_BEN	4.91	1.19	1527
ECON_COST	4.35	1.00	1527
TRUST_TECH	4.44	1.11	1527
TRUST_UTIL	4.68	1.23	1527
TRUST_IND	3.68	0.81	1527
TRUST_AUTH	3.42	0.96	1527
PER_RISK	3.09	0.85	1527
BIO_VAL	4.90	0.93	1527
ALTR_VAL	4.98	0.83	1527
HED_VAL	4.87	0.90	1527
EGO_VAL	3.37	1.07	1527
KNOWL_BIO	2.07	1.91	1527
AGE	48.76	15.24	1527
FEMALE	49.08		747
EDUCATION			1527
Did Not Complete High School	1.11		17
High School	19.58		299
Some College	25.93		396
Bachelor's Degree	32.42		495
Masters's Degree	16.57		253
Advanced Degree / Ph.D.	4.39		67
INCOME			1527
€5.000 or less	4.26		65
€5.001 - €15.000	10.09		154
€15.001 - €25.000	24.41		327
€25.001 - 35.000	22.66		346
€35.001 - €45.000	17.75		271

€45.001 - €55.000	7.92		121
€55.001 - €65.000	6.94		106
€65.001 - €75.000	4.39		67
€75.001 or more	4.58		70
Sample II (Hydrogen)			
SUP_IN_EN	3.84	0.74	1528
ATT_TOW_EN	3.53	0.64	1528
PERC_BEN	5.29	1.13	1528
ECON_COST	4.56	1.0	1528
TRUST_TECH	4.67	1.14	1528
TRUST_UTIL	4.72	1.20	1528
TRUST_IND	3.73	0.77	1528
TRUST_AUTH	3.49	0 89	1528
PER_RISK	3.03	0.83	1528
BIO_VAL	4.86	0.93	1528
ALTR_VAL	4.97	0.82	1528
HED_VAL	4.89	0.84	1528
EGO_VAL	3.35	1.07	1528
KNOWL_HYDRO	4.62	1.07	1528
AGE	48.36	14.99	1528
FEMALE	47.31		721
EDUCATION			1528
Did Not Complete High School	0.85		13
High School	20.55		314
Some College	25.59		391
Bachelor's Degree	32.53		497
Masters's Degree	15.58		238
Advanced Degree / Ph.D.	4.91		75
INCOME			1528
€5.000 or less	5.10		78
€5.001 - €15.000	10.14		155
€15.001 - €25.000	21.53		329
€25.001 - 35.000	20.35		311

€35.001 - €45.000	15.51		237
€45.001 - €55.000	10.41		159
€55.001 - €65.000	8.70		133
€65.001 - €75.000	3.53		54
€75.001 or more	4.71		72
Regional measures			
CDD	257.62	236.14	2854
HDD	1707.774	549.86	2854
RGDP	31243.62	9862.45	2854
RIS	94.93	24.90	2854
GVA			2854
Primary Sector	0.028	0.034	2854
Secondary Sector	0.192	0.129	2854
Tertiary Sector	0.778	0.144	2854
SMDR	7.43	5.49	2854

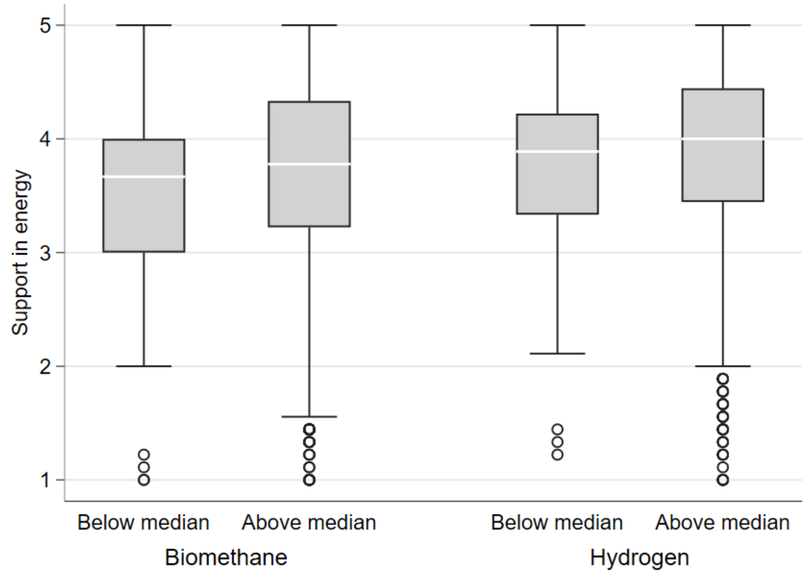
Note: The table presents descriptive statistics for the sample, covering both Biomethane and Hydrogen, alongside the regional variables utilized in the analysis. It's important to note that the number of observations for regional measures is slightly lower than the total sample size due to some respondents not disclosing their geolocation, preventing matching.

Figure 1. Kernel density plots highlighting regional differences for biomethane and hydrogen



Note: The above kernel density plots showing support for biomethane (upper panel) and hydrogen (lower panel) use an Epanechnikov kernel with a bandwidth of 0.5. This contrasts regions below and above the median SMDR to explore the influence of economic disparities on support for these energy sources.

Figure 2. Box plots highlighting regional support differences for biomethane and hydrogen



Note: The above box plots show support for biomethane (left) and hydrogen (right), with regions below and above the median SMDR contrasted to explore the influence of economic disparities on support for these energy sources.

Table 2: Linear Regression of the support for Biomethane on the regional material deprivation rate without (Columns 1-6) and with (Column 7) random intercepts.

Support Biomethane	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SMDR	-0.005	-0.004**	-0.004**	-0.011***	-0.016***	-0.016***	-0.016***
	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
Attitudes, Perceptions, Costs	No	Yes	Yes	Yes	Yes	Yes	Yes
Values	No	No	Yes	Yes	Yes	Yes	Yes
Regional Climate	No	No	No	Yes	Yes	Yes	Yes
Regional Economic Indicators	No	No	No	No	Yes	Yes	Yes
Socio-Demographics	No	No	No	No	No	Yes	Yes
Biomethane Knowledge	No	No	No	No	No	Yes	Yes
Multi-Level Model	No	No	No	No	No	No	Yes
Observations	1451	1451	1451	1451	1451	1448	1448

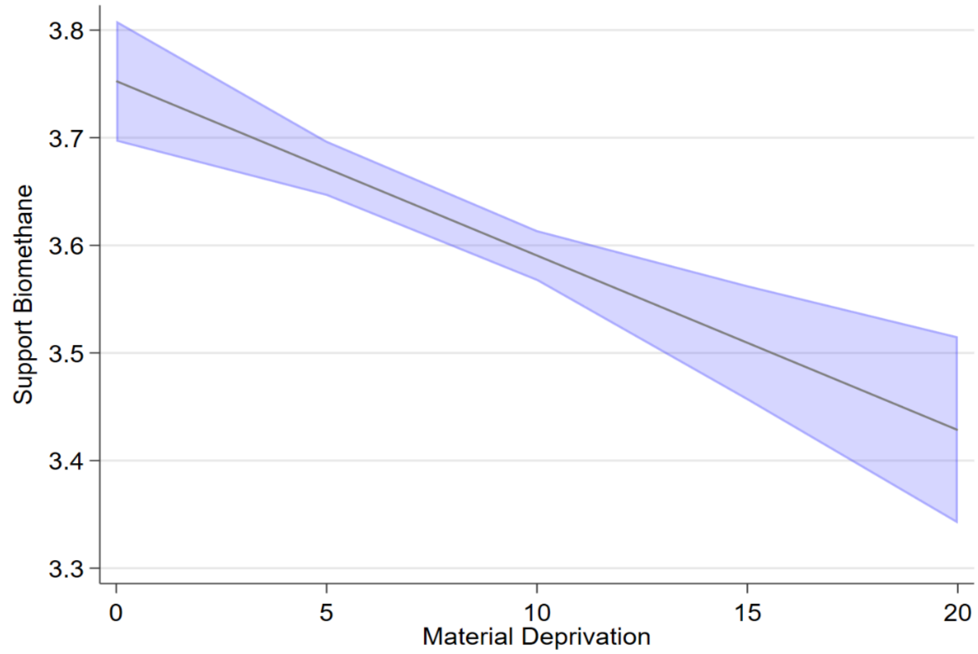
*Note: For a comprehensive list of covariates, refer to Section 2. The Appendix provides a detailed table of the results. Robust standard errors are denoted in parentheses. Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.*

Table 3: Linear Regression of the support for Hydrogen on the regional material deprivation rate without (Columns 1-6) and with (Column 7) random intercepts.

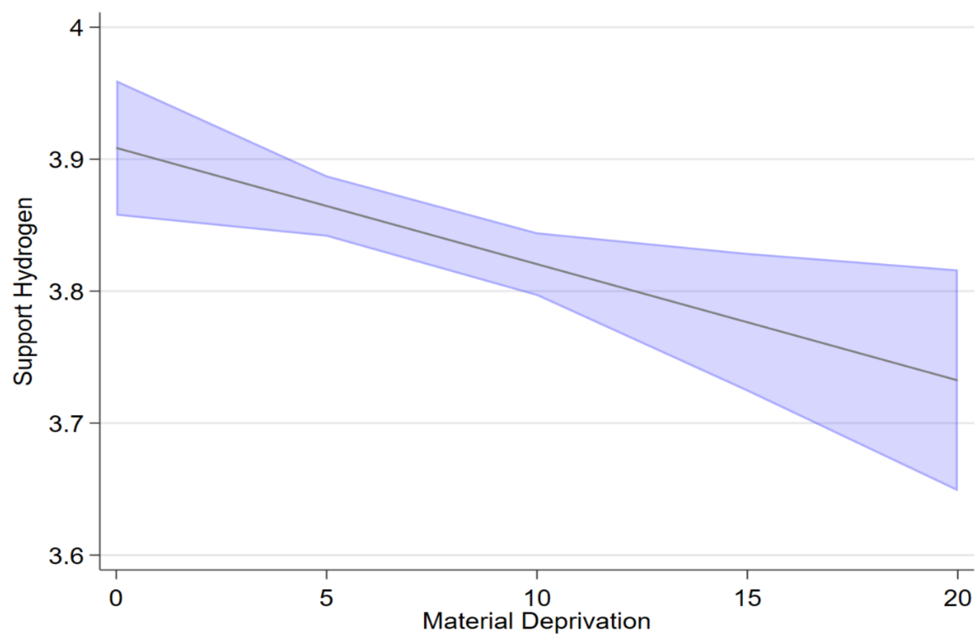
Support Hydrogen	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SMDR	0.003	-0.007***	-0.008***	-0.008***	-0.007**	-0.009***	-0.009***
	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
Attitudes, Perceptions, Costs	No	Yes	Yes	Yes	Yes	Yes	Yes
Values	No	No	Yes	Yes	Yes	Yes	Yes
Regional Climate	No	No	No	Yes	Yes	Yes	Yes
Regional Economic Indicators	No	No	No	No	Yes	Yes	Yes
Socio-Demographics	No	No	No	No	No	Yes	Yes
Hydrogen Knowledge	No	No	No	No	No	Yes	Yes
Multi-Level Model	No	No	No	No	No	No	Yes
Observations	1403	1403	1403	1403	1403	1400	1400

*Note: For a comprehensive list of covariates, refer to Section 2. The Appendix provides a detailed table of the results. Robust standard errors are denoted in parentheses. Significance levels: * p < 0.1, ** p < 0.05, *** p < 0.01.*

Figure 3. Estimated support for renewable energies as a function of severe material deprivation measured on the NUTS2 level.



(a)



(b)

Note: The figure shows the predicted values of support for Biomethane (panel a) and Hydrogen (panel b) as a function of regional (NUTS2) material deprivation. The shaded area indicates the 95% confidence interval. Predictions are adjusted for all model covariates, set to their respective sample means.

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Appendix

Table A1. Regional indicators overview

Indicator	Abbreviation	Regional Level	Latest Data Year	Source
Cooling Degree Days	CDD	NUTS3	2022	https://ec.europa.eu/eurostat/databrowser/view/nrg_chddr2_a/default/table?lang=en&category=nrg.nrg_chdd
Heating Degree Days	HDD	NUTS3	2022	
Regional Innovation Scoreboard	RIS	NUTS2	2021	https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/regional-innovation-scoreboard_en
Regional Gross Domestic Product in Purchasing Power Standards per inhabitant	RGDP	NUTS2	2021	https://data.europa.eu/data/datasets/dt5srkfskk9qye41akc4q?locale=en
Severe Material Deprivation Rate	SMDR	NUTS2	2020	https://ec.europa.eu/eurostat/databrowser/product/page/tgs00104
Gross Value Added at basic prices for primary and secondary sectors	GVA	NUTS3	2020	https://agridata.ec.europa.eu/Qlik_Downloads/InfoSheetSocioEconomic/infoC10.html

Table A2: Individual Variables

Variable Name	Description	Items	Level of measurement
Dependent variable			
SUP_IN_EN	Support in the type of energy	1. I intend to use energy produced with [biomethane/hydrogen] technology as often as necessary. 2. Assuming I have access to energy produced with [biomethane/hydrogen] technology, I intend to use it. 3. I find the quality of energy products produced with [biomethane/hydrogen] technology, is not as good as other renewable energy products. 4. I would support the use of [biomethane/hydrogen] technology products. 5. I will strongly recommend that others use energy produced with [biomethane/hydrogen] technology.	1 (strongly disagree) to 5 (strongly agree)
Independent variables			
ATT_TOW_EN	Attitude towards the type of energy	1. It is a good idea to invest in [biomethane/hydrogen] technology. 2. It is a good idea to apply [biomethane/hydrogen] technology in public transportation such as buses. 3. The use of [biomethane/hydrogen] as a fuel is good for the environment.	1 (strongly disagree) to 5 (strongly agree)

		4. We should make the transition to [biomethane/hydrogen] technology as soon as possible. 5. I think using [biomethane/hydrogen] as a fuel is a very good idea. 6. I think using [biomethane/hydrogen] as a fuel for me personally is acceptable. 7. I think using [biomethane/hydrogen] as a fuel is acceptable for society. 8. I think having a [biomethane/hydrogen] fuelling station at less than 300 meters from my home is acceptable. 9. I think that the consequences of using [biomethane/hydrogen] as a fuel are acceptable for the coming generations of people.	
PERC_BEN	Perceived of benefits of the energy	1. Employing [biomethane/hydrogen] technology gives us environmental and social benefits. 2. Overall, I feel that employing [biomethane/hydrogen] technology is beneficial for our society. 3. Using [biomethane/hydrogen] technology gives us more economic and industrial benefits than other energy technologies. 4. [Biomethane/hydrogen] technology energy helps to reduce the dependency on coal and other fossil fuels.	1 (strongly disagree) to 7 (strongly agree)

ECON_COST	Economic costs of the energy	1. I think the equipment cost of employing [biomethane/hydrogen] technology is more expensive than other energy technologies. 2. I think the maintenance cost of employing [biomethane/hydrogen] technology is more expensive than other energy technologies. 3. There are financial barriers to employing [biomethane/hydrogen] technology.	1 (strongly disagree) to 7 (strongly agree)
TRUST_TECH	Trust in the technology the energy is produced	1. [Biomethane/hydrogen] technology is more reliable than other energy technologies. 2. [Biomethane/hydrogen] technology is more trustworthy than other energy technologies. 3.[Biomethane/hydrogen] technology is more secure than other energy technologies.	1 (strongly disagree) to 7 (strongly agree)
TRUST_UTIL	Trust in utility companies	1. I trust my utility company overall. 2. I trust my utility company provides good service. 3. I trust my utility company cares about their customers. 4. I believe my utility company is honest.	1 (strongly disagree) to 7 (strongly agree)
TRUST_IND	Trust in energy industry	I trust that the energy industry will: 1. ensure that safe technology plants will be built. 2. have the relevant expertise to successfully build a safe technology plant. 3. operate the plant safely	1 (strongly disagree) to 5 (strongly agree

TRUST_AUTH	Trust in Authorities	I trust that the governmental authorities will: 1. take the concerns of residents into account. 2. make a responsible decision on whether or not to build the technology. 3. ensure that safe technology plants will be built. 4. execute safety checks to ensure the safe operation of the plant.	1 (strongly disagree) to 5 (strongly agree
PER_RISK	Perceived risks of the energy	1. I am concerned about the safety of [biomethane/hydrogen] infrastructures. 2. The operation of [biomethane/hydrogen] infrastructures constitutes a continuous threat to human health and the environment. 3. [Biomethane/hydrogen] accident may occur and cause irreparable damages to large geographical areas and people.	1 (strongly disagree) to 5 (strongly agree
BIO_VAL	Measure of biospheric values	1. It is important to me to prevent environmental pollution. 2. It is important to me to protect the environment. 3. It is important to me to respect nature. 4. It is important to me to be in unity with nature.	1 (strongly disagree) to 6 (strongly agree)
ALTR_VAL	Measure of altruistic values	1. It is important to me that every person has equal opportunities. 2. It is important to me to take care of those who are worse off.	1 (strongly disagree) to 6 (strongly agree)

		3. It is important to me that every person is treated justly. 4. It is important to me that there is no war or conflict. 5. It is important to me to be helpful to others.	
HED_VAL	Measure of hedonistic values	1. It is important to me to have fun. 2. It is important to me to enjoy the life's pleasures 3. It is important to me to do things I enjoy	1 (strongly disagree) to 6 (strongly agree)
EGO_VAL	Measure of egoistic values	1. It is important to me to have control over others' actions 2. It is important to have authority over others 3. It is important to me to be influential 4. It is important to have money and possessions 5. It is important to work hard and be ambitious	1 (strongly disagree) to 6 (strongly agree)
KNOWL_BIO	Measure of participants knowledge of biomethane	1. Do you know how biomethane is produced? (Yes/No) 2. Are you familiar with the biomethane supply chain? (Yes/No) 3. Do you know that biomethane can be produced from biogas? (Yes/No) 4. Do you know that with biomethane it is possible to produce electricity? (Yes/No) 5. Do you know that with biomethane it is possible to produce thermal energy? (Yes/No)	0 (no knowledge) to 6 (much knowledge)

		6. Have you ever visited biogas and biomethane plants? (Yes/No)	
KNOWL_HYDRO	Measure of participants knowledge of hydrogen	1. Have you heard about hydrogen energy? (Yes/No) 2. Is hydrogen harmful to humans? (Yes/No) 3. Does hydrogen smell? (Yes/No) 4. Is hydrogen flammable in air? (Yes/No) 5. Can hydrogen be stored as liquid? (Yes/No) 6. Can hydrogen be stored as gas? (Yes/No)	1 (no knowledge) to 6 (much knowledge)
AGE	Age of respondent	Survey data	Numerical value
FEMALE	Sex of respondent	Survey data	1 (Male), 2 (Female)
EDUCATION	Education of respondent	Survey data	1 (Did Not Complete High School), 2 (High School/GED), 3 (Some College), 4 (Bachelor's Degree), 5 (Master's Degree), 6 (Advanced Graduate work or Ph.D.)
INCOME	Income of respondent	Survey data	1 (€5.000 or less),

			2 (€5.001 - €15.000), 3 (€15.001 - €25.000), 4 (€25.001 - 35.000), 5 (€35.001 - €45.000), 6 (€45.001 - €55.000), 7 (€55.001 - €65.000), 8 (€65.001 - €75.000), 9 (€75.001 or more)

Table A3: Linear Regression of the support for Biomethane on the regional material deprivation rate without (Columns 1-6) and with (Column 7) random intercepts.

Support Biomethane	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SMDR	-0.005	-0.004**	-0.004**	-0.011***	-0.016***	-0.016***	-0.016***
	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.002)
ATT_TOW_EN		0.433***	0.432***	0.427***	0.429***	0.432***	0.432***
		(0.043)	(0.043)	(0.045)	(0.045)	(0.046)	(0.045)
PERC_BEN		0.319***	0.317***	0.318***	0.318***	0.312***	0.312***
		(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.029)
ECON_COST		0.006	0.005	0.006	0.006	0.007	0.007
		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.011)
TRUST_TECH		0.065***	0.064***	0.058***	0.056***	0.060***	0.060***
		(0.015)	(0.016)	(0.016)	(0.016)	(0.017)	(0.012)

TRUST_UTIL	-0.013	-0.013	-0.012	-0.012	-0.013	-0.013
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.012)
TRUST_IND	0.047**	0.046**	0.047**	0.048**	0.047**	0.047**
	(0.019)	(0.020)	(0.019)	(0.020)	(0.019)	(0.019)
TRUST_AUTH	0.015	0.015	0.020	0.019	0.021	0.021
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.019)
PER_RISK	-	-	-	-	-	-0.049*
	0.041***	0.043***	0.051***	0.051***	0.049***	
	(0.016)	(0.017)	(0.017)	(0.017)	(0.017)	(0.029)
BIO_VAL		-0.012	-0.014	-0.014	-0.015	-0.015
		(0.014)	(0.014)	(0.014)	(0.014)	(0.015)
ALTR_VAL		0.019	0.013	0.013	0.012	0.012
		(0.016)	(0.016)	(0.016)	(0.016)	(0.018)
HED_VAL		0.003	0.009	0.010	0.011	0.011
		(0.012)	(0.012)	(0.012)	(0.012)	(0.011)
EGO_VAL		0.006	0.002	0.002	0.003	0.003
		(0.010)	(0.010)	(0.010)	(0.010)	(0.011)
CDD			0.000	0.000	0.000	0.000
			(0.000)	(0.000)	(0.000)	(0.000)
HDD			-0.000**	-0.000*	-0.000*	-0.000**
			(0.000)	(0.000)	(0.000)	(0.000)
RGDP				-0.000*	-0.000*	-0.000**
				(0.000)	(0.000)	(0.000)
RIS				0.001	0.001	0.001
				(0.002)	(0.002)	(0.001)
GVA (Baseline: Tertiary Sector)						
Primary Sector				0.237	0.266	0.266
				(0.406)	(0.403)	(0.383)
Secondary Sector				0.088	0.052	0.052
				(0.101)	(0.102)	(0.078)
AGE					0.001	0.001
					(0.001)	(0.001)
SEX (Baseline: Male)						

Female						-0.007	-0.007
						(0.019)	(0.017)
EDUCATION (Baseline: Did not complete high school)							
High School/GED						-0.095	-0.095
						(0.138)	(0.132)
Some College						-0.079	-0.079
						(0.137)	(0.128)
Bachelor's Degree						-0.122	-0.122
						(0.137)	(0.131)
Master's Degree						-0.119	-0.119
						(0.137)	(0.135)
Advanced Graduate work or Ph.D.						-0.129	-0.129
						(0.140)	(0.122)
INCOME						0.010*	0.010**
						(0.005)	(0.004)
KNOWL_BIO						0.002	0.002
						(0.006)	(0.007)
Observations	1451	1451	1451	1451	1451	1448	1448

*Note: Robust standard errors are denoted in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*

Table A4: Linear Regression of the support for Hydrogen on the regional material deprivation rate without (Columns 1-6) and with (Column 7) random intercepts.

Support Hydrogen	(1)	(2)	(3)	(4)	(5)	(6)	(7)
SMDR	0.003	-0.007***	-0.008***	-0.008***	-0.007**	-0.009***	-0.009***
	(0.004)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)
ATT_TOW_EN		0.349***	0.349***	0.349***	0.348***	0.343***	0.343***
		(0.034)	(0.034)	(0.034)	(0.034)	(0.034)	(0.020)
PERC_BEN		0.347***	0.340***	0.340***	0.342***	0.334***	0.334***
		(0.018)	(0.019)	(0.019)	(0.019)	(0.019)	(0.013)
ECON_COST		-0.005	-0.004	-0.004	-0.005	-0.005	-0.005
		(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
TRUST_TECH		0.062***	0.067***	0.066***	0.065***	0.069***	0.069***
		(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
TRUST_UTIL		-0.015	-0.013	-0.012	-0.012	-0.013	-0.013
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
TRUST_IND		0.085***	0.078***	0.078***	0.078***	0.075***	0.075***
		(0.019)	(0.019)	(0.019)	(0.019)	(0.020)	(0.017)
TRUST_AUTH		-0.008	-0.007	-0.008	-0.007	-0.007	-0.007
		(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)
PER_RISK		-0.048***	-0.049***	-0.051***	-0.050***	-0.044***	-0.044***
		(0.012)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
BIO_VAL			-0.025*	-0.025*	-0.025	-0.026*	-0.026*
			(0.015)	(0.015)	(0.015)	(0.015)	(0.014)
ALTR_VAL			0.057***	0.056***	0.055***	0.051***	0.051***
			(0.018)	(0.018)	(0.018)	(0.018)	(0.017)
HED_VAL			-0.003	-0.003	-0.003	0.001	0.001
			(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
EGO_VAL			-0.009	-0.009	-0.009	-0.008	-0.008
			(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
CDD				-0.000	-0.000	-0.000	-0.000

	(0.000)	(0.000)	(0.000)	(0.000)
HDD	-0.000	-0.000	-0.000*	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
RGDP		0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
RIS		-0.000	-0.000	-0.000
		(0.001)	(0.001)	(0.001)
GVA (Baseline: Tertiary Sector)				
Primary Sector		0.416	0.321	0.321
		(0.485)	(0.497)	(0.366)
Secondary Sector		-0.004	-0.032	-0.032
		(0.094)	(0.094)	(0.092)
AGE			0.001*	0.001*
			(0.001)	(0.001)
SEX (Baseline: Male)				
Female			-0.015	-0.015
			(0.019)	(0.018)
EDUCATION (Baseline: Did not complete high school)				
High School/GED			0.040	0.040
			(0.085)	(0.095)
Some College			0.091	0.091
			(0.084)	(0.095)
Bachelor's Degree			0.090	0.090
			(0.084)	(0.096)
Master's Degree			0.023	0.023
			(0.086)	(0.097)
Advanced Graduate work or Ph.D.			0.118	0.118
			(0.095)	(0.104)
INCOME			0.005	0.005
			(0.005)	(0.005)
KNOWL_BIO			0.022***	0.022**

						(0.008)	(0.009)
Observations	1403	1403	1403	1403	1403	1400	1400

*Note: Robust standard errors are denoted in parentheses. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.*