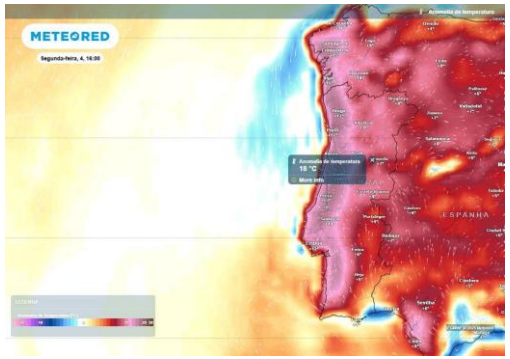
The research project is implemented in the framework of H.F.R.I call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union –Next Generation EU (H.F.R.I. Project Number: 016638).

The Portuguese case study

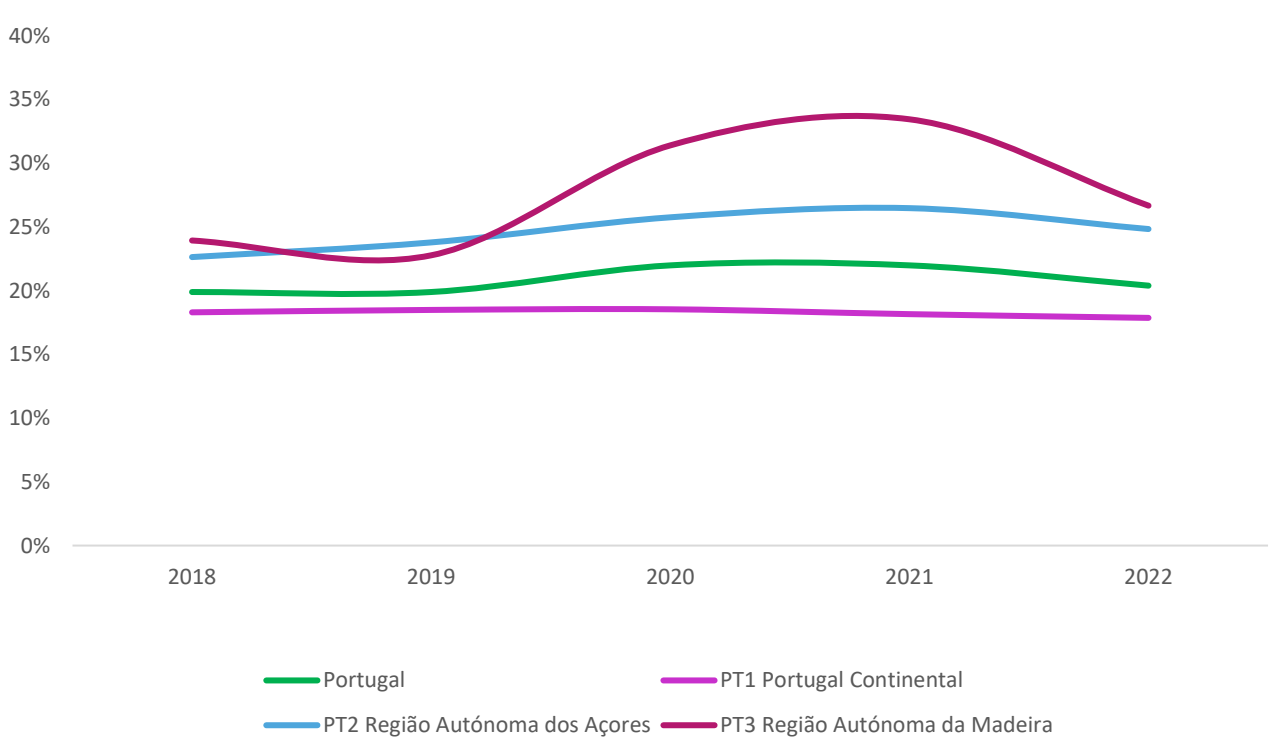
Pedro Palma, NOVA University, Lisbon, Portugal

The research project is implemented in the framework of H.F.R.I call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union –Next Generation EU (H.F.R.I. Project Number: 016638).

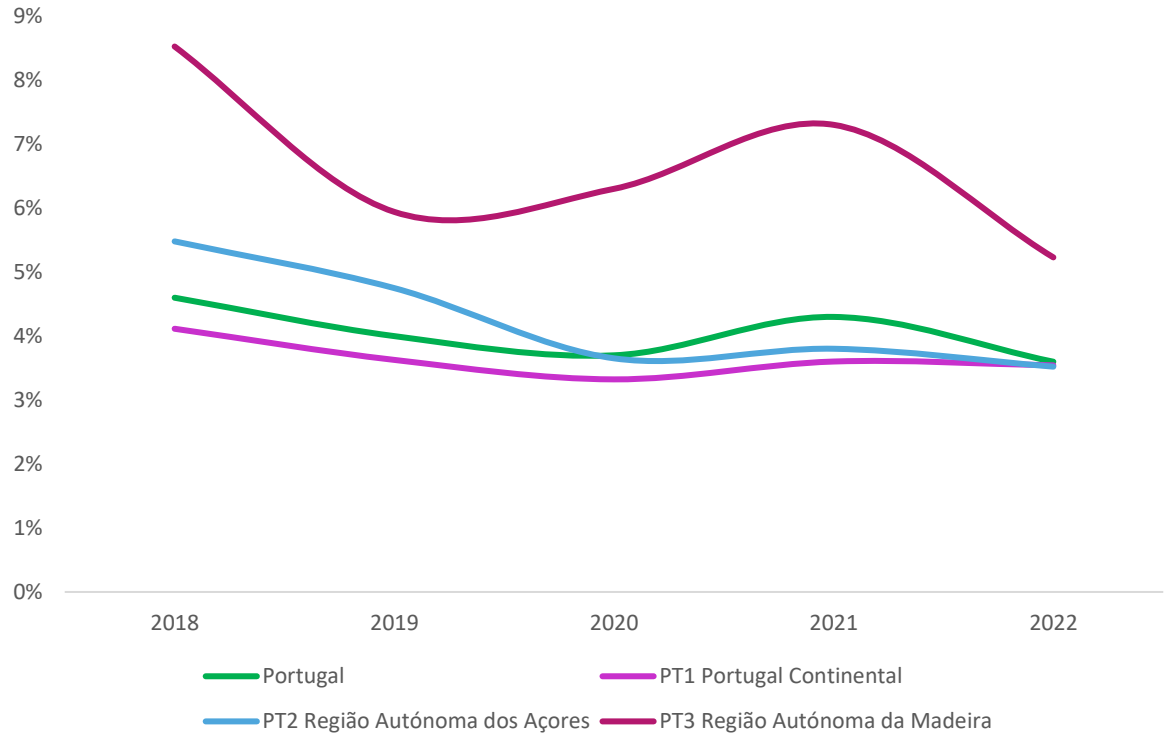
- Currently affects **at least 2 million people in the country**
- **Multidimensional issue** – Low energy performing buildings, high energy prices and low incomes
- Importance of **holistic efforts** involving all actors
- Focus on **Diagnosis:** European Commission, Energy Poverty Advisory Hub, Covenant of Mayors, C40
- Political commitment: **New developments** (National Observatory, Strategy and Action Plan, dedicated programs) but historically **insuficient**
- Important current circumstances: **Social Climate Plan** 2026-2032 unlocking **1.6 billion EUR**



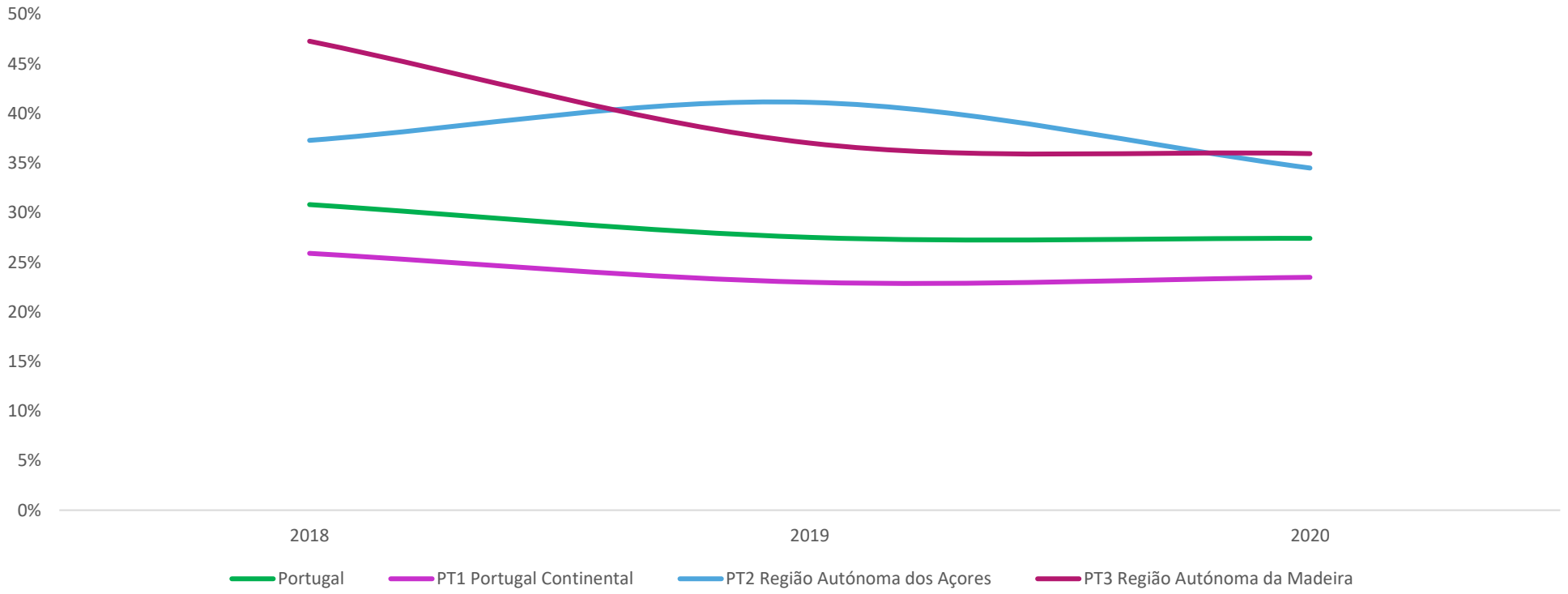
Inability to keep home adequately warm – NUTS1



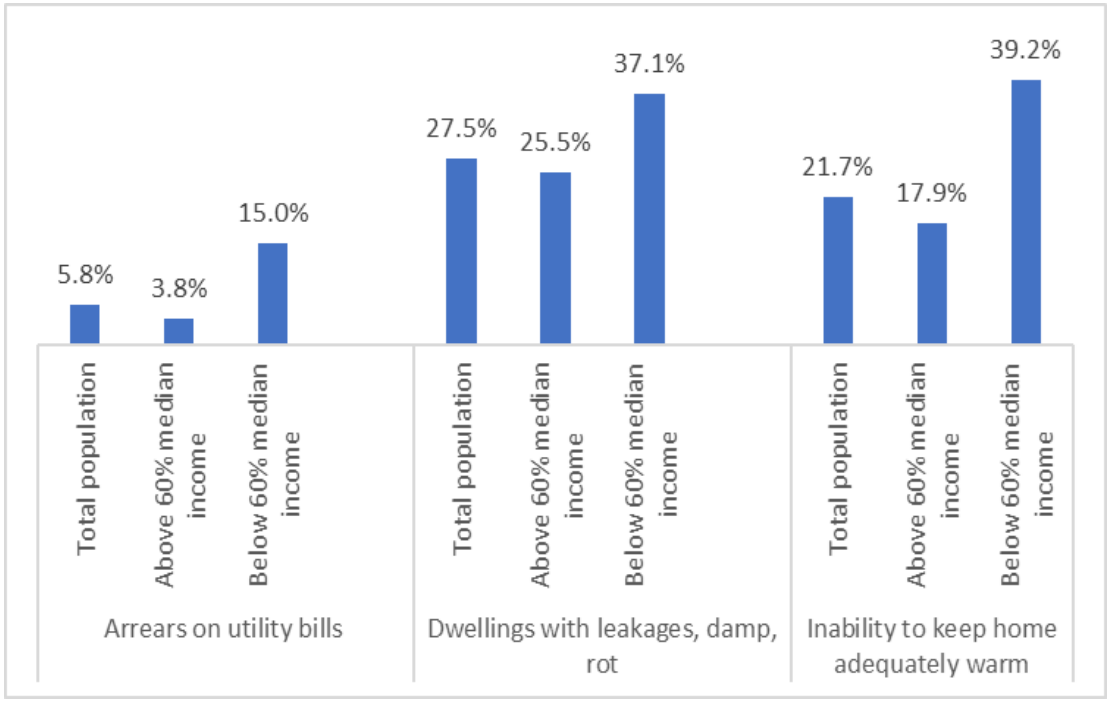
Arrears on utility bills – NUTS1



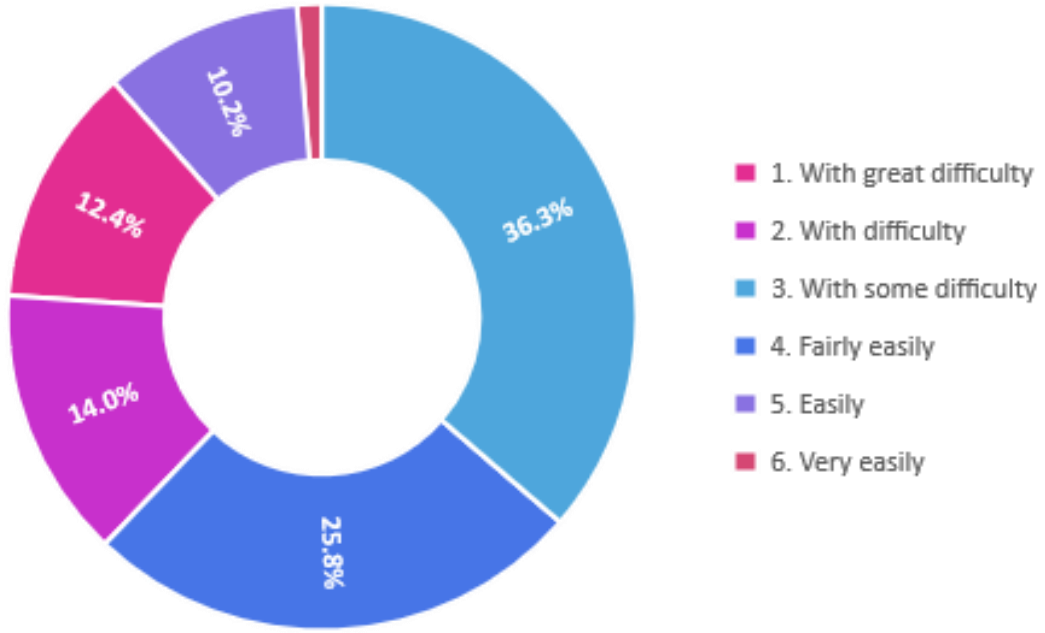
Dwelling with leak, damp, or rot – NUTS1



Average values of energy poverty EU-SILC indicators



Ability to make ends meet, average values



H.F.R.I. Hellenic Foundation for Research & Innovation
Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

The Portuguese case study - Econometric analysis

Model 1 - Inability to keep home warm

VARIABLES	2018	2020	2022
Ln(income)	-0.053*** (0.005)	-0.071*** (0.007)	-0.059*** (0.005)
Education	-0.103*** (0.014)	-0.077*** (0.014)	-0.083*** (0.013)
Age	0.0002 (0.001)	0.009*** (0.002)	0.008*** (0.002)
Age2	1.81e-06 (1.26e-05)	-5.43e-05*** (1.86e-05)	-5.03e-05*** (1.75e-05)
Unemployed	0.010 (0.011)	0.048*** (0.014)	-0.0001 (0.014)
Persons-per-rooms	0.039*** (0.010)	0.057*** (0.014)	0.031** (0.012)
Health	0.035*** (0.004)	0.021*** (0.005)	0.030*** (0.004)
Gender	0.018*** (0.006)	0.032*** (0.008)	0.016** (0.007)
Ability to make ends meet	0.077*** (0.003)	0.079*** (0.003)	0.078*** (0.003)
Observations	*13,704*	*11,294*	*12,342*

	2018	2020	2022
Região Autónoma dos Açores	0.035*** (0.010)	0.074*** (0.013)	0.064*** (0.012)
Região Autónoma da Madeira	0.024*** (0.008)	0.085*** (0.010)	0.054*** (0.009)
Observations	*13,704*	*11,294*	*12,342*

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Model 2 – Arrears on utility bills

VARIABLES	2018	2020	2022
Ln(income)	-0.006*** (0.001)	-0.003** (0.001)	-0.006*** (0.001)
Education	-0.002 (0.003)	0.001 (0.003)	-0.001 (0.002)
Age	0.001*** (0.0003)	0.002*** (0.000)	0.0009** (0.000)
Age2	-1.65e-05*** (3.40e-06)	-1.88e-05*** (4.13e-06)	-1.24e-05*** (3.22e-06)
Unemployed	0.009*** (0.002)	0.007*** (0.002)	0.003 (0.002)
Persons-per-rooms	0.0103*** (0.002)	0.009*** (0.002)	0.011*** (0.002)
Health	0.002** (0.0009)	0.003*** (0.001)	0.002** (0.0008)
Gender	0.002 (0.002)	0.004** (0.002)	0.006*** (0.001)
Ability to make ends meet	0.017*** (0.001)	0.014*** (0.001)	0.012*** (0.0009)
Observations	*13,647*	*11,281*	*12,314*

	2018	2020	2022
Região Autónoma dos Açores	-0.0008 (0.002)	-0.001 (0.002)	-0.005*** (0.002)
Região Autónoma da Madeira	0.013*** (0.003)	0.008*** (0.002)	0.002 (0.001)
Observations	*13,647*	*11,281*	*12,314*

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

Model 3 – Living in dwelling with deterioration signs

VARIABLES	2018	2020	2023
Ln(income)	-0.034*** (0.007)	-0.028*** (0.008)	n/a
Education	-0.016 (0.014)	-0.001 (0.014)	n/a
Age	-0.007*** (0.002)	-0.002 (0.002)	n/a
Age2	5.43e-05*** (1.70e-05)	1.34e-05 (2.06e-05)	n/a
Unemployed	0.046*** (0.016)	0.034** (0.017)	n/a
Persons-per-rooms	0.060*** (0.014)	0.092*** (0.016)	n/a
Health	0.056*** (0.005)	0.051*** (0.006)	n/a
Gender	0.037*** (0.008)	0.044*** (0.009)	n/a
Ability to make ends meet	0.057*** (0.004)	0.058*** (0.004)	n/a
Observations	*13,704*	*11,311*	

	2018	2020
Região Autónoma dos Açores	0.116*** (0.013)	0.112*** (0.014)
Região Autónoma da Madeira	0.196*** (0.012)	0.093*** (0.011)
Observations	13,704	11,311

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1*

- **Binary logistic** regression approach
- **Lower income** significantly correlated with **higher levels of EP** indicators
- Lower education linked to **higher inability to heat**
- Higher EP in **female individuals** and **overcrowded dwellings**
- **Mixed results** for age
- **General health decreases** as EP rises

Econometric analysis – pseudo panels

Inability to keep home adequately warm									
Models	LPM			Fraction Logit			Group binomial GLM		
Income	-0.050**	-0.05	-0.05	-0.018	0.125**	0.082	5.33e+06***	5.33E+06	6.40E+05
Household size	-0.165***	-0.165***	-0.165**	-0.122***	-0.235***	-0.250***	-1.43e+07***	-1.43e+07***	-1.43e+07***
Urbanization	-0.324***	-0.324***	-0.324*	-0.133	0.057	0.038	1.00e+07***	1.00E+07	5.75E+06
Detached house	-0.301***	-0.301***	-0.301**	-0.239***	-0.291***	-0.257***	-2.56e+07***	-2.56e+07***	-2.70e+07***
Employment	-0.025	-0.025	-0.025	0.008	-0.263**	-0.307**	8.98e+06***	8.98E+06	1.77E+07
Tertiary ratio	-0.001	-0.001	-0.001	-0.037	-0.166	-0.249*	-6.76e+06***	-6.76E+06	-1.84e+07***
HDD/CDD	-0.007	-0.007	-0.007	-0.011	0	0.016	2.50e+06***	2.50E+06	66143.625
Constant	1.184***	1.184***	1.184*						
Cohort effects (NUTS 1)	no	yes	yes	no	yes	yes	no	yes	yes
Time effects	no	no	yes	no	no	yes	no	no	yes
Observations	228	228	228	228	228	228	228	228	228

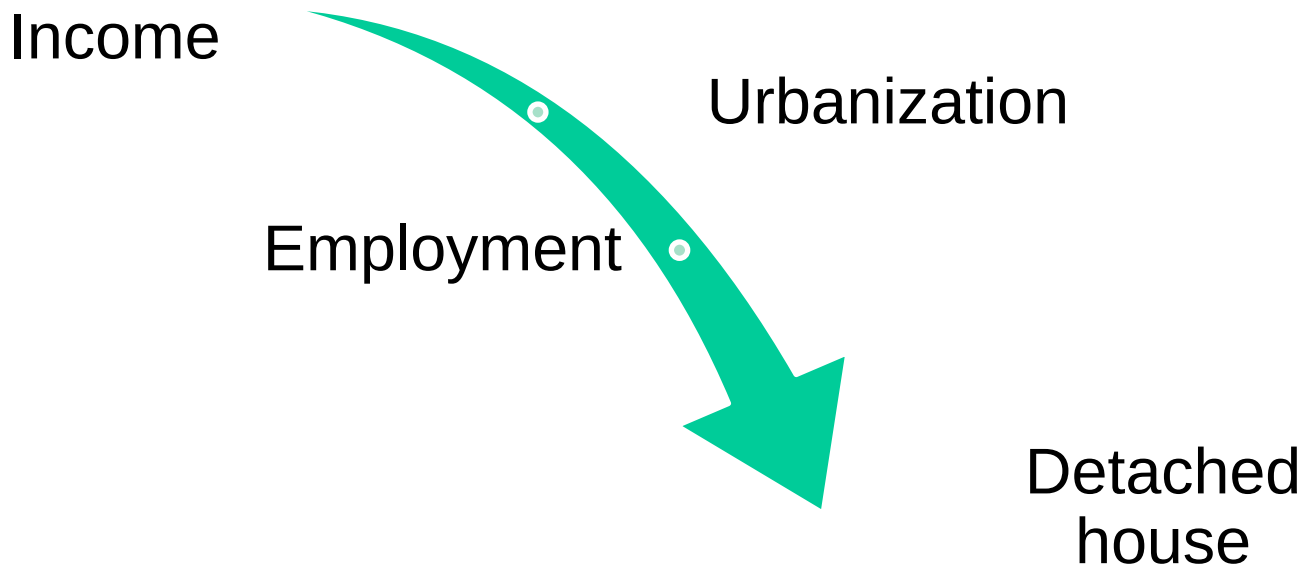
Econometric analysis – pseudo panels

Arrears on utility bills									
Models	LPM			Fraction Logit			Group binomial GLM		
Income	-0.041***	-0.051***	-0.084***	-0.075***	-0.053***	-0.065**	-1.91e+06**	-4.31e+06**	-5.05e+06*
Household size	0.048***	0.073***	0.100***	0.100***	0.097***	0.098***	3.42e+06**	6.89e+06***	7.32e+06***
Urbanization	-0.140***	-0.078	-0.055	-0.034	0.026	0.027	-1.29e+07***	-8.29e+06**	-5.17E+06
Detached house	-0.033*	0.077	0.074	0.023	0.064*	0.071*	1.02E+06	5.41E+06	6.07E+06
Employment	-0.015**	-0.01	0.054	-0.003	-0.104***	-0.094*	-1.52E+06	-7.55E+05	6.31E+06
Tertiary ratio	0.050***	0.031	0.014	0.027	-0.003	-0.009	-6.73E+04	2.72E+06	-5.80E+05
HDD/CDD	0.002	0.011**	0.004	-0.004	0.008**	0.012**	6.42E+05	2.10e+06**	3.42E+05
Constant	0.483***	0.472**	0.749**						
Cohort effects (NUTS 1)	no	yes	yes	no	yes	yes	no	yes	yes
Time effects	no	no	yes	no	no	yes	no	no	yes
Observations	228	228	228	228	228	228	228	228	228

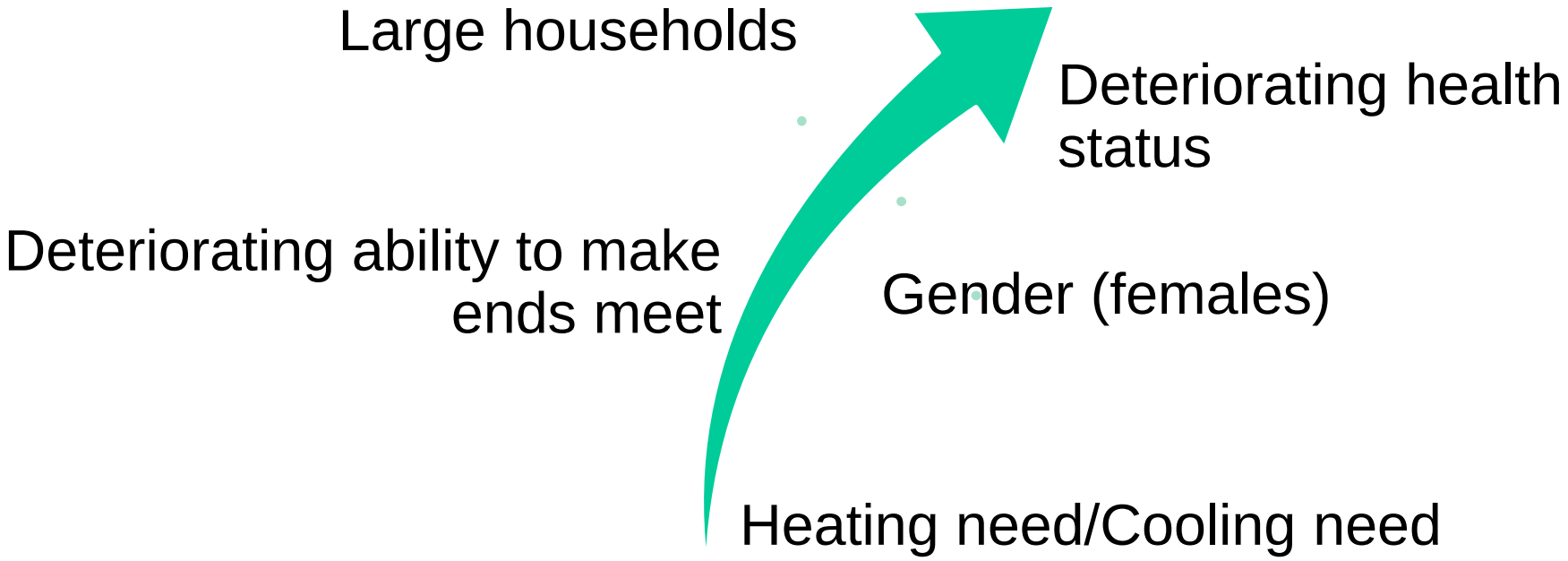
Econometric analysis – pseudo panels

Leaking roof, damp walls/floors/foundation, or rot in window frames or floor									
Models	LPM			Fraction Logit			Group binomial GLM		
Income	-0.042*	0.083*	-0.217*	-0.075**	0.223**	-0.052	1.79E+06	8.36e+06**	-2.28e+07*
Household size	-0.194***	-0.240**	0.006	-0.006	-0.168	-0.055	-1.44e+07***	-2.19e+07**	2.92E+06
Urbanization	-0.423***	-0.475***	-0.359***	-0.322***	-0.299**	-0.210*	-5.56e+07***	-5.09e+07***	-3.93e+07***
Detached house	-0.573***	-0.155	-0.194	-0.527***	-0.166	-0.268**	-2.34e+07*	-8.83E+06	-1.27E+07
Employment	-0.092***	-0.253**	0.012	0.001	0.002	0.169	-5.07e+06**	-2.74e+07***	2.54E+06
Tertiary ratio	0.492***	0.05	-0.008	0.378***	-0.165	-0.174	1.29E+07	-3.52E+06	-7.89E+06
HDD/CDD	-0.016	0.016	0.024***	-0.01	0.023**	0.037***	-6.11E+05	8.82E+05	2.38e+06***
Constant	1.312***	0.066	2.675**						
Cohort effects (NUTS 1)	no	yes	yes	no	yes	yes	no	yes	yes
Time effects	no	no	yes	no	no	yes	no	no	yes
Observations	156	156	156	156	156	156	156	156	156

Determinants of energy poverty in Portugal – overall insights

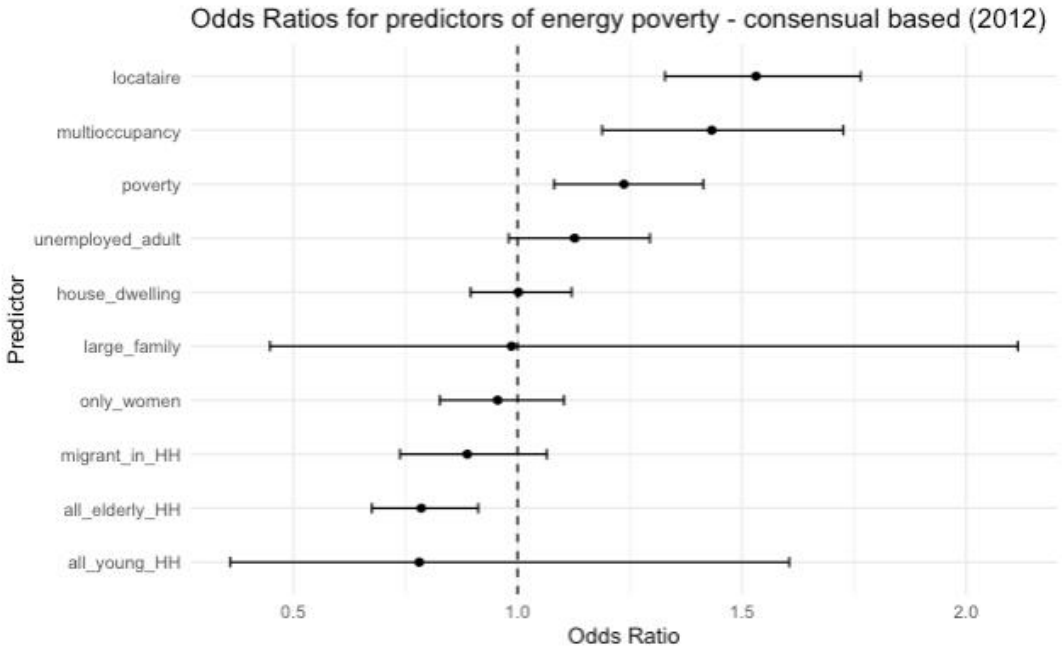


Determinants of energy poverty in Portugal – overall insights



Summer Energy Poverty Determinants Change - 2012

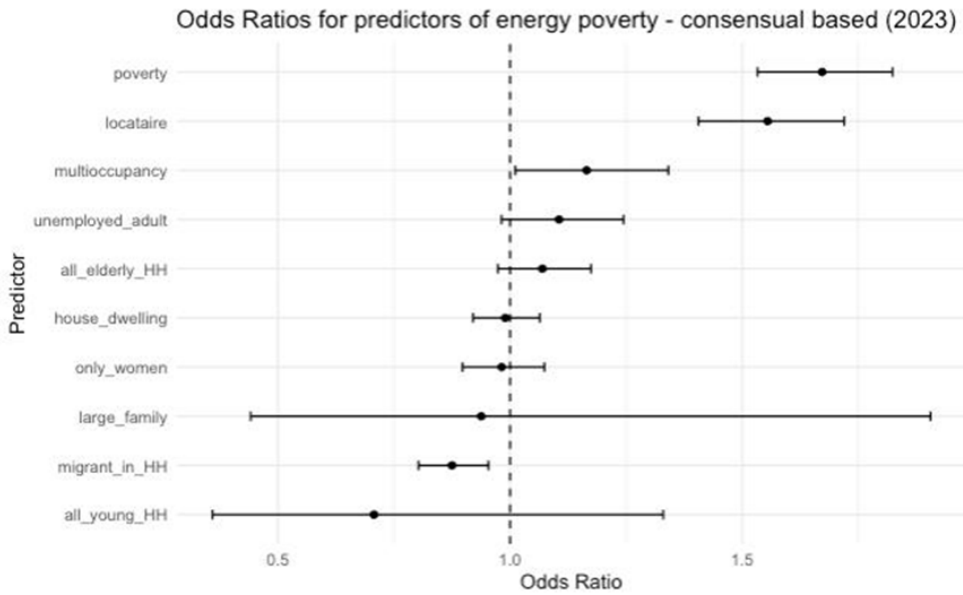
```
Coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)    -0.777951   0.048640 -15.994  < 2e-16 ***
unemployed_adult  0.119458   0.071034   1.682 0.092626 .
migrant_in_HH  -0.119180   0.093606  -1.273 0.202943
only_women     -0.045702   0.073661  -0.620 0.534969
all_elderly_HH -0.241947   0.076846  -3.148 0.001641 **
all_young_HH   -0.247640   0.377847  -0.655 0.512212
large_family   -0.013727   0.391906  -0.035 0.972059
house_dwelling  0.001486   0.057326   0.026 0.979320
multioccupancy  0.359690   0.095168   3.780 0.000157 ***
locataire      0.426254   0.072461   5.882 4.04e-09 ***
poverty        0.212646   0.068421   3.108 0.001884 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```



- Using EU SILC data
- Logistic regression model
- Significant correlations with **economic poverty, overcrowded housing, tenants, people aged 65+, unemployed people**

Summer Energy Poverty Determinants Change - 2023

```
Coefficients:
                Estimate Std. Error z value Pr(>|z|)
(Intercept)     -0.70628    0.03303 -21.381  < 2e-16 ***
unemployed_adult  0.10030    0.06050   1.658  0.09736 .
migrant_in_HH   -0.13350    0.04377  -3.050  0.00229 **
only_women      -0.01819    0.04576  -0.398  0.69099
all_elderly_HH   0.06722    0.04776   1.407  0.15930
all_young_HH    -0.34682    0.33112  -1.047  0.29491
large_family    -0.06412    0.36943  -0.174  0.86220
house_dwelling  -0.01050    0.03703  -0.284  0.77677
multioccupancy   0.15268    0.07197   2.121  0.03390 *
locataire        0.44138    0.05145   8.579  < 2e-16 ***
poverty          0.51413    0.04432  11.599  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```



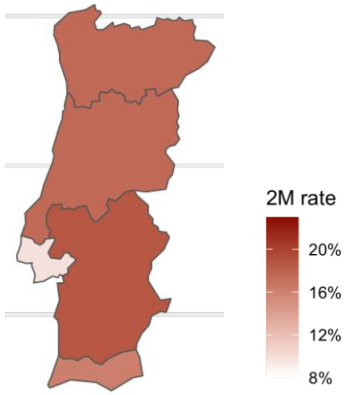
- 11 years later and different sample of people
- Maintained signficant correlations with **economic poverty, overcrowded housing, tenants, people aged 65+, unemployed people**

H.F.R.I. Hellenic Foundation for Research & Innovation
Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

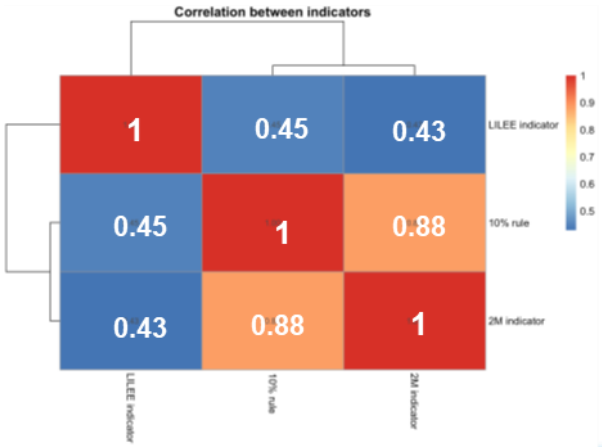
Other analyses

- **10% ratio between energy expenditure and income** (Boardman, 1991)
- **Inability to keep home adequately warm/cool in the winter/summer** (EPAH, 2025)
- **2M** – Share of energy expenditure over double the median (Rademaekers et al. 2016)
- **M/2** – Share of energy expenditure under half the median (Rademaekers et al. 2016)
- **LILEE** – Low income low EE (GOV.UK, 2022)

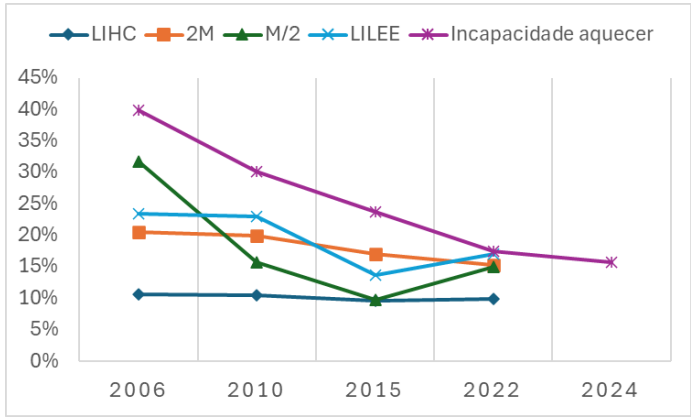
Regional NUTS2 Mapping



Indicator Overlap



Evolution of Household EP levels



H.F.R.I. Hellenic Foundation for Research & Innovation

Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN

Funded by the European Union NextGenerationEU

Objective: Support local municipalities in addressing energy poverty through the renovation of private multiapartment buildings for vulnerable residents.

Key Aspects:

- Multi-stakeholder **Co-creation process**
- Use of **Administrative data**
- **Toolkit** for **identifying energy-vulnerable households**, matching **tailored interventions** to their needs
- Integration in local policy - **SECAPs**

LOCATEE

Co-funded by the European Union

Co-Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure, and Environment executive agency (CINEA). Neither the European Union nor the European Climate, Infrastructure, and Environment executive agency can be held responsible for them.

Case studies - three small and medium-sized municipalities in Central and Southern Europe:

- Rumia (Poland)
- Torres Vedras (Portugal)
- Piraeus (Greece)

H.F.R.I. Hellenic Foundation for Research & Innovation
Greece 2.0 NATIONAL RECOVERY AND RESILIENCE PLAN
Funded by the European Union NextGenerationEU

LOCATEE

Report "**Varieties of domestic energy deprivation in private multi-apartment buildings. Insights from Poland, Portugal and Greece**"

Combination of **data at different levels:**

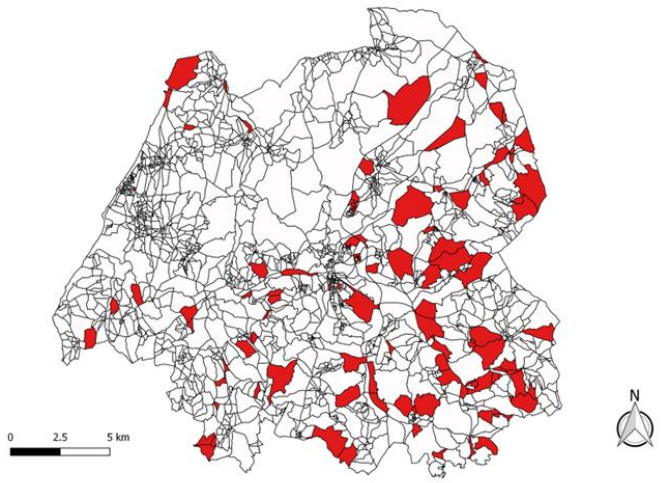
- **National/NUTSII** (e.g EP indicators, socioeconomic variables, climate from national surveys **HBS/SILC/ECS**)
- **Parish/district** (e.g. socio-economic and building parameters from **census**)
- **Building/postcode** (e.g. EPC data, type and age of building cadasters, housing and economic vulnerabilities, social support from city departments)

Creating an **EP probability map** at the building or neighbourhood level:

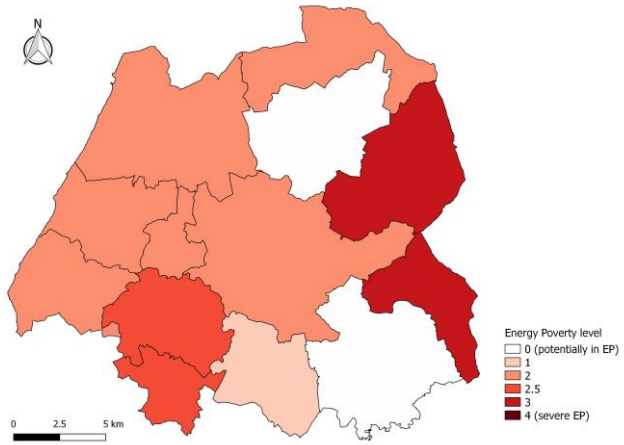
1) Test and select outcome energy poverty indicator and national covariables – e.g. **Low Income High Cost (LIHC)**
2) Define hierarchical Bayesian **predictive model**
3) Identify **equivalent covariables** at municipal/neighbourhood/building levels and prepare data for each dwelling
4) Monte Carlo simulation to randomize uncertain variables and obtain **EP probability distribution** and calculate averages

Report “**Varieties of domestic energy deprivation in private multi-apartment buildings. Insights from Poland, Portugal and Greece**”

Mixed method mapping approach



Vulnerability hotspot subsections in Torres Vedras from public and administrative data



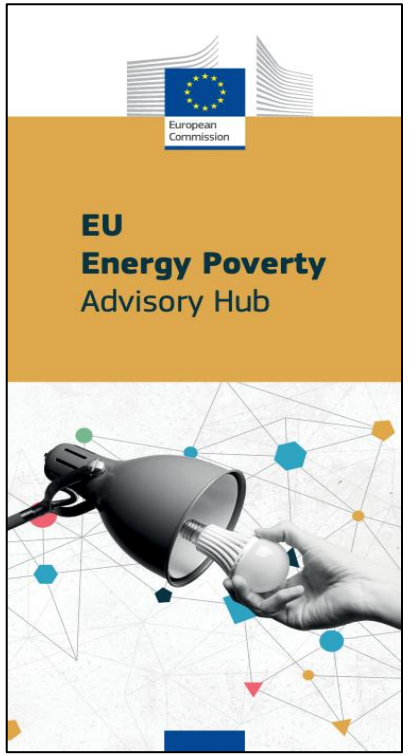
Mapping of local government representatives’ self-attributed Energy poverty rate

Mapped hotspots of vulnerability by the three stakeholder groups at the stakeholder group meeting

H.F.R.I.
Hellenic Foundation for Research & Innovation

Greece 2.0
NATIONAL RECOVERY AND RESILIENCE PLAN

Funded by the European Union
NextGenerationEU



www.energypoverty.eu/

The leading EU initiative run by the European Commission at the request of the European Parliament, is a collaborative network of stakeholders and the central platform of energy poverty expertise in Europe.

Consortium

Climate Alliance
AISFOR
NOVA SCHOOL OF SCIENCE & TECHNOLOGY
ecoserveis
akaryon

Antennas

ANAT LIKI S.A.
SOUTH EAST ENERGY AGENCY
Cyprus Energy Agency
DOOR
POLSKA SIEĆ Energie Cités
SEC

Energy/Fuel and human POverty: public policy and REcommendations in Southern Europe
December 3-4, 2025

H.F.R.I.
Hellenic Foundation for Research & Innovation

Greece 2.0
NATIONAL RECOVERY AND RESILIENCE PLAN

Funded by the European Union
NextGenerationEU

Establish network of support - enhance collaboration and knowledge sharing

Develop data and knowledge
Inform policy

Increase capacity of local communities

- **Website** as a knowledge hub
- **Podcasts and video stories** that share insights and experiences.
- **Events** such as International conferences, Policy sessions, Practitioner events, Lunch talks
- **Working groups** – Learning from other projects and building on each other's success.

- **In-depth reporting**, detailed assessments of conditions across European Member States.
- **Data and indicator analysis**, supporting the development of a structured and consistent framework.
- **Country-specific insights**, tailored analyses to help national institutions address energy poverty.

- **Direct support**: Two calls for technical assistance to help local communities.
- **Practical guidelines**: Concrete tips for addressing specific challenges.
- **Technical exchange**: Sharing existing solutions and strengthening overall capacity.

Energy/Fuel and human POverty: public policy and REcommendations in Southern Europe
December 3-4, 2025

The research project is implemented in the framework of H.F.R.I call “Basic research Financing (Horizontal support of all Sciences)” under the National Recovery and Resilience Plan “Greece 2.0” funded by the European Union –Next Generation EU (H.F.R.I. Project Number: 016638).

Thank you

Pedro Palma, NOVA University of Lisbon, Portugal

p.palma@fct.unl.pt

Energy/Fuel and human POverty: public policy and REcommendations in Southern Europe
December 3-4, 2025