EU-27 country mapping of financing schemes to decarbonize buildings, heating and cooling

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Abstract

Despite a significant decrease in greenhouse gas emissions from buildings (31 % in the EU between 2005 and 2021), the decarbonization of the sector is still too slow and the current trajectory is not on track to meet the 2030 and 2050 targets. Access to finance is still mentioned as one of the main barriers to building retrofit, despite a substantial offer of financing options proliferated in recent years, varying across countries in the number of programmes, scope and type of support offered. To shed some clarity, this study aims to answer the research questions: "What financing options are currently available for energy efficiency in buildings, in Europe?" and "Can we identify any factors driving financing in this sector?".

We carried out an EU-27 comprehensive and detailed mapping of funding supporting energy efficiency and renewable energy in buildings. Almost 600 private and public schemes were collected at the European and national levels, including some local ones. Focus sectors included building efficiency, efficiency and renewable sources in heating and cooling, and district heating and cooling, with additional focus on cooling alone and geothermal for district networks. As many programmes do not disclose their budget, a bottom-up sum of the budgets revealed, resulted in incomplete and inconsistent data. Thus, we used data from an external source on public expenditure in energy and energy efficiency in buildings and industry at the country level. The dataset was then assessed for correlations against selected social, energy, economic, and financial indicators.

The first finding is that traditional instruments dominate the offer, with grants, green loans, green mortgages, and tax rebates prevailing. These are not necessarily the most effective, but the easiest to set up and administer. A correlation can be identified between the size of public expenditure for energy efficiency in buildings and industry, the number of financing schemes, the population, and the total final energy consumption in buildings. Climate, and thus heating and cooling needs, do not seem to affect either public expenditure or the number of schemes dedicated to reducing energy demand and emissions in buildings while increasing winter and summer comfort. In particular, while heating is considered a need, cooling seems to be still considered a "nice to have" treat. A closer look at a few outliers suggests that country-specific dynamics play a significant role in shaping the offer of public and private financing for building decarbonization.

This mapping fills an important gap in the literature: as no similar work could be found to date, it can be considered the first EU-27 comprehensive and detailed database on financing options for building decarbonization. The study showed also that information on these schemes is fragmented, dispersed, hard to find, and suffering from fast obsolescence, which creates another barrier to finance in terms of access to information. Thus, to raise awareness among beneficiaries about their financing options and facilitate their access to them, targeted extracts of this mapping will be made available in the Support

Facility of the Project Act!onHeat[1], CoolLIFE[2] and SAPHEA[3] Tools and Knowledge Hubs.

Introduction

While it's widely acknowledged that decarbonizing the building sector is crucial to achieving carbon neutrality, progress remains insufficient. Greenhouse gas emissions from buildings decreased by 31 % in the EU between 2005 and 2021 (EEA 2023), yet the current trajectory is still not on track to meet the EU's 2030 and 2050 targets. The rate registered between 2015 and 2021 has to increase 7.5 times ('Buildings | ECNO' 2023) and a significant acceleration in energy renovations is needed to meet the 60 % decrease in building emissions by 2030 compared to 2015 and complete decarbonisation by 2050. (Jong, Petito, and al. 2022)

Building codes impose high-efficiency standards on new constructions, and in case renovations are undertaken, some incentives apply only if a certain energy class is achieved, but no regulation is imposed to start renovations, except seldomly for public buildings, offices (e.g. in the Netherlands), or private-rented dwellings (e.g., in France). For privates, starting the renovation of existing buildings remains an individual decision, motivated by several factors: some economic ones, such as future reduced energy bills and increased property value, compared to the initial investment, available capital and incentives, as well as non-economic, such as future improved comfort opposed to the temporary discomfort of works (Pérez-Navarro, Bueso, and Vázquez 2023). Several EU policies aim at stimulating investments in buildings' energy efficiency, (Renovation Wave, Energy Performance of Building Directive (EPBD) recast, and Energy Efficiency Directive (EED) recast) (Economidou et al. 2020) to bring renovation rates closer to the needed yearly 3 % (BPIE 2022).

Literature shows that access to finance and economic considerations remain one of the main barriers to building renovation: high initial costs, long payback periods, lack of financial incentives and regulatory challenges make building renovation less attractive compared to other investments (Liao, Ren, and Li 2023; D'Oca et al. 2018; EMBuild 2017; Ntouros et al. 2022; Cummins, Lynn, and Rosati 2023). A multitude of public incentives try to make renovations more attractive, but their disordered proliferation creates a barrier per se. Increasing funding is available, both in public and private schemes, growing in 2022 by 9 % across the EU, but it is still insufficient, reaching barely half of the estimated investment needs (I4CE 2024). Besides, information is fragmented, dispersed across multiple sources, and changing often. Multiple programmes with slightly different focus, overlap in terms of beneficiaries and measures. As a result, while a higher number of receivers could be reached, it remains hard to have a complete overview of currently active schemes, leaving beneficiaries mostly unaware of their full range of financing options.

To bring some clarity to this intricate landscape, we carried out a thorough mapping of currently available funding schemes, both public and private, at the EU and national level for each EU-27 Member State, with some regional and local insight where schemes were relevant and available. The resulting database collects over 600 schemes with a series of data and parameters.

In trying to understand which factors influence the amount, extension, and granularity of funding schemes, a first assessment of this dataset highlights any relevant trends and correlations between the public expenditure in building efficiency, the number of schemes and a series of social, economic, energy, climate, and financial indicators. This paper reports the outcome of these assessments to provide more insight into the current funding options to decarbonize the building stock and help advance the transition of this sector.

Methodology

This study involved a multifaceted approach to fill an important knowledge gap: obtain the first detailed and accurate mapping of financial instruments supporting building decarbonization across the EU-27. First, a thorough literature review was conducted to gather existing knowledge and reviews on financing schemes for building decarbonization (EEFIG 2022; DG Energy et al. 2022; Conforto and Hummel 2022; OECD 2021; EIB 2020; Economidou, Todeschi, and Bertoldi 2019; TPA Group 2018). Sources were systematically collected to establish a foundational understanding of overarching policies and initiatives at the EU level.

Existing mapping and datasets of national financing schemes were gathered across these sources and others found with further desk research (ODYSSEE-MURE, n.d.; EBRD, n.d.; ficompass, n.d.; EU COR, n.d.; IEA, n.d.; EEA, n.d.; OECD, n.d.; EIB, n.d.). Relevant national documents such as National Energy and Climate Plans (NECPs), National Energy Efficiency Action Plans (NEEAs), Long-Term Renovation Strategies (LTRS), Regional Recovery Plans (RRPs), and Comprehensive Assessments were collected and scanned for policies. A list of national agencies with a potential role in promoting climate action and disbursing funding was assembled. These included entities such as National Energy Agencies, National Energy Efficiency Funds, Environment, Innovation and Development Agencies, and relevant Ministries (Energy, Environment, Economics).

A structured desk research scanned the above-mentioned sources compiling a long list of schemes. This was complemented by desk research for each Country, using a list of keywords in English and translated into each national language. When additional major sources were found, such as portals listing multiple financing schemes, these were added to the list of sources, thoroughly inspected, and relevant schemes were added to the long list.

A meticulous shortlisting process kept only the schemes currently active and compiled two tables: one for public and one for private schemes. For each one, the following information was collected: name in original language and English, country, level (EU, national, regional, local), target sectors, type of instrument, start and end year, links to relevant sources, and short description. Target sectors included: building efficiency, heating and cooling (H&C) efficiency, renewable energy sourc-

1. Act!onHeat (Horizon 2020 Grant ID: 101033706) https://actionheat.eu/home.

2. CoolLIFE (LIFE21-CET-COOLING Grant ID: 101075405) https://coollife.revolve.media/.

3. SAPHEA (Horizon Europe Grant ID: 101075510) https://gogeothermal.eu/projects/saphea/.

es (RES) in H&C, district heating and cooling (DHC), cooling, geothermal in DHC, and residential and non-residential premises. Specific measures are listed in the description.

The mapping distinguished when sectors were addressed directly, explicitly mentioned, or indirectly, not explicitly mentioned, but reasonably included given the wording of the scheme. All results described and discussed in this paper refer to sectors directly addressed. However, for a matter of clarity and completeness, information disclosed in the Act!onHeat, CoolLIFE and SAPHEA projects include both sectors directly and indirectly addressed.

To enhance the robustness of this study, the mapping was revised by CoolLIFE project partners. Each partner was assigned an export of the mapping, completed with the relevant sources for the assigned countries. Partners provided feedback on any imprecisions on the collected schemes and scanned for any additional schemes that might not have been captured. Updates were checked and integrated into the mapping. This iterative process allowed for the refinement and validation of the gathered information.

At this point, we could assess relevant trends and correlations. A main limitation was given by the fact that the budget dedicated to each program is erratically disclosed for public schemes and never for private ones. Therefore, to assess the magnitude of the funds invested in each country, this study took aggregate data on public energy spending at the country level and its portion dedicated to buildings and industry efficiency (IEA 2024).

The dataset was complemented with additional indicators: public energy spending for energy and building and industry efficiency, total and per capita (IEA 2024), population (Eurostat 2022c), GDP per capita in Purchasing Power Standards (PPS) (Eurostat 2023a), Heating Degree Days (HDD) and Cooling Degree Days (CDD) (Eurostat 2022a), total final energy consumption (FEC) in buildings (EURAC 2023) converted to GWh from Mtoe, total Gross Floor Area (GFA) (EURAC 2023), building energy intensity per m^2 and capita (own calculations), electricity and gas prices (Eurostat 2022b), the share of DCH in FEC and share of geothermal energy in FEC (Bursich 2020), inflation (own calculation from Harmonized Index of Consumer Prices (Eurostat 2024), cost of borrowing (ECB 2024), interest rates (CEIC Data 2024), sovereign yield (MTS Markets 2024) and public deficit (Eurostat 2023b). We tried to consider the current political majority in the parliament or government but abandoned it, as current schemes were inherited from previous governments. All indicators were taken for the most recently available year, as summarized in Table 1.

This enriched dataset was analysed against its main features: country, sector, type of instrument, and start-end date. A correlation matrix was adopted to assess any correlation between the public expenditure, the number of schemes and the additional indicators.

Outliers with an exceptionally high or low number of schemes were identified and further factors were searched to try and explain their anomaly. This paper summarizes the main findings of the mapping and the assessment, to offer valuable insights for further analysis and decision-making.

Results and Findings

OVERALL MAPPING HIGHLIGHTS

The mapping collected a total of 597 funding schemes relevant to building decarbonization across the EU-27: 382 public schemes and 215 private ones. A higher public rather than private offer shows a policy attempt to lower the barrier of high initial costs and long payback periods. It is also aligned with the common perception bias, especially among investors and credit institutes, that energy efficiency even more than renewable projects is less attractive than other investments, besides bearing high transaction costs for their often small size. Only a few countries presented more private than public schemes: mainly Italy, Sweden, and Slovakia. This can hardly be reconnected to more mature markets but rather to a highly fragmented banking sector, where several credit institutions offer similar products. For instance, Italy ranks fourth in Europe for number of banks and credit institutes (EBF 2023).

Concerning the type of instruments offered, as shown in Table 2, public schemes prominently feature grants (51 %), soft loans (14 %), or a combination of them (8 %), and tax incentives (8 %). Private schemes mostly consist of green loans (60 %) and green mortgages (22 %), with a minor offer of green bonds (7 %). Green bonds are mostly promoted to investment rather than finance projects.

Table 1. Overview of sources of additional indicators used for the correlation matrix.

Source	Indicator (Reference Year)
CEICDATA	Interest Rate (2024)
ECB	Cost of borrowing (2023)
EURAC for EU BSO	Building FEC (GWh converted from Mtoe) (2021); Total GFA (m2) (2021);
Eurostat	Population (2021); GDP/capita (in PPS) (2021); HDD (2023); CDD (2023); Electricity Prices (2022); Gas Prices (2022); Inflation (2023); Public Deficit (2022) (2022)
IEA	Public Energy Spending (bn €) (2024); Public Energy Spending in Building and Industry Efficiency (bn €) (2024)
IREES-Bursich for EU Commission	DHC in FEC (%) (2018); Geo in FEC (%) (2018)
MTS Markets	Sovereiegn Yied (2024)
Own Calculation	Energy Spending (€/capita) (2024); Energy Spending in Building and Industry Efficiency (€/capita) (2024); Financing Schemes - Total (2024); Financing Schemes - Public (2024); Financing Schemes - Private (2024); Building Energy Intensity (MWh/cap) (2021); Building Energy Intensity (kWh/m2) (2021)

Table 2. Types of instruments in public and private schemes. Sectors coverage among all schemes.

Public Schemes

Types of instrument	Count	%
Grant/Subsidy	199	51%
Debt financing	55	14%
Grant/Subsidy, Debt Financing	32	8%
Tax Incentives	30	8%
Multiple (Grant/Subsidy, Tax rebate, Debt, Equity, Guarantee, TA)	17	4%
Energy efficiency obligations	15	4%
Other public scheme	13	3%
Advisory Service, Technical Assistance	9	2%
Guarantee	7	2%
Equity financing	5	1%
Grand Total	**382**	**100%**

Private Schemes

Types of instrument	Count	%
Green Loan	128	60%
Green Mortgage	47	22%
Green Bonds	14	7%
Equity financing	6	3%
On-bill financing	5	2%
Green Leasing	4	2%
Grants/ subsidy	4	2%
Advisory Service, Technical Assistance	3	1%
Green Loan, Advisory Service	2	1%
Guarantees	2	1%
Grand Total	**215**	**100%**

All Schemes

Sector	Count	%
Building Eff	457	77%
H&C Eff	495	83%
H&C RES	459	77%
DHC	203	34%
Geo DHC	181	30%
Cooling	296	50%
Residential	418	70%
Non-Res	299	50%
Grand Total	**597**	

Table 3. Financial Instruments for energy efficiency in buildings, building renovation, H&C, DHC.

<table>
<tr><th></th><th colspan="2">Traditional</th><th colspan="2">Innovative</th></tr>
<tr><td>Non-repayable</td><td colspan="2">Grants, Prizes and Subsidies
Tax Incentives</td><td colspan="2">Energy-Efficiency Feed-in-Tariff</td></tr>
<tr><td rowspan="4">Debt</td><td colspan="2" rowspan="2">Loans</td><td>Green/Soft Loans</td><td>Energy Efficient Mortgages</td></tr>
<tr><td>Green Bonds, Community Municipal Investment Bonds, Social Bonds</td><td>On-Bill Financing (OBF) Loans, Tariffs</td></tr>
<tr><td colspan="2" rowspan="2">Credit Enhancement (guarantees, securities, insurances, additional collateral, etc.)</td><td rowspan="2">Energy Performance Contracting (EPC) and Agreements (EPA)</td><td>Energy Service Agreement (ESA)</td></tr>
<tr><td>Green/Energy Revolving Funds</td></tr>
<tr><td>Equity</td><td colspan="2">Third-Party Funding</td><td colspan="2">Energy Communities/Cooperatives</td></tr>
<tr><td rowspan="2">Other</td><td rowspan="2">Technical Assistance (TA), Project Development Assistance (PDA)</td><td>Advisory Services</td><td colspan="2">Energy Efficiency Quota Obligations</td></tr>
<tr><td>Capacity Building</td><td colspan="2">One-stop shops (OSS)</td></tr>
</table>

While previous literature found several types of innovative instruments, the strong inclination towards traditional instruments highlighted in this mapping shows a preference of both public administrations and private financers towards instruments that are well known and easier to implement and administer. This raises questions about the scalability of innovative financing approaches and their potential to attract private capital. Table 3 reports the complete range of types of instruments previously documented in the literature (Conforto and Hummel 2022), with the instruments most frequently found in the mapping, in darker shades.

Delving into thematic areas, as shown in Table 2 and Table 4, most schemes address energy efficiency in H&C (83 %) the use of RES in H&C (77 %), and overall envelope building efficiency (77 %). Much fewer schemes target specifically cooling (50 %), district networks (34 %) and geothermal for DHC (30 %). Regarding the use of buildings, residential dwellings (70 %) are addressed more often than non-residential premises (50 %).

A focus on cooling highlights that mentioning "heating and cooling" together is mostly mainstreamed in the EU policy. Cooling is thoroughly addressed in financing schemes at the EU level and in countries with a high number of schemes, as these arguably aim for more specific targeting. However, it is inconsistently supported in countries with high cooling needs: poorly in Malta (2) and Spain (6) but widely included in Cyprus (7) and Portugal (16), despite these countries rank among those with the fewest schemes. A scheme supporting the upgrade of AC systems was launched in Greece and Cyprus as part of the Recovery Plan, but it was then discontinued. This could be due to limited available public spending, prioritized towards other topics, but it also points in the direction that cooling is still perceived as a "nice to have" luxury, rather than a need such as heating.

A focus on geothermal energy found that this source is often supported to increase the share of renewable energy in H&C, but rarely specifically supplying district networks. Schemes supporting DHC almost always apply to the use of RES but rarely mention explicitly geothermal as a source. Only 3 public schemes across all member states are dedicated specifically geothermal energy, and in total 16 schemes between public and private mention explicitly geothermal in the description. This constellation could change soon as geothermal is gaining momentum, the EU Parliament just adopted a resolution urging for a common European geothermal strategy and more support.

It is worth noting that the private offer, mostly made of green loans and mortgages, almost always addresses building ef-

ficiency (85 %), H&C efficiency (79 %), RES in H&C (77 %), and residential dwellings (82 %). The coverage drops sharply for non-residential premises (33 %), arguably object of corporate credit negotiated on a one-by-one basis, and DHC (18 %), which often implies such large investments that not only are negotiated individually and not portrayed in the standardized offer of commercial products, but often require an ad-hoc public-private partnerships among the local administration, energy utility and network manager.

Looking at the country level, the study found on average 22 schemes per country: 14 public and 8 private ones. The top outliers are Germany (50), France (47), Poland (42) Austria (40) and Belgium (35). Conversely, the bottom outliers are Romania (8), Greece (8) Lithuania (8), Cyprus (12), Malta (13), Estonia (13), and Croatia (13).

Concerning public expenditure in building and industry efficiency, Italy towers above everyone else, followed by Germany, France, Sapin, Austria, Sweden, Ireland and Poland. The Italian value is arguably inflated by the expensive scheme "Superbonus", addressed more in detail later on in the country focus.

CORRELATION WITH SOCIOECONOMIC, CLIMATE, ENERGY AND FINANCIAL INDICATORS

The study collected a few indicators that could arguably affect the public and private offers of financing schemes for the decarbonization of buildings, as reported in Table 1 and Table 5. A correlation matrix was run on this dataset, as shown in Table 6. A strong correlation could be observed between the public expenditure on energy and building efficiency and the population (0.92–0.87), the total FEC in buildings (0.96–0.87), the gross floor area (0.94–0.89), and the number of financing schemes (0.69–0,62). Interestingly, no significant correlation could be seen between the public expenditure in building efficiency and the financial indicators.

The correlation to the population is especially strong for the top outliers, Italy, Germany, France Spain, and Poland, becoming weaker for the bottom outliers where countries with the smallest population are not those with the smallest expenditure. Italy and Spain focus their public expenditure on building efficiency in a smaller number of larger schemes. The opposite can be seen in Austria and Belgium, which disperse modest values of public expenditure in building efficiency in a high number of schemes.

Table 4. Overview of the number of active public and private schemes by Country and target sector.

Public Schemes

	Schemes	Building Eff	H&C Eff	H&C RES	DHC	Geo DHC	Cooling	Residential	Non-Res.
Grand Total	**382**	**274**	**326**	**294**	**164**	**145**	**206**	**242**	**229**
Country		**72%**	**85%**	**77%**	**43%**	**38%**	**54%**	**63%**	**60%**
Germany	42	27	38	31	10	8	19	24	24
France	31	26	30	31	17	16	30	20	14
Austria	27	7	17	12	17	9	8	9	22
Belgium	26	22	22	17	8	5	7	12	17
Poland	26	13	26	24	16	15	14	19	11
EU	23	19	21	21	21	21	21	22	22
Netherlands	19	17	16	17	12	12	14	16	13
Spain	15	6	12	13	3	9	4	11	14
Slovenia	13	13	8	8	4	5	8	11	4
Bulgaria	12	9	9	7	1	1	4	7	9
Ireland	12	10	10	10	1	1	3	9	6
Czechia	11	8	10	7	4	1	5	4	7
Luxembourg	11	8	11	11	5	5	6	7	4
Italy	10	8	9	6	5	5	5	6	4
Croatia	9	7	9	7	3	3	8	5	5
Denmark	9	4	8	6	3	1	3	5	3
Finland	9	6	8	8	5	4	5	5	6
Hungary	9	9	9	8	4	4	8	4	6
Latvia	9	9	8	9	4	5	6	7	6
Portugal	9	9	8	8	0	0	9	7	4
Estonia	7	5	3	3	2	0	0	6	2
Malta	7	4	2	1	1	1	1	5	4
Romania	7	5	6	3	3	0	0	5	6
Slovakia	7	5	7	7	5	5	5	4	4
Sweden	7	5	5	5	1	0	0	4	2
Cyprus	6	6	5	5	4	4	5	4	5
Greece	5	4	5	5	1	1	4	2	4
Lithuania	4	3	4	4	4	4	4	2	1

Private Schemes

	Schemes	Building Eff	H&C Eff	H&C RES	DHC	Geo DHC	Cooling	Residential	Non-Res.
Grand Total	**215**	**183**	**169**	**165**	**39**	**36**	**90**	**176**	**70**
Country		**85%**	**79%**	**77%**	**18%**	**17%**	**42%**	**82%**	**33%**
Italy	18	17	18	18	1	1	6	17	3
France	16	14	16	16	3	3	16	16	3
Poland	16	11	13	12	1	0	1	10	6
Sweden	14	11	11	11	7	6	2	12	3
Austria	13	9	9	9	8	8	8	8	9
Denmark	11	10	10	10	1	1	3	10	2
Slovakia	11	11	7	7	1	1	3	10	3
Netherlands	10	9	5	5	0	0	5	9	2
Belgium	9	8	7	6	2	2	2	6	4
Luxembourg	9	7	7	7	1	1	5	7	4
Finland	8	6	4	4	0	0	0	6	5
Germany	8	7	8	8	7	7	8	6	7
Ireland	7	7	3	3	0	0	0	7	0
Portugal	7	7	7	6	2	1	7	6	3
Cyprus	6	6	5	4	1	1	2	4	1
Estonia	6	6	5	5	1	1	2	5	1
Malta	6	4	4	3	0	0	1	6	1
Spain	6	5	4	5	0	0	2	3	4
Czechia	5	5	5	5	0	0	3	4	1
Hungary	5	5	5	5	1	1	5	5	3
Latvia	5	4	5	5	1	1	2	5	1
Croatia	4	3	3	3	0	0	2	2	2
Lithuania	4	4	3	3	0	0	1	4	0
Bulgaria	3	2	2	2	1	1	2	2	1
Greece	3	3	0	0	0	0	0	3	0
EU	2	0	0	0	0	0	2	0	0
Slovenia	2	1	2	2	0	0	0	2	0
Romania	1	1	1	1	0	0	0	1	1

In Austria, this is supported by a high public expenditure for energy per capita, while in Belgium, the high number of schemes can be reconducted to the federal organization of the country, where almost all schemes are found at the regional level, with an obvious multiplication of the total number of schemes.

The economic development and living standards indicated through the GDP per capita in PPS, show no correlation to the public expenditure for energy and building efficiency. The top outliers are slightly wealthier than average but do not have the highest level of wealth, and Poland is even among the lowest-income countries. Conversely, the GDP per capita in PPS shows a moderate correlation to the energy intensity of buildings, per capita (0.62) and the HDD (0.64). Understandably, wealthier countries have less energy poverty and higher indoor comfort, which results in a higher final energy consumption especially in colder climates, given that the average efficiency of the building stock in Europe is still modest.

Heating Degree Days (HDD) and Cooling Degree Days (CDD) do not show a correlation to the public expenditure for building efficiency. The countries with the highest heating needs, are not those with the highest public expenditure, as they happen to have smaller populations. However, they show a strong correlation to the energy intensity in buildings (0.63), due of course to the colder climate.

Conversely, for cooling, high needs (CDD) do not translate into high consumption, as summer comfort is still largely not met. Cooling is a topic particularly neglected, or sparsely addressed. While it could be understandable to find no schemes addressing specifically cooling in Estonia, it is not the case in Romania or Malta, which have remarkably warm summers. Interestingly, cooling started being addressed in northern countries as insulation materials thought for heating often negatively impact summer comfort, creating a heat trap.

While we noted the almost perfect correlation (0.99) between the public expenditure in building efficiency and the total FEC in buildings, population, and gross floor area, no correlation can be seen with the energy intensity per capita (toe/capita) and per surface (kWh/m^2). Of course, with the progress of the energy transition, it is expected that higher indoor comfort will be achieved with a smaller energy consumption. Electricity and Gas prices also offer no correlation to public expenditure in building efficiency.

The share of DHC in FEC shows a strong correlation with HDD. Countries with small or no district networks have the lowest number of schemes addressing this technology. Greece, Ireland, Malta and Portugal have virtually no schemes addressing DHC, except for the energy efficiency obligation schemes (not in Portugal), which could be used to promote also DHC, but their share of DHC in total FEC is zero or close to zero. Conversely, several schemes address DHC in Lithuania, Croatia, Bulgaria, Austria, and Poland, where this technology is present, but the share of DHC in FEC is not yet the highest. The priority repeatedly given to DHC systems at the EU level to decarbonize the building sector, has not yet been received in countries new to this technology, or where conditions for DHC are not favourable, e.g. low heat demand and/or density such as in Malta or Portugal.

The financial indicators analysed, offer no significant correlation to the amount of public spending for building and industry efficiency. With regards to the temporal dimension, most schemes commenced in the past 5 years, and further in the past fewer and fewer schemes are found that are still ongoing. This is easily understandable as with evolving needs, political priorities and market conditions, new schemes are started, merged, or discontinued.

COUNTRY FOCUS: SIGNIFICANT OUTLIERS

Outliers add depth to the narrative; hence this section explores the specific circumstances shaping the offering of funding instruments in a few of them.

Austria shows one of the highest public energy expenditures in building and industry efficiency per capita in the whole EU, with the lowest share of schemes addressing energy efficiency in buildings. This constellation can partly be explained by the choice to put more emphasis on H&C systems rather than building envelopes, as a large renovation wave took place in 2002–2003; partly, by the fact that the regions (Länder) act as implementers of national schemes, without a multiplication of financing schemes.

Spain shows a moderate public expenditure in building efficiency, despite its large population and gross floor area. Remarkably few schemes address Building Efficiency and Cooling alone. This data is aligned with the previous country analysis carried out by Odyssée-Mure (Rousselot and Morgan-Price 2021), which noted the renovation rate in Spain is still too slow and the depth of renovations is significantly lower than in other EU countries. Also, Spain shows a modest number of schemes because, like in Austria, regions (Autonomous Communities) play a strong role in building renovation, but only as implementers of national renovation schemes.

Conversely, in Belgium, energy efficiency policies fall under regional competencies, which translates into the multiplication of regional schemes and almost no nationwide scheme that this study documented.

Italy presents the highest public expenditure in building and industry efficiency. That is most probably due to the "Superbonus" programme. This controversial incentive offered a 110 % tax rebate for expenses related to energy-efficient building renovations providing an improvement of a minimum of 2 energy classes. The scheme proved abnormally expensive (it costed about 100 billion Euros so far (ENEA 2023)) for such a modest increase in the energy efficiency of the building stock, compared to other interventions, especially looking at the social cost of carbon (Alpino, Citino, and Zeni 2022). In fact, it was conceived in 2020 mainly to revive the economy and the construction sector, rather than advancing the energy transition. The nature of the scheme is another reason that caused great debate, as it is regressive: taking public funds, from the whole tax-payers pool, it supports mostly building owners, who are not the poorest share of the population, have at least a property, and it facilitates renovations, which increase properties value and therefore homeowners' wealth, virtually at no expenses. In addition, the incentive rate set at 110 % created not only a sharp expansion in renovations but a not-so-transparent increase in renovation prices, as the pricier the renovation, the higher the extra margin. Another analysis of this scheme's multiple impacts was carried out by the MICAT project[4].

4. https://micatool.eu/seed-micat-project-wAssets/docs/publications/policy_briefs/January-2024-Superbonus-110-The-generous-Italian-scattergun-and-its-small-but-fine-impacts.pdf

Table 5. Socio, economic, energy, climate, and financial indicators.

Country	Energy Sp. (bn €)	Energy Sp. Build. & Ind. Eff (bn €)	Energy Sp. (€/capita)	Energy Sp. Build. & Ind. Eff (€/capita)	Financing Schemes - Total	Financing Schemes - Public	Financing Schemes - Private	Population	GDP/cap (PPS)	HDD	CDD
EU	-	-	-	-	25	23	2	-	100	2,858	140
Germany	311.9	30.3	3,697	359	50	42	8	84,358,845	117	2,736	34
Italy	161.8	41.4	2,750	704	28	10	18	58,850,717	97	1,735	375
France	137.8	26.2	2,024	384	47	31	16	68,070,697	100	2,036	117
Spain	82.2	11.0	1,711	229	21	15	6	48,059,777	86	1,478	384
Netherlands	42.8	1.0	2,405	55	29	19	10	17,811,291	130	2,396	18
Poland	37.6	5.3	1,023	144	42	26	16	36,753,736	79	3,200	41
Ireland	30.8	5.6	5,939	1,081	19	12	7	5,194,336	235	2,549	0
Croatia	29.6	1.0	7,676	269	13	9	4	3,850,894	73	2,115	210
Austria	27.6	8.4	3,032	928	40	27	13	9,104,772	124	3,229	29
Czechia	25.6	0.9	2,366	83	16	11	5	10,827,529	90	3,083	27
Finland	16.0	3.0	2,884	545	17	9	8	5,563,970	110	5,277	2
Greece	13.8	2.9	1,332	282	8	5	3	10,394,055	67	1,538	372
Denmark	12.9	1.7	2,177	283	20	9	11	5,932,654	136	3,019	3
Sweden	11.6	5.6	1,106	532	21	7	14	10,521,556	119	4,919	2
Portugal	10.6	1.6	1,009	152	16	9	7	10,467,366	79	968	287
Belgium	10.5	1.8	889	155	35	26	9	11,754,004	120	2,377	28
Romania	7.2	0.1	378	3	8	7	1	19,051,562	76	2,751	146
Hungary	5.3	0.7	549	74	14	9	5	9,597,085	76	2,550	164
Lithuania	4.4	0.8	1,555	277	8	4	4	2,857,279	89	3,773	19
Estonia	2.2	0.2	1,630	148	13	7	6	1,365,884	85	4,118	16
Slovakia	1.8	1.0	337	180	18	7	11	5,428,792	71	3,043	68
Slovenia	1.6	0.1	761	63	15	13	2	2,116,792	90	2,644	81
Bulgaria	1.4		221	-	15	12	3	6,447,710	62	2,307	202
Latvia	1.1	0.4	596	189	14	9	5	1,883,008	73	4,026	14
Luxembourg	1.0		1,490	-	20	11	9	660,809	256	2,671	30
Cyprus	0.6		640	-	12	6	6	920,701	94	696	698
Malta	0.5		950	-	13	7	6	542,051	104	544	842
Total	**990.5**	**151.0**	**2,209**	**337**	**597**	**382**	**215**	**448,387,872**			

Country	Building FEC (GWh)	Total Gross Floor Area (m2)	Build. En. Intensity (MWh/ capita)	Build. En. Intensity (kWh/m2)	Electricity Prices	Gas Prices	DHC in FEC (%)	Geo in FEC (%)	Inflation	Cost of borrowing	Interest Rate	Sovereiegn Yied	Public Deficit (2022)
EU			9.6	132.5	0.29	0.06	6%	0.1%	6.4%	4.1%	3.3%	3.2%	-1.0%
Germany	986,478	6,778,247,840	11.7	145.5	0.41	0.05	6%	0.1%	6.1%	4.1%	2.2%	2.9%	-3.5%
Italy	549,094	4,642,068,603	9.3	118.3	0.38	0.08	1%	0.5%	5.9%	4.9%	3.8%	2.5%	3.3%
France	685,985	4,857,889,366	10.1	141.2	0.23	0.05	2%	0.1%	5.7%	4.1%	2.7%	2.9%	-3.5%
Spain	280,447	4,065,651,173	5.8	69.0	0.18	0.06	0%	0.0%	3.4%	4.2%	3.2%	2.8%	-0.8%
Netherlands	179,333	1,126,647,786	10.1	159.2	0.48	0.08	2%	0.3%	4.1%	4.1%	2.5%	3.7%	-3.2%
Poland	333,567	1,732,315,106	9.1	192.6	0.18	0.04	13%	0.0%	10.9%		5.2%	4.3%	-2.9%
Ireland	58,245	201,170,034	11.2	289.5	0.25	0.06	0%	0.0%	5.2%	4.2%	2.6%	2.8%	1.7%
Croatia	35,296	266,680,627	9.2	132.4	0.13	0.03	4%	0.2%	8.4%	4.0%	3.3%	6.2%	-6.2%
Austria	109,223	759,515,049	12.0	143.8	0.27	0.06	10%	0.1%	7.7%	3.8%	2.7%	3.2%	0.1%
Czechia	117,872	575,448,159	10.9	204.8	0.32	0.06	9%	0.0%	12.0%		3.9%	2.5%	-0.3%
Finland	93,762	724,498,529	16.9	129.4	0.24		14%	0.0%	4.3%	4.7%	2.8%	3.5%	-4.6%
Greece	71,889	953,594,457	6.9	75.4	0.23	0.08	0%	0.0%	4.2%	4.3%	3.3%	2.4%	1.1%
Denmark	71,045	571,197,133	12.0	124.4	0.38	0.13	30%	0.0%	3.3%		2.3%	2.8%	-4.8%
Sweden	130,136	788,575,499	12.4	165.0	0.27	0.13	19%	0.0%	5.9%		2.2%	2.3%	-2.5%
Portugal	60,194	934,780,458	5.8	64.4	0.21	0.06	0%	0.1%	5.3%	4.5%	3.0%	6.4%	-6.3%
Belgium	142,849	1,009,376,184	12.2	141.5	0.44	0.09	0%	0.0%	2.3%	3.9%	2.7%	3.3%	2.4%
Romania	114,459	567,928,845	6.0	201.5	0.42	0.06	5%	0.1%	9.7%		6.1%	3.3%	-4.7%
Hungary	92,815	472,868,919	9.7	196.3	0.12	0.02	5%	0.7%	17.0%		6.0%	5.4%	-3.7%
Lithuania	23,371	128,296,485	8.2	182.2	0.28	0.06	20%	0.0%	8.7%	6.5%	2.9%	3.0%	-3.6%
Estonia	16,419	125,901,602	12.0	130.4	0.22	0.08	24%	0.0%	9.1%	7.5%	3.3%	3.0%	-3.0%
Slovakia	44,811	241,263,156	8.3	185.7	0.19	0.03	17%	0.0%	11.0%	4.1%	3.4%	3.9%	-8.0%
Slovenia	17,542	107,601,143	8.3	163.0	0.19	0.05	6%	0.2%	7.2%	3.9%	3.1%	3.6%	-5.7%
Bulgaria	40,178	483,619,499	6.2	83.1	0.11	0.08	8%	0.3%	8.6%		3.9%	3.8%	-0.7%
Latvia	19,372	96,150,612	10.3	201.5	0.31	0.07	21%	0.0%	9.1%	7.2%	3.4%	2.6%	-0.1%
Luxembourg	11,564	44,830,896	17.5	258.0	0.20	0.08	5%	0.0%	2.9%	4.1%	2.6%	3.4%	-2.4%
Cyprus	6,996	132,322,399	7.6	52.9	0.37		6%	0.0%	3.9%	5.0%	3.3%	3.5%	-2.0%
Malta	2,611	18,647,303	4.8	140.0	0.13		6%	0.0%	5.6%	2.4%	3.4%	3.1%	-0.3%
Total	**4,295,555**	**32,407,086,861**											

Table 6. Correlation Matrix from the Data Table shown in Table 5.

	Energy Sp. (bn €)	Energy Sp. Build. & Ind. Eff (bn €)	Energy Sp. (€/capita)	Energy Sp. Build. & Ind. Eff (€/capita)	Financing Schemes - Total	Financing Schemes - Public	Financing Schemes - Private	Population	GDP/cap (PPS)	HDD	CDD	Building FEC (GWh)	Total Gross Floor Area (m2)	Build. En. Intensity (MWh/cap)	Build. En. Intensity (kWh/m2)	Electricity Prices	Gas Prices	DHC in FEC (%)	Geo in FEC (%)	Inflation	Cost of borrowing	Interest Rate	Sovereiegn Yied	Public Deficit (2022)
Energy Sp. (bn €)	1																							
Energy Sp. Build. & Ind. Eff (bn €)	0.87	1																						
Energy Sp. (€/capita)	0.33	0.21	1																					
Energy Sp. Build. & Ind. Eff (€/capita)	0.29	0.42	0.57	1																				
Financing Schemes Total	0.69	0.62	0.17	0.32	1																			
Financing Schemes Public	0.70	0.50	0.19	0.20	0.94	1																		
Financing Schemes Private	0.36	0.58	0.07	0.44	0.71	0.42	1																	
Population	0.92	0.87	0.14	0	0.73	0.71	0.47	1																
GDP/cap (PPS)	0.04	0.11	0.33	0	0.19	0.13	0.22	0	1															
HDD	-0.12	-0.28	0.03	0.26	0.03	-0.03	0.13	-0.17	0.07	1														
CDD	-0.04	0.33	-0.17	-0.26	-0.28	-0.28	-0.16	-0.01	-0.26	-0.77	1													
Building FEC (GWh)	0.96	0.87	0.19	0.24	0.78	0.77	0.49	0.97	-0.02	-0.08	-0.08	1												
Total Gross Floor Area (m2)	0.94	0.89	0.17	0.24	0.70	0.68	0.44	0.98	-0.06	-0.18	0.03	0.96	1											
Build. En. Intensity (MWh/cap)	0.08	0.05	0.28	0.33	0.30	0.21	0.34	-0.05	0.62	0.64	-0.62	0.08	-0.02	1										
Build. En. Intensity (kWh/m2)	-0.11	-0.21	0.17	0.18	0.04	0.03	0.04	-0.15	0.56	0.41	-0.54	-0.09	-0.24	0.42	1									
Electricity Prices	0.32	0.23	0.01	0.08	0.27	0.26	0.17	0.26	0.15	0.07	-0.20	0.31	0.26	0.19	0.02	1								
Gas Prices	-0.16	-0.04	-0.17	0.10	-0.08	-0.20	0.17	-0.18	0.30	0.29	-0.16	-0.16	-0.12	0.32	-0.15	0.42	1							
DHC in FEC (%)	-0.26	-0.30	-0.19	-0.02	-0.17	-0.26	0.09	-0.31	-0.12	0.68	-0.39	-0.24	-0.31	0.28	0.12	0.01	0.34	1						
Geo in FEC (%)	0.17	0.31	-0.02	-0.04	0.05	0.02	0.09	0.20	-0.22	-0.20	0.07	0.18	0.19	-0.15	-0.06	-0.12	-0.34	-0.32	1					
Inflation	-0.15	-0.23	-0.15	-0.18	-0.17	-0.13	-0.18	-0.10	-0.45	0.25	-0.19	-0.10	-0.20	-0.19	0.33	-0.35	-0.61	0.22	0.42	1				
Cost of borrowing	-0.14	-0.19	-0.16	-0.03	-0.31	-0.31	-0.18	-0.16	-0.24	0.55	-0.35	-0.16	-0.16	0.15	0.05	0.15	0.24	0.71	-0.13	0.44	1			
Interest Rate	-0.21	-0.16	-0.33	-0.36	-0.26	-0.22	-0.24	-0.03	-0.44	-0.09	0.15	-0.12	-0.15	-0.39	0.15	-0.21	-0.45	-0.11	0.42	0.71	0.25	1		
Sovereiegn Yied	-0.21	-0.30	0.14	-0.27	-0.11	-0.07	-0.16	-0.19	-0.24	-0.25	0.07	-0.21	-0.22	-0.21	-0.15	-0.41	-0.54	-0.23	0.35	0.31	-0.18	0.29	1	
Public Deficit (2022)	0.12	0.34	0.04	0.35	0.14	0.11	0.15	0.12	0.23	-0.18	0.21	0.10	0.15	0.03	0.01	0.21	0.33	-0.31	0.02	-0.26	0.00	-0.06	-0.56	1

Discussion

This comprehensive analysis unfolds a rich tapestry of findings, offering nuanced insights into the distribution, nature, and impact of financial instruments for building decarbonization across EU member states. However, a few points remain open for discussion.

Firstly, it is essential to acknowledge the inherent limitations of such mapping exercises. While efforts were made to ensure comprehensiveness, it is impossible to certify that the mapping is 100 % complete and the dynamic nature of such dispersed funding offer poses challenges, as schemes start, end, or are modified constantly, leading to a rapid obsolescence.

The absence of a historical overview of expired schemes hampers the ability to contextualize the current situation relative to the past. For instance, without historical data, it is challenging to assess trends such as spikes in public funding, particularly in response to events like the COVID-19 pandemic, or upcoming elections.

A significant constraint in comparing total funding availability arises from the lack of precise information on funds allocated to each program, not only in the private sector where disclosure is almost absent, but also in public schemes, which do not always set a budget, or set a budget for multiple programmes jointly, or multiple years, without a yearly breakdown. This opacity hindered meaningful comparisons between single public and private financing initiatives, forcing us to use aggregated data. Moreover, while the mapping identifies available schemes, it does not provide insights into their effectiveness, as seen in the Italian case, and their actual use. For instance, many schemes in theory address both heating and cooling, but if we had access to data about their actual use, we would most probably find that they are mostly used to retrofit buildings in favour of a smaller heating demand, or to improve heating systems, much more rarely to address cooling. Space cooling in fact is widely seen as a plus, a luxury, not a need, its needs do not fully translate in demand and remain largely unmet.

The varying public expenditure on building efficiency could be considered a proxy of the intensity of public support for energy efficiency in buildings. Conversely, the number of schemes is not a clear proxy of the intensity of public support for the decarbonization of buildings, but rather a proxy of the strategy used: umbrella schemes covering all types of actions or aiming at overall energy performance, leading to a smaller number of schemes, or multiple specific schemes, differentiated in terms of interventions, e.g. building envelope, HVAC systems, segments of the building stock, e.g. individual houses, multi-family buildings, non-residential buildings, or beneficiaries, e.g., private citizens, businesses or public administrations.

Besides the assessed indicators, other factors, harder to quantify could influence the discrepancy across countries concerning both the size of public expenditure and the number of schemes aimed at decarbonizing the building stock. Potentially, drivers of greater public support could include the perceived importance and urgency of advancing the energy transition, the need to tackle energy poverty, political commitment, and initiatives such as electrifying and decarbonizing the heat supply through renovations, which can support the economy and employment level, especially in the construction sector, as seen with the Italian Superbonus.

Countries with well-developed private finance sectors may exhibit higher levels of market maturity, and private investors are more prone to see renewables and efficiency projects as profitable investments, experiencing lower transaction costs also for smaller projects. Differences in interest rates across countries further shape the landscape, with grants and loans reducing initial investments but failing to address interest rate differentials. Guarantees could potentially mitigate this issue by discounting rates or reducing the need for collateral.

Despite such a blossoming of public and private financing schemes, the renovation gap remains still too wide. This study points in the direction of two main theses. First, incentives alone without a legal obligation to renovate buildings are still not enough to close the renovation gap and bring the trajectory back on track, as the need to renovate is not felt in all its importance and urgency, and investing in building efficiency is still perceived as less profitable and riskier than it is, making it less appealing compared to other investments. Second, existing schemes need much more clarity and visibility to effectively reach building owners and investors, as sometimes there are too many schemes changing too rapidly.

Looking ahead, identifying, and addressing these challenges will be crucial in improving financing incentives to advance building decarbonization.

Conclusion

Despite the existence of numerous schemes, concerted efforts from European and national policymakers are imperative to accelerate the transition of buildings towards decarbonization. This necessitates the implementation of enabling policy and financing frameworks, encompassing legislative mandates, incentives for building renovation, promotion of renewable energy technologies, support for vulnerable households, and the phasing out of fossil heating. Additionally, investment in technical assistance, capacity building, and workforce training programs is essential to facilitate the effective deployment of decarbonization initiatives.

A systematic mapping of financing schemes for building decarbonization proved considerably resource-intensive, despite its inherently transient nature. Hence it is clear that there is room for improvement in the findability of information on available funding schemes for building decarbonization. Centralized access points, such as national portals offering a comprehensive overview of available incentives alongside pertinent details and direct links to application pages could greatly benefit a capillary and effective use of the resources made available in such schemes.

In the effort to lower the information barrier on funding schemes, this mapping has informed the case study reports provided by the Support Facility of Act!onHeat to the applicant public administrations. The Report "Review of financing schemes relevant for sustainable space cooling at EU and national levels" produced in the framework of the CoolLIFE Project was also built largely on this study. Targeted extracts of the mapping dataset will serve as a foundational resource for the financing schemes layers of the Tool and Knowledge Hub developed under the CoolLIFE and SAPHEA projects. Recognizing the challenge of obsolescence, proactive measures have been implemented to mitigate this risk. By curating sources and employing targeted keywords, users can verify the status of listed schemes and identify emerging opportunities, ensuring the mapping remains current and relevant. Integration into these platforms will empower stakeholders to access comprehensive information and leverage it to foster informed decision-making and develop science-based strategies for achieving Europe's net-zero future.

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