Annex 1: Overall project description: Promoting the Energy Efficiency Transition of EU Firms

1. BACKGROUND

1.1 Motivation

Reduction of GHG emissions is a time-sensitive and critical global action to reduce the severity the effects of climate change. Current estimates of the available global carbon budget point to an alarming need for urgent action (Earth Syst. Sci. Data, 2022). The 2018 *IPCC 1.5C Special Report* had estimated a global carbon budget of roughly 580 $GtCO_2$ for a 50 percent probability of limiting warming to 1.5C degrees, and a 420 $GtCO_2$ budget for a 66 percent probability of limiting to 1.5C degrees (IPCC, 2018). The 2022 Global Carbon Budget Report indicates that the remaining carbon budget for a 50 percent likelihood to limit global warming to 1.5C and 2C degrees has reduced to 105 GtC (380 GtCO2) and 335 GtC (1230 GtCO2), respectively, which is equivalent to 9 and 30 years of continued emissions at the 2022 levels.

In the short run, improving energy efficiency is also an urgent and critical priority in Europe after the energy price shock. The rapid energy price increases and supply challenges across Europe, precipitated by Russia's invasion of Ukraine, have led to the worst energy crisis of a generation and put significant strain on European businesses. Despite a recent drop in European gas prices and a subsequent decline in global energy prices, businesses continue to feel significant pressure from the energy crisis combined with supply chain challenges, precipitated by the COVID-19 pandemic, especially in value chains that are heavily reliant on international trade markets and logistics.

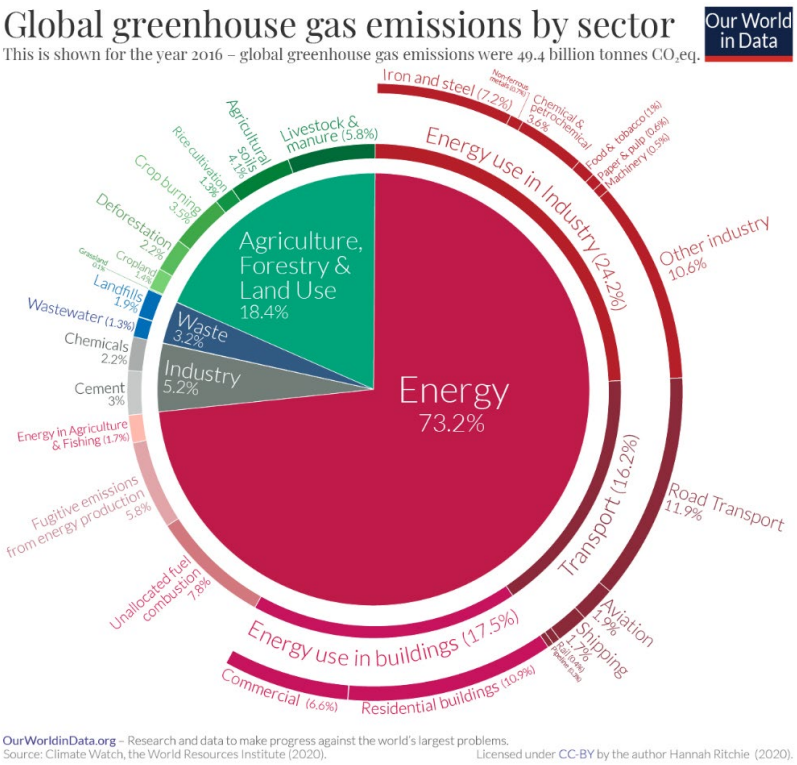
GHG emissions are largely driven by energy consumption, with energy use in three sectors representing 73.2 percent of global carbon emissions: buildings, transportation, and industry (Fig.1). At global level industry alone is responsible for 30 percent of overall GHG emissions, of which 24.2 percent through scope 2 emissions (i.e., energy related). In the European Union, industry is among the top sources of GHG emissions, accounting for almost 34.9 percent in total: scope 1 industrial processes (9.1 percent) and scope 2 energy consumption (25.8 percent) (European Energy Agency, 2022).

On one hand, reductions in GHG emissions have been pursued through lowering the carbon footprint of energy production, i.e., through increasing the share of renewables in the energy supply. The economic effects of the COVID-19 pandemic and the invasion of Ukraine led to significant volatility in the global price and supply of energy, which had led to short term increase in the demand for fossil fuels, including coal (International Energy Agency, 2022). 2021 was the first year in the last decade for which new renewable energy installations have dropped year-on-year[1]. After remaining flat for several years, global clean energy investment finally ramped up and reached $1.4 trillion in 2022, accounting for almost three quarters of the growth in overall energy investment and a 12 percent annual increase (IEA, 2022).

On the other hand, GHG emission reductions by lowering demand - i.e., through increases in the efficiency of energy consumption – are also a top public policy priority in the overall energy transition strategy of most economies. Energy efficiency investment has seen impressive growth, rising by 21 percent in 2021, which is the largest increase since such flows have been tracked by the IEA. This increased investment is mainly driven by higher prices for oil and gas and is expected to continue in 2022-2023. One major component of this rise is increased interest in more efficient heating and cooling technology.

[1] Measured in Giga Watts; International Energy Agency, October 2022

Figure 1: Global greenhouse gas emissions by sector



Improving energy efficiency in the three above mentioned sectors would have significant impact on global GHG emissions, but the focus of policymakers so far has overwhelming been on buildings and transportation and less so on industry. In 2021, for example, the building efficiency investment increased by 16 percent, by far the largest annual increase since such flows have been tracked (IEA, 2022), with increased emphasis in many countries on high energy performance standards in new construction and new technologies, such as electric heat pumps. In contrast, there has been less attention, and consequently, less research, data, and impact analysis on the best ways to accelerate the energy transition and increase investments in efficiency improvements by private firms in the industrial sector. **CO2 emissions from industry need to be reduced by 65 to 90 percent from 1990 levels by 2050 to limit global warming to 1.5C, suggesting the need for a rapid acceleration of energy efficiency** (IPCC, 2018). Unlike the energy sector, however, industry is less comprehensively covered by structural policies to cut GHG emissions –and the recent Green Deal Industrial plan is key opportunity to increase the level of granularity of targets for non-energy industrial enterprises and facilitate implementation.

This project focuses on deepening the understanding of firm-level drivers of energy consumption and emissions in the private sector, with a specific focus on energy efficiency, to identify policy opportunities and funding possibilities that align firm competitiveness with the climate agenda and to evaluate the potential contribution of EU Cohesion funds, through grants and financial instruments, to firm-level decarbonization. Progress on reducing emissions (while improving firm productivity) is slowed down by gaps in knowledge, awareness, financing opportunities and other informational asymmetries. The project would generate evidence to inform programs and regulatory reforms for removing growth constraints for firms that improve their energy efficiency and have lower environmental footprint, as well as design policies for reducing usage of energy and emission footprint of the private sector. The scale and pace of transition could be hindered by an unintended consequences of national and EU regulations that constraint growth of more efficient firms, and ineffective support policies. Delivery of the project would result in development

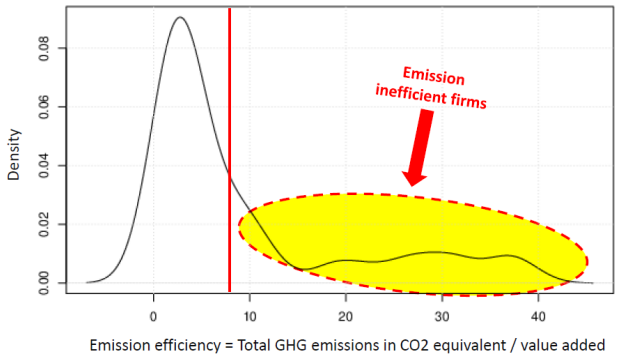
of novel actionable analytical tools, methodologies, and knowledge, which would be widely applicable not only in the EU context. *Given Europe's global leadership role in the energy efficiency and climate agenda more broadly, this effort will* also contribute to informing strategies and practices in this policy area across global regions, specifically in middle-income countries.

An integrated approach is crucial for ensuring an efficient and inclusive green transition. Therefore, while this project aims to identify the key needs and challenges faced by European firms to accelerate their green transition, it will also provide recommendations on how MSs and the EC can help ensure that the ecosystem is optimal to support them through it. This includes capturing market gaps not only from the demand side, but from the supply side as well, including capacity failures at different levels of stakeholders (e.g. implementing agencies and financial intermediaries).

1.2 Opportunities in improving firm-level energy efficiency

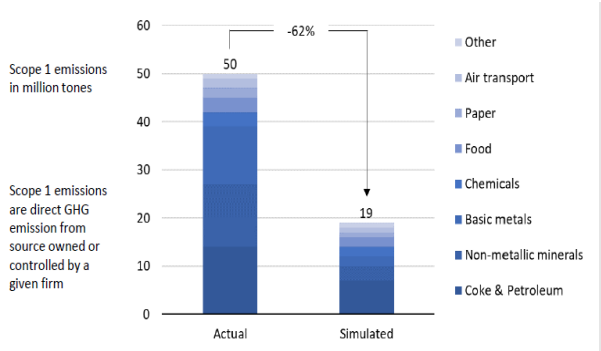
Improving industrial energy efficiency can play a pivotal role in reducing overall GHG emissions, while also improving firms' bottom line, competitiveness, and resilience to future energy supply and price shocks. Even minor adjustments to industrial processes can yield large gains – for example, the total energy intensity of the industrial sector can be reduced by 25 percent through modernizing technology, particularly in developing countries (Liu & Tromop, 2016). Firms are very heterogeneous in their levels of energy efficiency (Fig. 2). World Bank analysis of efficiency data of Polish firms[2] found that overall emissions can be more than halved by improving the efficiency of all firms below the median to the level of median firm (in each respective sector) (Fig.3). Simulating the consequences of improving firm-level efficiency within each sector to the level of the median firm would reduce total firms' emissions levels in 2020 by 62 percent (World Bank Group, 2022).

Figure 2: Poland's density vs. emission efficiency calculations, 2022



Source: Authors from (World Bank Group, 2022)
Notes: Non-metallic minerals covered by EU-ETS in Poland

Figure 3: Simulated impact of improving emissions efficiency to sector median, million tons, 2020



Source: World Bank analysis based on emissions data from the European Union Transaction Log (EUTL) and financial information from the ORBIS database (World Bank Poland Country Economic Memorandum)

Reduced energy demand is both good public policy and good business. It can improve energy security, reduce infrastructure bottlenecks, and reduce the severity of the environmental impacts of industrial energy production and use. Improvements in industrial energy efficiency are also good business – they could lead to lower costs and higher profits with positive implications for growth. For individual enterprises,

[2] This analysis only includes the subset of firms required to communicate their emissions under the ETS Scheme.

improving energy efficiency strengthens the bottom line, often reducing direct energy costs by 10 to 30 percent.[3]

Box: Using Energy consumption vs emissions

A potential concern with the proposed analysis is that energy intensity (efficiency) is not accurately captured through the energy-to-revenue ratio (revenue-to-energy ratio) in the case that energy tariffs (price per unit of energy Kilowatt hour -KWh-) differs across firms or varies substantially over time. For instance, energy regulators may set non-residential energy prices according to businesses' characteristics such as the consumption or voltage level, location or sector of activity. In such cases differences in energy efficiency would be driven by price discrimination or tariff adjustment factors, rather than by the actual output produced per unit of energy unit.

To address these concerns, we will try to obtain firm-level prices and perform robustness checks using energy consumed quantities instead of value costs. Firm-specific prices are often available. This is equivalent to one-quarter of businesses that report positive electricity and gas costs. For the remaining 75% of firms that report electricity and gas consumption but do not report quantities consumed, we use the average price at the sector-size-year level to estimate electricity and gas quantity consumption. Next, we estimate fossil fuels quantity consumption by dividing consumption value by the average price of gasoline, diesel and kerosene fuels at the year level and oil quantity consumption by dividing oil value consumption by the average price of oil. Since the unit of measurement of energy consumption varies with the energy source, we convert them into Terajoules (TJ) using net calorific value factors. Conclusions hold after using energy quantity consumption instead of value consumption.

Energy quantity consumption estimates provide a unique opportunity to understand which are that channels through which energy consumption translates into carbon (CO_2) emissions. In the light of climate change, measuring the environmental footprint of economic activity is vital to assess whether policy actions are effective in transitioning towards a greener economy. The correlation between energy consumption efficiency and CO_2 emissions efficiency, although it is expected to be high, does not necessarily need to be 1 because there are different factors with varying potential that affect how energy quantity consumption results into emissions. Identifying the channels through which energy quantity consumption translates into carbon emissions is particularly important since the potential for climate mitigation can vary considerably.

The first channel is related to industry composition shifts. Changes in the sectoral composition towards less emission-intensive activities have the potential to reduce the aggregate carbon intensity of the economy. However, while this could be regarded as a cleanup, from the environmental perspective benefits may be quite limited (Levinson, 2015). For example, if these sectoral changes are driven by outsourcing goods and services whose production involves higher CO_2 emissions per unit of output, this will reduce emissions within country but will not help mitigate total emissions.

Second, switching energy sources has the potential to change the aggregate level of emissions intensity, but this potential can be exhausted in the short- or mid-term (Rottner & von Graevenitz, 2021). For instance, changing from fuel to electricity consumption could lead to a substantial reduction of emissions per unit of output due to differences in CO_2 energy content of each source. Many countries, especially high-income ones, have already made substantial progress moving from fossil fuel to renewable energy sources, while in less advanced ones it is still an open margin for advance in this direction.

Lastly, technology adoption could reduce the level of emission intensity beyond changing energy sources. The third channel to reduce the level of emissions and pollution needed to generate one unit of output involves changing the production technique by using machinery and equipment that emits less carbon while also using energy more efficiently. Technology-led changes are expected to yield higher benefits and to offer the largest potential for global pollution reduction (Rottner & von Graevenitz, 2021; Levinson, 2015).

The estimated firm-level elasticity between energy and CO2 emission efficiency ranges between 1.05-1.06 when energy quantity is used, and between 0.92 and 0.94 if expenses are used instead. Regarding how firm-level factors can change emission intensity, we assess the relationship between energy and carbon emission efficiency,

[3] http://www.iipnetwork.org/IEE

calculated as the logarithm of the sales-to-energy and sales-to-emission ratio respectively, by regressing CO_2 emission efficiency on energy efficiency and controlling for industry, geographic and firm FE. Regression results show that a 1 percent increase in energy (expenses) efficiency is associated with a 0.92-0.94 rise in carbon emission efficiency on average. This implies some imperfect pass-through of energy efficiency on carbon emission changes. However, once changes in energy prices are cleaned up, a 1 percent rise in energy (quantity) efficiency is associated with a 1.05-1.06 increase in carbon emission efficiency, which would suggest a larger than 1 pass-through. This result is consistent with firms not investing in greener, less pollutant technology and processes, and switching towards more pollutant energy fuels. Moreover, energy carbon content factors can change over time, which also affects the pollution content of energy use.

Public interventions play a pivotal role in providing incentives for the private sector because market failures or barriers often prevent firms from making financially viable investments in energy efficiency. Insufficient information on existing inefficiencies, lack of knowledge on the energy performance of different technologies or processes, and unknown returns on investment can prevent firms from investing in energy efficiency. Suboptimal financing conditions can present a further barrier if financial institutions miscalculate the investment risk and return due to unfamiliarity with energy efficiency measures or technologies. As the adoption of green technologies might not singlehandedly improve productivity, firms do not systematically prioritize such investments, so governments could introduce carefully calibrated interventions that aim to address behavioral barriers and improve managerial capabilities to align the social objectives of green transition with firms profit priorities. There is evidence that firms that receive public support through programs promoting innovation (whether green or horizontal) are more likely to register green patents (World Bank Group, 2022) suggesting that public investment can play a key role in supporting innovation, technology diffusion, and energy efficiency at the firm level.

Despite sizable public investment aimed at improving energy efficiency in the private sector, firm-level granular analysis on drivers of emissions and adoption of energy efficiency technology and processes remains scarce in most sectors. The EC has funded a variety of programs (see more details in section 1.4) aimed at reducing GHG emissions by improving energy efficiency. While these efforts are critical, robust evidence on the mechanisms of driving energy efficiency at the firm level are limited in detail, including knowledge of the most binding constraints to energy transition at the firm, market, or sector level.

There is also a dearth of rigorous impact evaluations to help identify which programs or policy can successfully incentivize green transition at scale. Such knowledge is necessary for understanding the impact of business regulations, industrial policies, and increasing returns from multi-billion investments in reducing emissions of the private sector, and in energy and infrastructure assets (Song B. and Choi D., 2018). Moreover, there is scarce evidence on heterogeneity of impact of changes in energy prices on firm performance, which would be crucial for policies minimizing impact of energy crisis on industrial competitiveness in the short term and navigating transition away from fossil fuels in medium time horizon (IMF WP/22/152).

1.3 Leveraging Europe's data-rich environment for actionable and evidence-based diagnostics and policy assessment

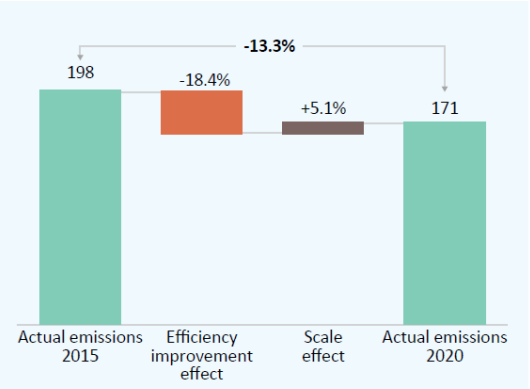
Understanding the drivers of firm-level emissions, based on firm-level data analysis, is the first step for policymakers to identify priority interventions aimed at improving the energy efficiency of firms. Overall emissions (economy-wide) due to private sector activities can be decomposed into:

i. scale or the changes in emissions due to overall growth in outputs;
ii. structural transformation or changes in emissions due to the expansion or contraction of sectors with different levels of efficiency;

iii. *within firm* efficiency or the changes in emissions due to evolution of average level of efficiency at firm-level within sectors; and
iv. *between-firm* changes in emissions due to reallocation between firms (including entry or exit) with different efficiency levels within sectors.

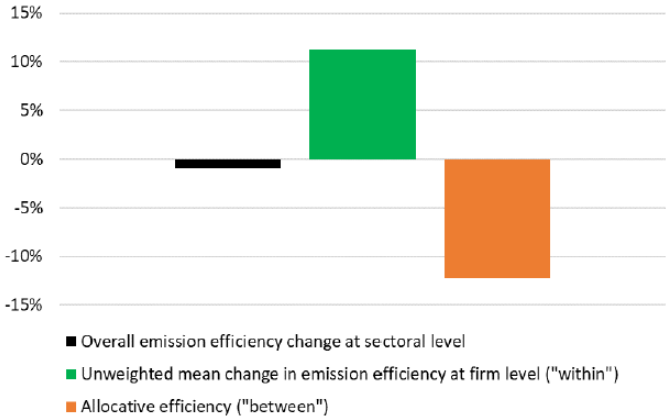
Granular firm-level data can identify whether the changes in emissions are driven from within firms (efficiency) or between firms (misallocation and market functioning) and at what magnitude. For example, firm-level analysis from Poland shows that during 2015-2020 period overall emissions were reduced because efficiency improvements compensated for the negative contribution of the scale effect (Fig. 4). At the same time, while average firm efficiency improved, misallocation neutralized these gains with less efficient firms expanding their market shares (Fig. 5). Similar decomposition analysis of Finnish manufacturing firms in 2000-2019 found that continuing firms were the main driver of carbon productivity, while the contribution of exiting and entering firms was negative (Kuosmanen & Maczulskij, 2023). Challenges in improving the 'Within' component stem from low adoption and usage of modern, mostly digital, technologies, and gaps in firm capabilities, most notably managerial practices – including green business practices (Cusolito, 2017). Evidence points to good managerial practices and behavioral factors (Gosnell et al, 2020) as critical and strongly and significantly correlated with lower energy intensity (Bloom N., 2010) (Fig. 6). Barriers for improvement of the 'Between' component are related to anti-competitive regulations, market design or fiscal instrument which decreases efficiency of resource allocation in the economy (World Bank, 2022a). Examples of such barriers include unequal access to finance for SMEs and large firms, barriers to firm entry and exit, or regulatory uncertainty, and their impact may extend beyond industry and affect companies in all sectors of the economy. As a result, firms that improve their internal productivity or energy efficiency have difficulties in increasing their market share over incumbents with more modest improvements.

Figure 4: Change in emissions due to efficiency improvements and scale, million tones, 2015-2020, Poland



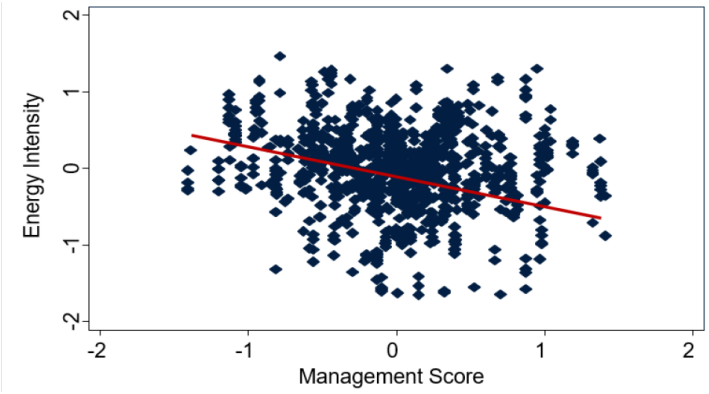
Source: World Bank analysis based on emissions data from the European Union Transaction Log (EUTL) and financial information from the ORBIS database.

Figure 5: Change in emissions efficiency in manufacturing in Poland in 2015-2016 vs. 2019-2020



Note: 165 manufacturing firms in the sample
Source: Poland Green Growth Country Economic Memorandum (CEM)

Figure 6: Correlation of management score and energy efficiency



Source: Bloom, N. 2010

Granular decomposition of the sources of emissions (e.g., within-firm efficiency and between-firm market reallocation) is critical in informing the design of regulations, policies, or public investments that can address distortions, as well as market and capacity failures and maximize energy efficiency gains. Policies that can remove distortions and support better allocation of resources toward more efficient firms include, for example, regulations, removal of investment barriers, or effective labor market interventions that would enhance labor mobility and support re-training of workers. Improving the functioning of markets in this manner not only fosters energy efficiency but also promotes productivity and growth (Marć Ł., 2021). Public policies that could improve within-firm energy efficiency include targeted policies for the acceleration of reduction of emission in high-emitting sectors (e.g., voluntary or mandatory energy savings agreements, incentive grants for verified energy savings), information and energy audits to benchmark energy efficiency levels across firms, promotion of best practices, promotion of the adoption and use of efficient technologies to support firms in catching up with moderate levels of efficiency (e.g., tax incentives for the installation of efficient equipment), and improvements in the quality and use of firm-level data on fuel and energy consumption. At the macro level, energy prices (such as removal of energy subsidies), access to finance (such as green lines of credit), and green regulations (such as green certificates and seals, minimum energy performance standards of energy-consuming equipment, external audits, stricter environmental policy frameworks), can also be key policy levers to increase the flow of green investments and encourage reduction in energy use and greenhouse gas emissions.

1.4 Current EU policy and investment response: sequencing actions to achieve long-term goals

The EU has launched a range of both shorter and longer-term policy mechanisms, aimed at responding to the energy crisis and creating a better framework to mobilize more resources toward climate action. The 'Fit for 55' package centers on reducing greenhouse emissions by 55 percent by 2030 and uses a variety of policy mechanisms to do so, including emissions trading systems, aviation offsets, and targets for the deployment of green infrastructure, such as charging networks. The REPowerEU initiative leverages additional funding and promotes a rapid roll out of solar and wind energy projects, combined with renewable hydrogen deployment to save around 50 bcm of gas imports and bridge the supply gap in the short-term. REPowerEU also targets the short- and long-term deployment of energy technology, efficiency improvements (by increasing the binding Energy Efficiency Target under 'Fit for 55' from 9 to 13 percent),

and a transition to a more diverse energy economy. And Resilience and Recovery Facilities (RRFs) have the power to move with agility to deploy catalytic resources (such as reforms and investments) to accelerate recovery from the global energy crisis. In addition, EU Cohesion Policy funding targets green investments, including a substantial earmark of 30 percent through the European Regional Development Fund, which aims to reduce disparities in levels of development between European regions, as well as a 37 percent financial allocation for climate objectives in the Cohesion Fund, which promotes sustainable development in Member States with gross national income per capita less than 90 percent of the EU average.

There is sizable scope within these existing programs to increase the granularity of data, knowledge, and guidance regarding energy efficiency within industry. Initiatives, such as REPowerEU and Fit for 55, contain much more detailed guidance and activities for clean energy production, as well as energy efficiency in buildings and transport, compared to energy savings in industry. The rigorous identification of barriers to energy efficiency and transition among firms in the industrial sector would require granular data analysis at firm level. The effectiveness of public policy initiatives could be greatly enhanced by firm-level data as well as robust impact evaluations of current programs.

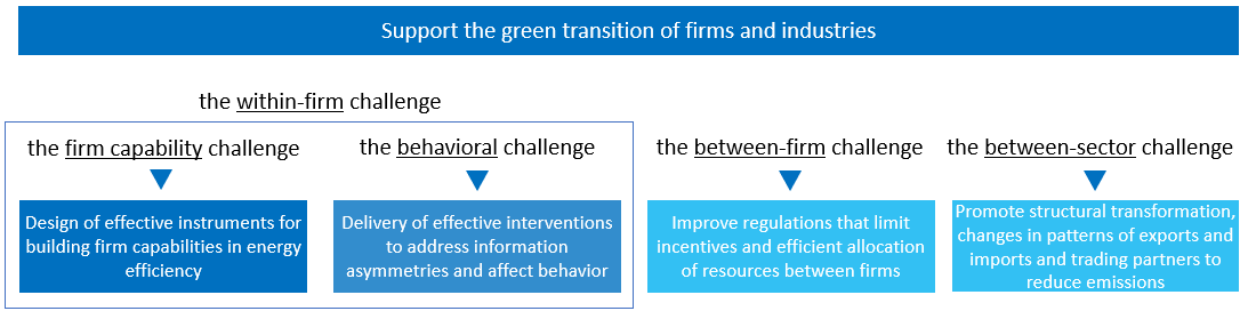
2. Project Objective

The objective is to develop an evidence-based toolbox that enables EU Member States to better target reforms and investments, at national and subnational levels, to improve the energy efficiency of firms. Granular firm-level analysis is critical in identifying the key challenges and behavioral gaps limiting the green transition within firms, between firms, and between sectors. The project will enhance the understanding of the effectiveness of different policy interventions, which is a vital input in the design of an effective public policy mix (including legislation, regulations, and financing programs) that can be successful in promoting the energy efficiency of firms. The proposed activities will focus on a sample of two Member States (at national and subnational levels), selected competitively from a long list provided by the EC (see section 3), but will also extract and include lessons learned from previous WB analyses on a subset of firms in Poland[4]. The two pilots will produce outputs specific to the countries, including best practices and lessons learned, but the tools, surveys, approaches, and methodologies that will be developed through the pilots will be fully replicable so that other governments can reproduce the analysis with own data in any country or subnational region. Overall, the aim is to address the following key questions:

- What are the drivers of firm-level energy consumption at sectoral and subnational level?
- Which constraints to a green transition are most binding for firms?
- Which sectors and types of firms should be priority targets to reduce emissions and save energy?
- What are the barriers (supply and demand side) that distort market functioning negatively affecting reduction of emissions and energy consumptions?
- What are the institutional gaps in mechanisms of supporting green transition of firms?
- What programs have more potential to support the energy transition without hampering firm-level competitiveness?
- What are market and capacity (private and institutional) failures and gaps for smooth providing the required support for green transition of firms?

The objectives are divided by the type of changes promoted, as indicated below:

Figure 7: Project objectives



[4] This work was part of the World Bank Country Economic Memorandum on Poland, in 2022. If the analysis on energy efficiency of firms in Poland is broadened to a more closely comparable scope to the one foreseen in this exercise (through a separate assignment specific to Poland), the conclusions will also be reflected in the reports of this activity, for comprehensiveness.

3. Proposed Activities

The project is composed of a series of activities that combine i) granular and actionable diagnostics, and ii) regulatory, institutional, and functional reviews of the business environment and support programs (particularly those under the EU Cohesion funds). The framework is grounded in detailed firm-level evidence and presents a modular approach that can be customized to specific circumstances, giving policymakers flexibility. Pillars 1 and 2 can inform the design of critical policies and EU funding programs. Subject to availability of additional budgets in subsequent years, they could also inform the selection of potential pilots that could be rolled out and evaluated under a potential future third pillar. The latter will be meant to evaluate the impact of policy initiatives that complement and have the potential to increase ROI of financial instruments already rolled out with financing from Cohesion Funds', thereby improving future policy design (in particular instruments implemented under the EU Cohesion funds).

The expected results of the proposed activities include:

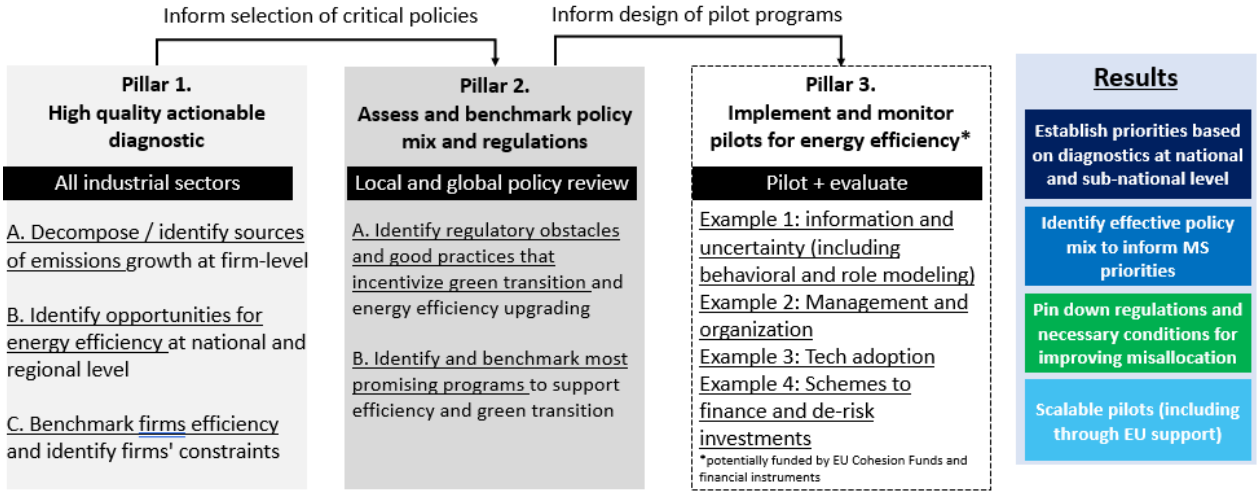
- Identifying key drivers of firm-level emissions at sectoral and subnational level in a sample of EU economies, while extracting lessons that could be applicable to other MSs.
- Identifying critical constraints for energy transition of firms at sectoral and subnational level in that sample; while extracting lessons that could be generalized to EU-27. This includes market failures, regulatory constraints, gaps in programming, and capacities across the ecosystem (including firms, managing authorities and financial intermediaries).
- Identifying priorities sectors and groups of firms to target to maximize impact of investments to support efficiency in the sample of EU-27 Member States.
- Identifying effective interventions and policy mixes to inform MSs and EC priorities more broadly, based on diagnostics and global benchmarking.
- Defining recommendations that can improve regulations and business conditions in the EU-27 (learning from the exercise) to reduce misallocation and increase energy-efficiency among firms.
- Identifying the potential contribution of EU Cohesion policy to address the challenges and in what form (incl. financial instruments or its' combinations with grants).

The project will involve both usage of firm-level data, case studies and novel qualitative and quantitative data collection mechanisms on adoption of technologies and managerial practices relevant for energy efficiency and green growth. Firm-level data collected through Structural Business Survey (SBS) will provide granular information on key variables such as energy consumption (in value and quantity), value added, employees, assets, and other characteristics such as exporter status, reliance on imported inputs, ownership or investments in R&D. These firm-level data could be merged with data on emissions collected by specific agencies or, using appropriate conversion factors, be used to estimate firm-level of emissions.

Structure case studies will collect information about specific obstacles for firms upgrading and improving energy efficiency, as well as regulatory barriers and obstacles. These case studies will rely on interviews and focus groups with entrepreneurs as well as experts.

Finally, a survey to generate quantitative evidence and expand the qualitative evidence of case study will allow the team to obtain information on green tech adoption and adoption of green managerial practices.

Figure 8: Proposed project design



Pillar 1. High quality actionable diagnostic at national and subnational level

Description: Pillar 1 develops and implements a methodology and actionable toolkit for diagnostics on the energy-efficiency of the private sector based on firm-level data, including quantitative and qualitative surveys, and creating statistical packages that will allow the replication of this methodology across EU Member States.

Scope: All economic sectors (industry and services).[5]

Main objective: To inform of critical constraints and policy areas, identify market and capacity failures.

OUTPUT 1.A. DECOMPOSE AND IDENTIFY SOURCES OF EMISSIONS GROWTH AT FIRM-LEVEL

In selected countries/regions (see box 1), the team will perform a process in partnership with relevant national statistical offices of obtaining the relevant data for analysis. Using the firm-level data at national and sub-national level, decomposing overall change in energy consumption by sector and firm size (of the countries and/or regions participating in the project), and due attention to disparities within leading and catching-up regions within participating MSs. Careful sampling will be conducted to minimize distortions in the analysis based on inherent differences in firm energy use due to sector, size, ownership, local energy prices or policies, etc. Decomposition could be performed only in data-rich environments, as it requires firm-level panel data with consistent information on performance, energy, or emissions over 7+ years. Main variables used for conducting decomposition analysis are presented in Table 1. The decomposition methodology is adaptable to variables available in a given country/region, and information from various data sources could be merged to inform the analysis. Where available, energy audit reports will be consulted to improve and cross-check sector and country level data. Since the quantitative analysis will be complemented with audits and qualitative analysis (including through case studies), the team will try to also incorporate "light audits" (not an investment grade audit).

[5] Depending on the scope of sectors covered by available Structural Business Statistics collected by Member State.

Table 1. Key data for decomposition analysis

Type of data	Variables	Data sources
Energy	Energy consumption disaggregated by: • Source of energy (purchased externally, generated internally); • Type of fuel (e.g., coal, gas, solar, wind) • Natural units (e.g., MWh, GJ, tones, cubic meters);	Statistical Offices, environmental protection agencies
	Energy cost disaggregated by: • Source of energy; • Type of fuel;	
	Energy / fuel subsidies: • Type of subsidy (e.g., direct transfer, fuel subsidy,) • Value of subsidy • Action mechanism (structural vs conjunctural subsidies)	Competition and Consumer Protection Offices
Emission	Emission and energy certificate trading, including: • EU-ETS system • Guarantees of Origin (GOs) • Voluntary offsets;	Public / private operators of exchange platforms
	Financial performance: • Revenue • Value added • Employment	Statistical Offices, commercial databases
Competitiveness	Innovation outlays: • R&D expenditure • Investments	Statistical Offices, commercial databases (e.g., ORBIS / EMIS)
	Participation in international markets: • Foreign ownership • Exporting activity	
Territorial disparities	Variation in firm-level energy efficiency across regions within MS: • Performance variation within sectors by region (leading vs lagging) • Variation in predominant sectors between regions	Statistical Offices, commercial databases

Decomposition would include changes in energy efficiency, energy consumption and emissions of all firms, with particular emphasis on the variations between subnational regions. It would broaden the analysis already performed in Georgia and Poland, which evidenced discrepancy of efficiency among firms within sectors and indicated existence of barriers in allocative efficiency in manufacturing sectors.

The analysis will focus on the following drivers:

a. *Scale growth*: Changes in emissions and energy consumption through expansion of output and scale of production.
b. *Within-firms energy efficiency gains*: Changes in emissions and energy consumption driven by firms becoming more efficient.
c. *Market reallocation* (between firms within sectors): Changes in emissions and energy consumption depending in which firms expand/contract their market share, and depending on entry and exit of firms.
d. *Structural changes* (between sectors): Changes in emissions and energy consumption due to patterns of sectoral specialization as the economy specializes more in activities that are less (more) energy and emissions intensive.

The decomposition will involve close collaboration with entities collecting firm-level data on energy and emission, including national and/or regional statistical offices, and environmental agencies. Results of the decomposition would form the basis for identification of opportunities for improvement of energy efficiency under Output 1.B. This analysis will also be useful to inform and contract with similar efforts conducted globally in less data-rich environments.

Deliverables 1.A:

- Report on sources of emission per country (at, both, national and subnational level)..[6]

OUTPUT 1.B. IDENTIFY OPPORTUNITIES FOR ENERGY EFFICIENCY AT NATIONAL / SUBNATIONAL LEVEL

Granular firm-level data can enable analysis to help identify the largest opportunities for improving energy efficiency. Such data will be used to implement a simulation analysis and assess what would happen if inefficient firms were to become as efficient as the median firm in their own sector (as well as limit the comparator median to firms in their own sector and location, and also of a similar size). A simulation will also be conducted comparing inefficient firms with the top 25 percent of firms within the sector, location, and size.

These simulations with firm-level data provide information about potential gains from improving firm-level energy efficiency at the aggregate level as shown in Figure 9 (based on the example of the recent analysis performed for Georgia). A first result of these simulations in Georgia is that a "moderate" improvement in levels of energy efficiency can generate significant improvements in terms of overall energy savings, even when the typical cost-reduction at firm-level remains small. These simulations can be then used for the identification of sectors where improving energy efficiency could lead to bigger gains (Fig. 10 for an example from Georgia's analysis), which is in turn the primarily deliverable of this output. A similar analysis will also be performed at subnational level by the shortlisted country, to identify regions-sectors with large opportunities for improving efficiency, identifying differentiated implications by region.

Figure 9: Simulation of consumption, costs, and VA (Georgia)

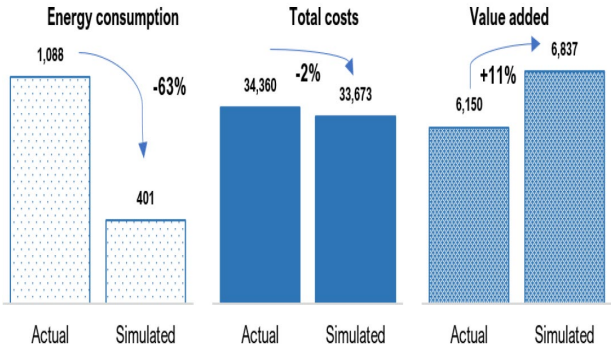
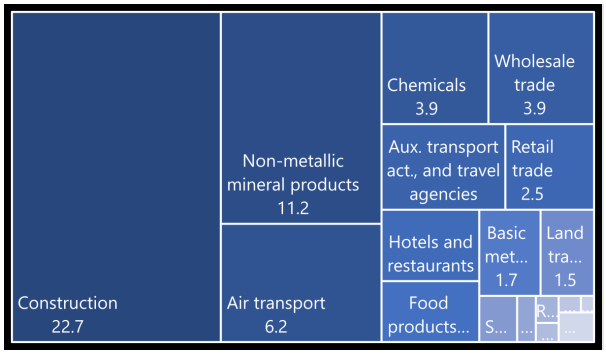


Figure 10: Simulation of relative sectoral impact (Georgia)



Source: Authors from World Bank Group, 2022

Deliverables 1.B:

- Report on energy efficiency opportunities per country (at national and/or subnational level).
- Methodological note for the decomposition and how to implement it so it can be replicated.

[6] A decision about the level of geographic analysis should be done with specific Member State.

OUTPUT 1.C. BENCHMARK FIRMS' EFFICIENCY AND IDENTIFY FIRMS' CONSTRAINTS

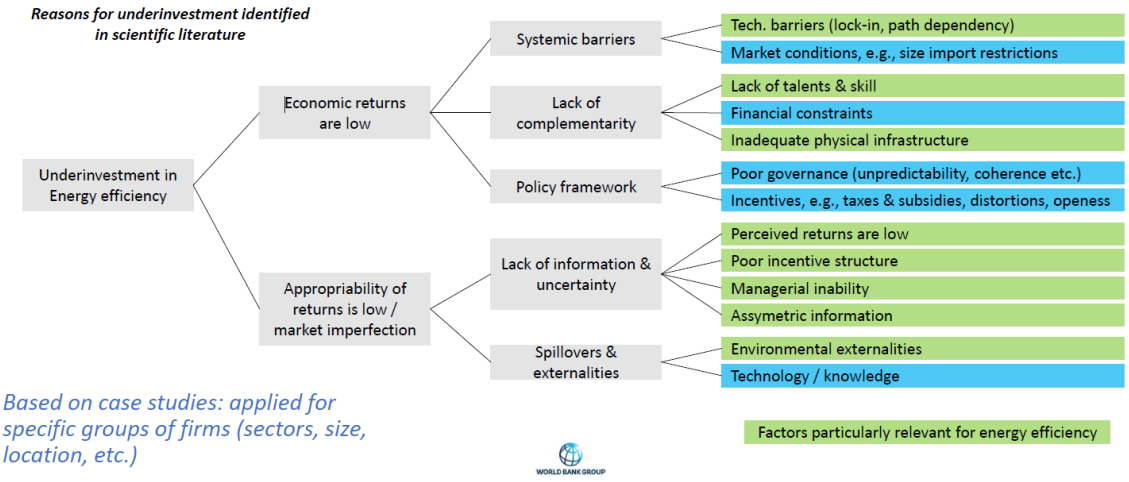
Based on the conclusions of Outputs 1.a and 1.b, this activity will identify the binding constraints in firms' energy efficiency in a short list of 2-4 priority sectors, which will lead to the identification of policy areas where the most impact can be achieved. Leveraging also the broader work conducted by the World Bank globally on bottlenecks to improving firm-level energy efficiency, the team will follow a systematical approach towards this identification process, following scientific literature and previous case studies. The preliminary framework presented below (Fig. 11) will be adapted based on Output 1.a and Output 1.b. and structure the diagnostic in a way that challenges industry assumptions and leads to the identification of specific and relevant constraints where intervention is most impactful.

The diagnostic will be specific for groups of firms in each specific sector and size group identified as priority through Output 1B. For each sector and group of firms, the diagnostic will rely on two approaches, qualitative and quantitative. The qualitative approach will collect in-depth information from a limited number of firms (approximately 5-10 per sector) through in-depth interviews and case studies, while the quantitative approach will use a survey to collect broader data and information from a larger number of firms (approximately 35-40 per sector). The survey will use a revised version of the World Bank technology adoption survey questionnaire with a focus on green technologies (sample size is estimated to 150-250 firms per MS). The results of both types of analysis will be described in detail in a final report outlining the most binding constraints and promising areas of interventions for identified sectors and country/region.

Deliverables 1.C:

- Report on most binding firm-level constraints and most impactful areas of intervention per sector and country (or subnational region) based on quantitative and qualitative analysis.

Figure 11. WBG proposed systematic approach for identification of main energy efficiency constraints



Pillar 2. Assessment and benchmark of most relevant regulations, policies, and programs

Description: A local and global review of policy mixes and initiatives that either generate or respond to identified constraints.

Scope: Local and global policy review.

Main objective:

- To inform on policy reforms and toolboxes available to selected Member States (MSs), in function of previously identified constraints.
- To inform the design of pilot programs that can be implemented in the subsequent phase, including the design of instruments under the EU Cohesion funds'.

OUTPUT 2.A. IDENTIFY REGULATORY AND CAPACITY-RELATED OBSTACLES AND GOOD PRACTICES THAT INCENTIVIZE GREEN TRANSITION AND ENERGY EFFICIENCY UPGRADING

A novel policy business environment review methodology will be designed and developed through this activity, drawing on the global experience of the World Bank in this area, to inform the reviews of regulations and governance, and to identify causes of low efficiency of resource allocation between firms at various levels of energy and/or emission efficiency. Informed by collaboration with global technical experts, both from within and outside WBG, the methodology will cover areas related to access to finance by SMEs, fiscal incentives, barriers to firm entry and exit, regulatory uncertainty and issues related to competition distortions generated by different factors (e.g. monopolistic behaviors, SOEs, etc.).

The design of the survey will partially build on relevant experiences in the World Bank's global portfolio on technology adoption and investment climate, but will also be supplemented by extensive review by legal, regulatory, and industry experts, and in-depth consultations with the European business sectors through private sector associations and other relevant stakeholders. Specifically, it will pilot a toolkit for identifying barriers to green investment in the economy through expert surveys as well as firm-level surveys. Once developed (with its design and dofile documented through the outputs of this Pillar), the Review could be more easily replicated or scaled in other MSs. For example, this output will design and implement an expert opinion survey instrument that will collect information on the most critical regulatory obstacles to green transition and good practices that could incentivize improvements in energy efficiency in selected MS. The findings will be described in detail in a final report.

Deliverables 2.A:

- Design of a national/subnational survey instrument (template to be rolled out in all EU countries)
- Report on the most binding constraints (Both regulatory and institutional capacity) for energy transition per country (or subnational region), based on rollout of the survey instrument and complementary diagnostics.
- Recommendations how to improve and to best respond to the identified constraint in activities 1.C and 2.B at firm-level and in the ecosystem

OUTPUT 2.B. POLICY MAPPING, REVIEW AND BENCHMARK OF PROGRAMS TO SUPPORT EFFICIENCY AND GREEN TRANSITION

This output will include a mapping and assessment (functional review) of existing national (and/or EC funded) programs that aim to incentivize energy efficiency and green transition, to understand alignment between needs of enterprises, and priorities identified in previous sets of output. Characteristics of all the current and planned firm-level instruments in the participating Member States and/or subnational regions will be mapped and analyzed. The review will also include an assessment of the institutional capacity of implementing agencies. In addition, the review will assess the absorptive capacity and overall expected effectiveness of the programs, through semi-structured interviews with program managers on design, implementation, and governance practices. This analysis will expand on the existing methodology of Innovation and Competitiveness Expenditure Review but will not conduct a full Public Expenditure Review

that includes an efficiency and effectiveness analysis and rather focus on an assessment of the use of resources based on a detailed mapping of objectives/instruments/characteristics etc., as well as a functional assessment - i.e., a structured analysis of each program including assessment of quality of design, implementation, and governance. For programs with promising prospects of impact, additional 'beneficiary surveys' will be conducted to complement the functional analysis and identify reforms with potential high impact as well as gaps. Finally, activities will include the organization of online events across practitioners and stakeholders in MSs to exchange on good experiences and practices of energy efficiency interventions (financial and non-financial programs).

The output will produce an analysis and benchmarking of most promising EU and global programs. The objective of this activity is to identify benchmark that would allow improving existing programs (in targeted MSs and related wider EU programs), as well as extension of the scope of current policy mix. Some examples of programs to benchmark are listed in the table below. The global benchmarking analysis will focus on programs that directly impact the internal upgrading decisions of firms and those best fitted to respond to the identified constraints within firms. This benchmarking will provide guidance about how existing national programs can be improved or expanded to cover areas of potential impact. If data and information is available, the team will also review policies that may have had a detrimental effect on energy efficiency, as well as longer term policies. The recommendations will be informed by the conclusions of the various outputs in Pillar 1.

This output will also include an assessment of institutional supply capacities with a focus on 3 key actors: (I) Managing authorities, (II) Key government agencies in charge of program implementation, (III) financial institutions (I.e. banks). This assessment will focus on the existence of institutional capacities and will be based on structured questionnaires. As an example of the type of structured questionnaire to be used for financial institutions see Annex 2.

1. Programs to promote investments: •Credit guarantees for green investments •Sustainable energy financing facilities •Accelerated depreciation for green/efficient machineries •Sustainable energy transition subsidy scheme (SDE++)	2. Programs to spur change in organization and management •Energy Efficiency Campaign Networks •Energy consulting and funding for companies •Mandatory Energy Audits
3. Programs to support skills and workers: •The Swedish National Energy Efficiency Network •European Energy Managers (EUREM)	4. Programs to promote innovation and technology adoption •Renewable Energy Sources Act (Germany) •Subsidies for research and innovation •Energy Efficiency Campaign Networks

Deliverables 2.B:

- Mapping and diagnostic of existing programs focused on energy efficiency in targeted countries (and subnational regions)
- Global review of programs (basis for benchmarking)
- Assessment of institutional and supply capacities of key stakeholders (i.e. managing authorities, key implementing agencies, banks)

Pillar 3. Experiment and evaluate to increase impact of programs implemented by Member States

Description: Technical assistance to member states to design rigorous evaluations of their programs and support with designing and experimenting to integrate into the currently planned programs (e.g. financial support and blended finance) interventions to raise awareness and provide behavioral nudges to increase take up and increase impact of financial support to firms.

Scope: Technical assistance to 2 member states and/or the EC

Main objective:

- To inform policy makers about effectiveness of currently designed interventions
- To increase take up and return on investment of currently planned support through "soft" complementary interventions.

OUTPUT 3.A. DESIGN OF IMPACT EVALUATION OF EXISTING INTERVENTIONS

This output will include the design of an impact evaluation of existing interventions planned under existing national and/or EC funded programs that aim to incentivize energy efficiency and green transition. This output will include the preparation of a concept note and a pre-analysis plan, as well as the development of survey instruments for both baseline and follow up surveys, and in coordination with Member States a plan for data collection to be jointly implemented.

OUTPUT 3.B. IMPLEMENTATION AND EVALUATION OF PILOTS TO COMPLEMENT EXISTING INTERVENTIONS

This output will include the design and impact evaluation of low costs complementary pilot interventions to complement current financials and blended finance programs to promote energy efficiency. These pilots will focus on soft interventions (e.g., information, awareness and behavioral nudges) that could complement current financial support programs (e.g. credit lines or blended finance) in order to increase their take up and improve their return on investment.

OUTPUT 4. FINAL REPORT

Report with policy recommendations to the EC and MSs based on lessons learned from the diagnostic on the 2 shortlisted countries and/or subnational regions and/or EC program; the report will include recommendations on which programs would benefit from a pilot with rigorous impact evaluation.

Annex 1: References

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