Funding concept for a global climate fund or a multilateral development bank

Demand-side flexible energy technology roll-out in Colombia

Technical proposal

24/03/2023

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1 Context of the current state of play

Energy transition and climate change are a priority for Colombian public and private entities. In December 2020, the country presented a revised NDC with the target of limiting greenhouse gas emissions (GHG) to 169.4 MtCO2e by 2030, 51% below the country's reference scenario baseline in that year, aiming to achieve carbon neutrality by mid-century (Gobierno de Colombia, 2020). Colombia's Integral Plan for Climate Change (PIGCC) outlines how NDC targets are to be achieved among sectors and shows four strategic lines of action within the energy sector, with potential to avoid 11.2 MtCO2e cumulatively by 2030. These are: energy efficiency, power generation diversification, active demand management and targeting fugitive emissions (Minenergía, 2021).

Colombia's relatively clean energy mix (predominantly hydro) renders the electrical system vulnerable to climate change. Approximately 65% of the country's electricity consumption derives from hydroelectricity, and the remaining 35% is from fossil fuel-based power plants (Parra, Gómez, Montoya, & Henao, 2020). Diversifying power generation with what in Colombia constitutes Non-Conventional Renewable Energy (NCRE), such as biomass, small hydro, wind, geothermal, solar, and marine power (Minenergía, 2022), is therefore crucial to promote low carbon development. The cost-competitiveness of these sources is, fundamental to ensure affordability and protect the competitiveness of local industries.

Greater penetration of more variable and less predictable electricity generation from NCRE, in addition to growing demand from the electrification of transport with a target of 600,000 electric vehicles by 2030 (Gobierno de Colombia, 2020), will require the power system to become more flexible. The power sector can overcome this challenge by unlocking the potential of demand-side flexibility, which refers to the portion of system demand that can be reduced, increased, or shifted within a given duration (IRENA, 2019).

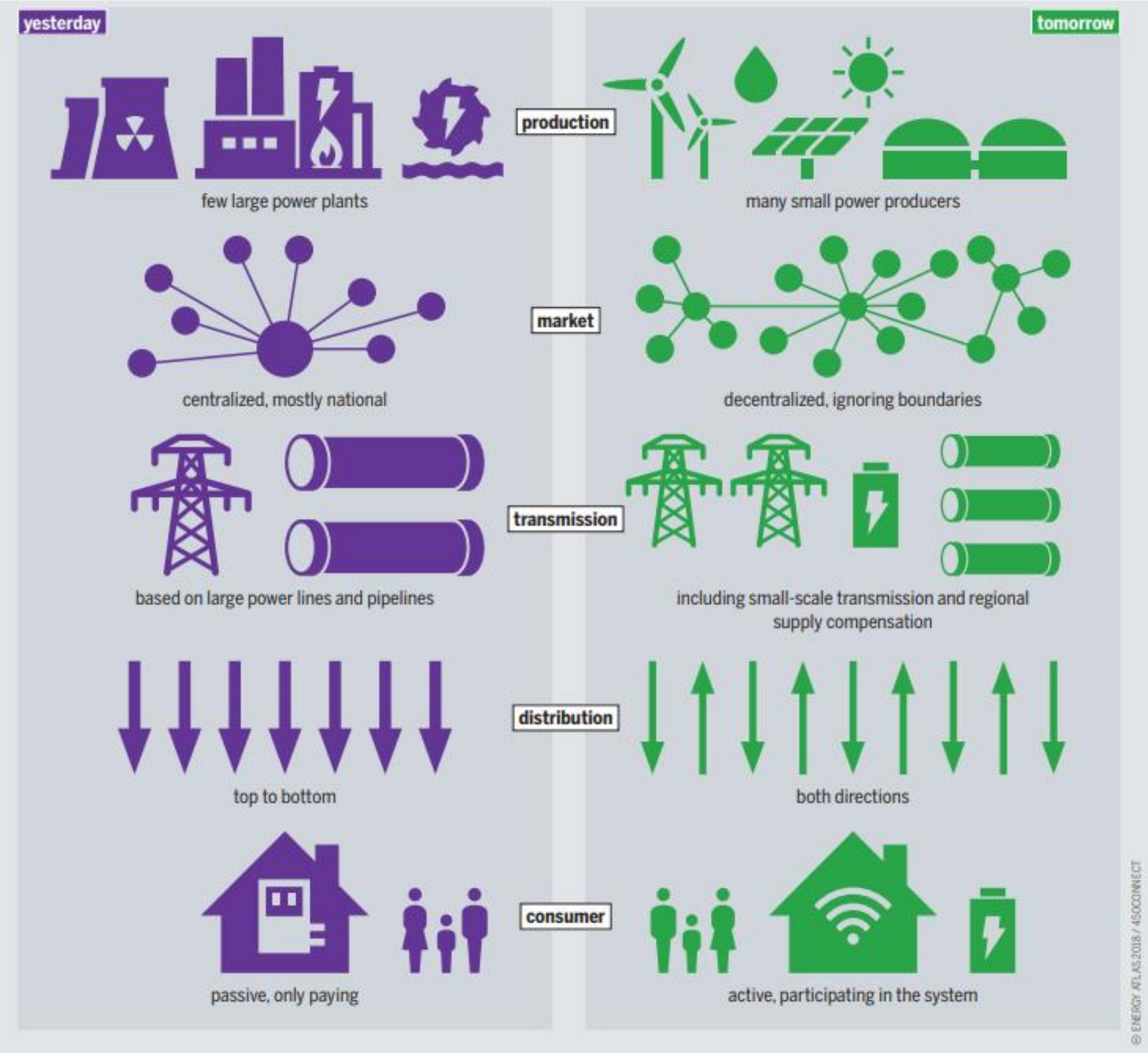
The decarbonisation of the electricity system through non-dispatchable variable renewable sources of energy produces a need for greater flexibility to maintain a reliable and safe operation. Flexibility refers to the ability to vary the energy consumed and generated, or to the provision of power reserve necessary for the balance between generation and demand in the electricity system. Smart grids allow consumers to actively participate in providing the required flexibility, transforming themselves into prosumers.

Smart grids are also essential for enabling electricity market transformation and cost-effective system decarbonisation along the entire value chain. They are also expected to change dramatically over the coming decades. Understanding the required changes and adapting the current energy system in Colombia, including greater demand-side flexibility, will be an essential part of the change process. These changes are likely to include:

- Large-scale energy storage technologies that provide flexibility in generation; advanced transmission equipment that allows the control of voltage, energy and transmitted power;
- Advanced distribution equipment that allows voltage and power control, and automation of network configuration; distributed energy resources of generation and consumption made by a variety of small devices connected to the distribution network;
- Advanced Measurement Infrastructure that allows hourly reading and pricing, either in real time or from time to time;
- Demand management and response systems through energy and power aggregators from heterogeneous residential and/or commercial generation and consumption sources;
- ICT infrastructure (information and communication technologies) composed of equipment and protocols that allow communication between equipment, meters and network or system

operators for the purpose of controlling the operation of the electrical system and associated markets in the face of sufficient cybersecurity

Figure 1. Expected structural changes in the energy system enabled by increased use of digital tools



Source: The Energy Atlas. (Maria Aryblia, 2018)

Distributed Energy Resources (DER) need to be rapidly deployed to introduce demand-side flexibility in a significant measure. The term 'DER' covers a wide range of technologies that are located close to customers or behind the meter, such as energy efficiency, demand response solutions, solar photovoltaic (PV), battery energy storage solutions (BESS) and electric vehicles (EVs), among others. Because these technologies are behind the meter, they are considered part of demand-side flexibility and a key part of the push to develop smart grids in Colombia. The deployment of DER will facilitate a cost-effective low-carbon transition of the power system and will enable the creation of *energy communities*[1] for a just transition. In concrete, these technologies have a positive impact due to reductions in CO2 emissions from renewable distributed generation, decreased use of transmission lines, increased self-consumption and the increasing independence of customers from central grid power (Eid, Codani, Perez, Reneses, & Hakvoort, 2016).

In terms of the status of the DER deployment, Colombia implemented one programme that built awareness of energy efficiency and mandated the labelling of appliances. The Programme for the Rational and Efficient Use of Energy and non-Conventional Sources (PROURE) did achieve its targets but did not unlock the full potential of Colombia's energy efficiency opportunities. Distributed installed capacity of solar PV is also estimated to be 103 MW by the end of 2022 and is forecasted to reach 1,132 MW by 2036 - an average annual growth of 23%, which is a clear step in the right direction (UPME, 2022a). However, more work needs to be done to accelerate energy efficiency and DER/flexible technologies in the country if Colombia's ambitious carbon reduction targets for the energy sector are to be achieved.

Greater flexibility cannot be achieved by reducing grid consumption alone, from energy efficiency and solar PV, consumers must respond to operators' requirements to increase or decrease demand, utilise their own DER systems or BESS, and balance the system. This funding proposal aims to move to the deployment of a full suite of DER technologies to accelerate grid flexibility, and further maturation of market mechanisms and actors, including aggregators, and ESCOs.

2 Discussion of the problem

Demand-side flexibility will be a valuable asset in maintaining a reliable, optimal and continuous service in a rapidly changing electricity system. In the journey to a resilient and low-carbon power system, Colombia has optimistic projections for the deployment of NCRE. While in 2019, the share of NCREs was marginal, by 2030, they could account for 17% of the installed capacity, and by 2050, more than 40%, according to the Energy National Plan 2020 – 2050 (UPME, 2020). However, these need to be backed up by a clear strategy and funding options. Therefore, the Colombian electricity sector must be prepared for the diversification of generation and the change in demand patterns, considering the upcoming electrification of the transport sector, which UPME estimated to grow by 2036 to 5,464 GWh-years, accounting for 5% of the total demand (UPME, 2022a).

The first step towards flexibility is to assess and address energy efficiency opportunities to get the consumer ready to upgrade to flexible technologies. This cost-effective approach first reduces energy consumption and then focuses on integrating technologies to build or increase demand response in the power system. Although a part of energy efficiency measures can be achieved through behavioural change, most improvements are implemented through technological change. Unfortunately, the latter, and flexibility technologies, often have high upfront costs, making it difficult for end-users to access and deploy such solutions. In addition, in many cases, end-users are faced with very high project costs that require external capital financing. In this regard, several financing facilities have been offered by local banks, as described in detail in 11, though these have often been perceived as unattractive due to banks' high collateral requirements. There is limited awareness across the energy efficiency value chain and flexibility

[1] Energy Community: group of people, legally stablished or not, who articulate in an organised way to manage the solutions to the energy problems of the community.

solutions of how these technologies can increase business competitiveness, provide alternative revenue generation (grid services), and contribute to a less stressed and smarter electricity system that optimally manages energy use.

Even if the consumers had the financial capacity to install flexible technologies (such as smart meters, solar PV or BESS), the current market conditions enable only large consumers to participate in the flexibility market and leverage demand response mechanisms. This is often because only large consumers have loads large enough to participate in flexibility markets or can justify the use of Energy as a Service (EaaS) providers. Although smaller consumers have lower loads and less resources to participate by themselves, they still have the potential to develop *energy communities* or to participate in flexibility markets through an aggregator or Energy Service Company (ESCO). The aggregator brings together several individual loads of short-term flexible consumption to trade them as a block, bidding up or down electricity consumption and guaranteeing energy savings for companies or consumers. However, this still requires the right market conditions and regulations to incentivise participation.

3 The case for energy efficiency and flexibility in Colombia

In a high NCRE integration scenario, energy efficiency and demand-side flexibility will be valuable assets to optimise the Colombian electrical system, resulting in lower development, maintenance, and operative costs. In 2020, Carbon Trust in collaboration with Imperial College London, Universidad Nacional de Colombia and UPME, quantified the systemic benefit of smart grid technologies deployment and its value in reducing cost-effectively greenhouse gas (GHG) emissions from the electricity sector. The study estimated the avoided costs of reinforcing the grid, with the deployment of BESS and Demand Side Response (DSR) mechanisms in three different decarbonisation goal scenarios compared to a BAU with no emissions restrictions, would be 60% by 2030 (4.48 MtCO2e), and 100% by 2040.

By 2030 with a 60% decarbonisation scenario, the savings would be USD 42M, which comes from avoided costs in grid reinforcement requirements and avoided OPEX of thermoelectric plants. By 2040 and 2050, distribution savings would still be relevant, but the avoided cost of the generation required to decarbonise the system would be several times higher. This, added to the savings in thermoelectric generation OPEX from fuels, adds up to savings of USD 726M in 2040 and USD 428M in 2050 (UPME; Carbon Trust, 2020).

The results provide relevant information for the upcoming power system development plans around the following four value axes:

- Lower electricity infrastructure development costs
- Enable further emission reductions from the power sector
- Increase diversification and resilience of generation sources
- Change demand characteristics

To achieve Colombia's ambitious climate goals, energy efficiency offers some of the fastest and most cost-effective actions to reduce CO2 emissions as a first stage to deploying flexible technologies. According to the PROURE Action Indicative Plan (PAI-PROURE) conducted by the UPME (2022b), energy efficiency yields a potential mitigation of 85 MtCO2e between 2022-2030, and a cost reduction potential of between USD 6.6B and 11B per year, which contributes to improving the competitiveness of national production and the affordability of energy for the country's inhabitants. Energy efficiency provides benefits to end users in the form of reducing energy demand and therefore costs. In the power system, energy efficiency optimises energy management through metering and monitoring systems, manages demand and improves productivity by controlling and eliminating disturbances, such as consumption peaks, making the system more efficient and responsive.

4 Barriers holding back Colombia's energy efficiency and demand-side flexibility potential

Despite the multiple benefits outlined above and the fact that DER technologies feature in Colombia's NDC strategy, there are numerous barriers that have so far limited the deployment of these technologies. Table 1 below categorises these barriers between regulatory, financial, technical, and knowledge-related; dissects the logic behind each; and attributes a priority factor to each barrier according to the market's perception, and interviews with key stakeholders over the past two years.

Table 1: Identified and prioritised barriers per category and stakeholder.

Stakeholder	Barriers	Priority *(H/M/L)*
Regulatory		
End-users: Industrial, commercial, and residential sector	Lack of market-based regulatory incentives, financial regulatory incentives, and tariff schemes (price signals) for the adoption of DER. These could include regulations to promote market-based pricing such as time-of-use tariffs or dynamic pricing. It could also include greater incentives for renewable energy generators and aggregators to accelerate more demand side participation.	H
Government / Policy Makers	Lack of knowledge of international regulatory best practices to drive DER uptake. Particularly on how to promote interoperability and options for the best market design.	M
Financial		
End-users: Industrial, commercial, and residential sector	High upfront costs and investment's long period of return of some technologies, requiring external financing.	H
Financial institutions	Despite existing credit lines in the market, the perception of high risk and of non-payment remains and consequently, commercial banks set high collateral and guarantee requirements. DER projects have a perception of a high risk investment.	H
Technical		
Financial institutions	The lack of standardisation and simplicity of DER projects leads to high transaction costs to serve many individual businesses.	H
Service providers: auditors, consultors, and installers	Lack of skills to define business cases and carry out audits, assessments, installations, monitoring, and verification for complementary DER.	M
Knowledge & commitment		
End-users: Industrial, commercial, and residential sector	Users are unaware of potential suppliers, equipment, and technologies. Users are unaware of the economic benefits from DER.	M
Utilities/ESCOs	Lack of understanding of the business models required for the deployment of behind-the-meter technologies that enable the provision of grid services and demand-side flexibility.	H

Source*: Workshop:* "Identificar las barreras: Redes Inteligentes". (Carbon Trust, 2021).

5 Existing attempts to resolve barriers

Several initiatives have been identified as targeting the barriers above, but they only partially resolve these barriers. These initiatives have been designed and operated in siloes by different players between the Colombian Government and the private sector, and at different scales and timelines. Nonetheless, this provides a practical base upon which this proposed programme builds. All initiatives identified are listed below in subsections for **regulatory** incentives, **financial** mechanisms, and **technical-assistance** or **other pilot** efforts. The upsides and downsides of these initiatives are briefly discussed in each subsection.

5.1 Regulatory incentives

The Colombian policy and regulatory framework have been focused on renewable energy and energy efficiency. The Government has taken significant steps forward in adopting fiscal incentives and investment programmes in these areas, which are presented in Table 2. In addition to the existing regulatory mechanisms, the regulatory agenda for the upcoming years includes definitions for a flexibility market, hourly tariffs, and aggregators.

Table 2. Existing regulatory incentives or mandates.

Initiative name/lead	Description	Barrier addressed	Ups and downsides
Law 1715 – 2014: General regulatory framework for Non-Conventional Sources of Renewable Energy	The law 1715 encourages the integration of alternative energy in the Colombian Energy mix. It provides fiscal incentives, including: 1. income tax deduction of 50% of investment value for up to 50% of taxable income for up to 5 years. 2. VAT exemption for renewable energy equipment and services. 3. import duty exemption for renewable energy equipment not produced locally. 4. accelerated depreciation of up to 20% per year for renewable energy investments. (IEA, 2018)	High upfront costs of some technologies require external financing (especially in the case of long-term repayments).	- Impact the profitability of projects, improving economic indicators such as internal rate of return on investment and levelized cost of energy - Most end users still face high upfront costs in Colombia for developing low-carbon projects since the capital investment required for NCREs remains slightly higher today than in the case of conventional technologies.
CREG resolution 174 of 2021: Regulating small-scale self-generation and distributed generation activities in the National Interconnected System.	To regulate the activities of small-scale electricity generation and distributed generation by means of NCREs. This resolution defines the rules that allow users to connect to the Network Operator, either as self-generators or distributed generators.	Lack of market-based regulatory incentives, financial regulatory incentives, and tariff schemes (price signals) for the adoption of demand-side flexibility technologies.	- Thanks to this resolution, users with small-scale self-generation can sell their surplus energy to the national interconnected system - The lack of dynamic tariff schemes limits the willing of consumers to flex their demand, meaning most opportunities for energy savings and smarter grids remain locked.

Law 1955 – 2019: National Development Plan of the Government of President Iván Duque (2018-2022)	Law 1955 of 2019 established that taxpayers may claim a special deduction over 15 years, beginning in the tax year after the renewable energy or Energy Efficiency project becomes operational.	High upfront costs of some technologies require external financing (especially in the case of long-term repayments).	- Updated the 1715 law to extend the period for tax deduction, previously, it had to be claimed over five years, beginning in the tax year after the investment was made. - Most end users still face high upfront costs in Colombia for developing low-carbon projects since the capital investment required for NCREs remains slightly higher today than in the case of conventional technologies.
Law 2099 – 2021: Energy Transition Law	The law establishes that the tax benefits currently available for NCRE projects will also apply to smart metering systems and power management for NCRE, as well as investments in goods, machinery and equipment used in the manufacturing, storage, packaging, distribution, re-electrification, research, and final use of green and blue hydrogen.	Users are unaware of potential suppliers, equipment, and technologies	- Promotion of the diversification of demand-side technologies through tax incentives that worked with NCREs. - Most end users still face high upfront costs in Colombia for developing low-carbon energy projects
PROURE: Programme for the Rational Use of Energy	Outline the energy efficiency and CO2 emission reduction potentials for different sectors of the economy as a result of the adoption of improved technologies and fuel switching.	Lack of knowledge of international regulatory best practices to drive energy efficiency and smart grids uptake.	- The PROUE projects the impact of energy efficiency on demand and emissions in the period 2022-2030 and performs a benefit-cost analysis of energy efficiency measures to identify those that would be eligible for tax incentives. - End users

Source: Workshop: "Identificar las barreras: Redes Inteligentes". (Carbon Trust, 2021).

5.2 Financial Mechanisms

At least nine relevant financial mechanisms are available for energy efficiency and smart-grid-related investments in Colombia from public and private sources. Table 3 below summarises these. However, despite such mechanisms, these have not managed to get medium-sized industries and commercial establishments to invest in energy efficiency and DER interventions at scale.

Table 3. Financial mechanisms available to support energy efficiency and smart-grid related investments in Colombia.

Credit line/ program name	*Technology focus (EE; RE; BESS; EV)*	*Route to recipient (direct or indirect)*	*Target clients/sectors*	*Loan size range (COP million)*	*Payback time limit (years)*	*Approx. Interest rate (per year)*
Incentivos a eficiencia energética	EE	Indirect	SMEs	< 1 - 200	15 - 20	N/A
Línea economía sostenible adelante	EE, RE	Indirect	N/A	300	N/A	IBR NMV +0.5% (intermediaries)
Línea sostenible	EE, EV	Direct	Public sector and companies with sales > 280 million COP	50-200	7	< 29.04%
Leasing sostenble solar	RE	Direct	SMEs, businesses, corporations, and Government.	50-200	10	Variable: DTF ~ 15-20%
Línea verde	EE	Direct	SMEs, all sectors	100-500	10	Variable: DTF + fixed points ~ 20-28%
Línea verde	RE	Direct	SMEs, all sector	100-500	12	Variable: DTF + fixed points ~ 20-28%
Línea Desarrollo Sostenible	EE, ER	Direct	SMEs (Industry, commerce and Transport)	50-500	3 - 10	N/A

Source: Bancolombia ampliará créditos sostenibles para los proyectos de economía circular (larepublica.co)

5.3 Technical assistance or other relevant initiatives

Few technical assistance initiatives work in tandem with the financial mechanisms outlined above to encourage demand-side flexibility investments in Colombia. The exact amount of technical assistance and pilot efforts available to catalyse the market for demand-side flexibility is unknown since the initiatives are decentralised, often combined with broader programmes/budgets, and there is limited or no data available on their expenditures or performance. All major technical assistance initiatives identified to promote the flexibility market in Colombia are listed in Table 4, including basic information on their focus and target audience.

Table 4. Technical assistance and pilot efforts

Initiative name and lead implementer/ funder	Description	Target audience
Colombia Inteligente/ BID	Smart Grids Colombia Vision 2030 – Roadmap for the implementation of smart grids in Colombia	Network operators and policy makers
Enersinc/ World Bank and Korea Green Growth Partnership	Energy Demand Situation in Colombia	Policy makers, utilities, and end users
IRENA	Colombia power system flexibility assessment	Network operators and policy makers
Carbon Trust/ UK PACT	Supporting the roll-out of smart grid technologies in Colombia	Network operators, policy makers and end users
Colombia Inteligente	Fomento programas respuesta a la demanda	Networks operators and industrial and commercial users

Source: Workshops Redes Inteligentes (Carbon Trust, 2021)

6 Our proposed solution

Despite regulatory drivers, finance mechanisms, technical assistance and pilot initiatives listed above, the full scale of energy efficiency, DER and smart grid opportunities in Colombia are yet to be fully realised. The systemic benefits of these opportunities are far greater than the costs of investing in and maintaining energy efficiency measures and demand-side flexibility. From this section onwards, this document lays out how a programmatic effort, supported by international donor climate finance, can unlock these opportunities most efficiently at a demonstration scale, igniting a transformational change in the Colombian energy market.

The programme described herein is the result of a multi-stakeholder consultation exercise led by the Carbon Trust, consisting of background research efforts; thorough mapping of relevant stakeholders; multilateral workshops with UPME, Ministerio de Minas y Energía, CREG, utilities, Universidad Nacional, and Colombia Inteligente; and 30+ bilateral interviews (see Appendix A for details of key workshops delivered). Drawing from international best practice on similar programmes, relevant players in Colombia were encouraged to systematically consider each remaining barrier and how to most efficiently address these, leading to a multi-dimensional programme that is supported by all institutions that co-sign this proposal; namely: that generates demand for energy efficiency and demand-side flexibility projects; that builds a pipeline of high-quality and low-risk projects; and leverages a guarantee mechanism to enable banks to finance such projects.

The proposed programme aims to accelerate commercial investments in energy efficiency measures and demand side flexibility including DER technologies such as BESS and Solar PV, across residential, commercial, and industrial sectors in Colombia. The programme looks to provide energy savings for users, reduced carbon emissions and increased flexible capacity. To do so, this programme will be split in three core components or activities, summarised below and detailed in subsequent sections:

1. **Generate demand: A USD 2M awareness-raising programme** that reaches the target audience and generates demand for energy efficiency and DER projects and loans, leveraging existing networks and a targeted marketing campaign **(see Section 8.1).**
2. **Building and implementing a pipeline of high-quality and low-risk projects: A USD 3M capacity-building programme** that will upskill local independent consultants, aggregators and ESCOs to standardise how energy audits are offered and energy efficiency and flexible technology investment cases are built. This includes subsidising the cost of providing these services e.g. energy audits. This also includes technical assistance and capacity building for the public sector and banks to improve their understanding of the processes, technologies and risks involved **(see Section 8.2).**
3. **Unlock finance: A guarantee mechanism of USD 15M** aimed at addressing the two major financial-related barriers: a perception of high risk amongst government and financial institutions; and the high collateral requirements posed by banks vis-a-vis low capacity to provide collateral by end-users **(see Section 8.3).**

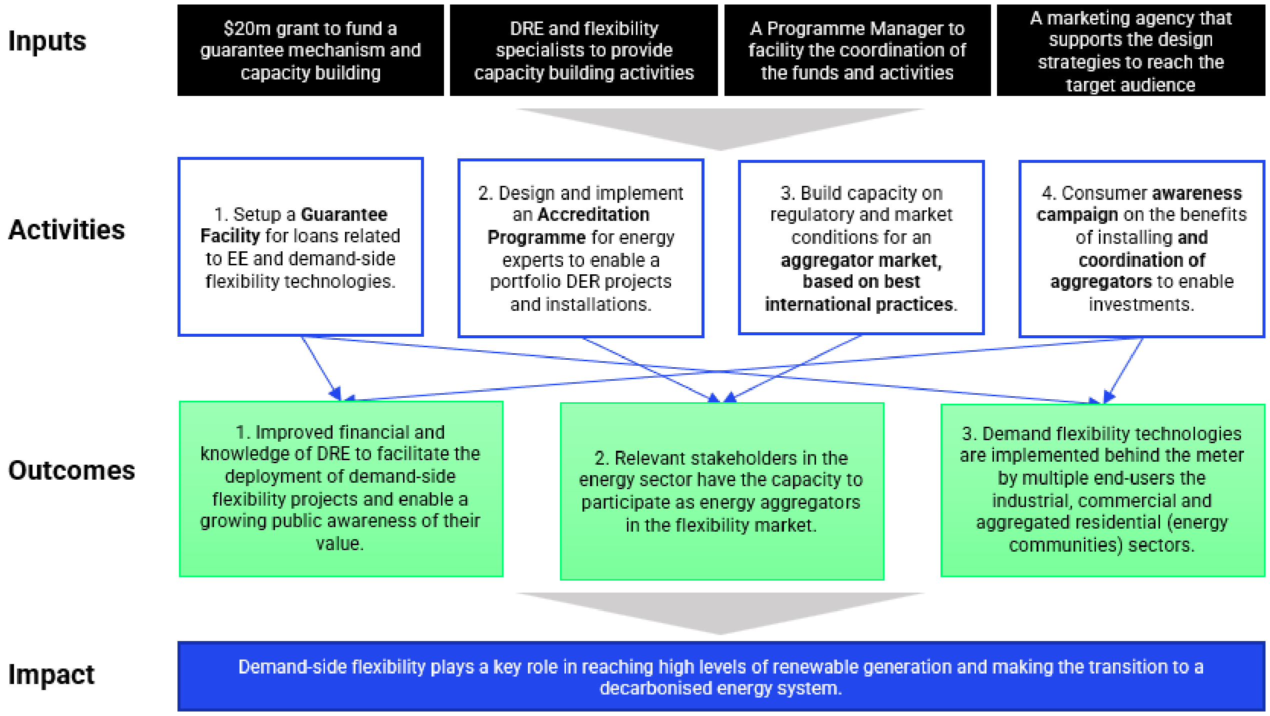
The following sections demonstrate this programme's theory of change; delivery structure; core activities; eligible technologies; business case and cash-flow analysis for an investment case; and determine/dissect the target audience, potential programme impact and a timeline of activities.

7 Theory of change

Problem definition: A lack of understanding of energy efficiency measures and high upfront costs of DER technologies have led to a lack of investment in demand-side flexibility in Colombia historically. A lack of knowledge and understanding of many of these technologies and their use cases, particularly from financial institutions, means investments are often perceived as risky. This can lead to higher interest rates and collateral requirements. In addition, there are a lack of joined-up market-based regulatory incentives, financial regulatory incentives, and tariff schemes (price signals) to accelerate the adoption of energy efficiency measures and flexible technologies. These challenges are set against a backdrop of an ambitious NDC target to limit GHG emissions to 169.4 MtCO2e by 2030, and a need to decarbonise Colombia's energy sector more broadly (Minenergía, 2021).

Change required: To accelerate the adoption of energy efficiency measures and flexible technologies through investments in DER, private investment needs to be attracted, and investors and users need to be upskilled on the relevant technologies and their benefits. This will require capacity building activities to upskill stakeholders, and de-risking activities to help leverage larger amounts of private capital for investments in energy efficiency and DER projects. Aggregators and ESCOs will also be required, particularly in the residential and commercial sectors, to pool users, thereby acting to simplify and de-risk the investment required. Aggregators would also improve access to flexible technologies that may not have been installed without their intervention.

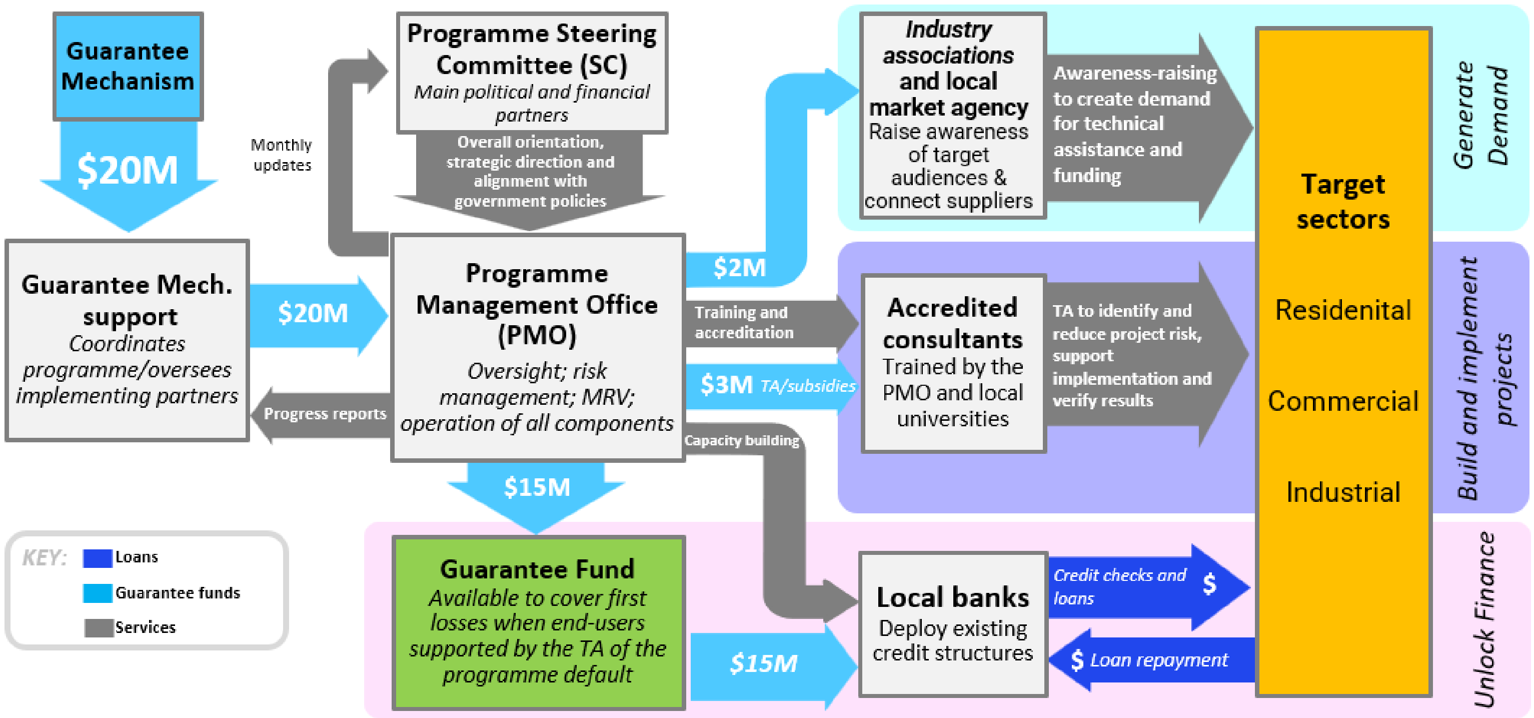
Figure 2. The key inputs, activities, outcomes and impacts from this theory of change



8 Delivery structure and programme components

A Programme Management Office (PMO) will be contracted by the programme funders, sponsors and partners (e.g. industry associations such as ANDI and local marketing agencies) and will act as a central delivery agent to operationalise the programme. The PMO is responsible for programme oversight, risk management, monitoring, reporting, planning, coordinating, and tracking the delivery of the programme's three components, including subcontracting delivery partners. In parallel, the PMO operates as a secretariat and advisor to the Steering Committee, composed of the programme's key political sponsors who guide the programme, while ensuring it is aligned with the Colombian Government's priorities. The financial flows from the donors to the PMO and the PMO's routes to deliver the three core activities are summarised in Figure 2 below:

Figure 3. Overview of delivery structure, financial flows and components



8.1 Generate demand

USD 2M is expected to be assigned to an awareness-raising programme that reaches the target audience and generates demand for loans to fund energy efficiency activities, smart grid audits, and installations of flexible technologies. This would be targeted across sectors including residential, commercial, and industrial. This activity leverages the Colombian Industries' Association's (ANDI) networks to direct efforts towards companies that have been identified as interested parties in demand-side flexibility or fit into a target audience eligibility criteria **(see details in Section 11)**. Following global best practices, a local marketing agency will be selected and subcontracted through an open tender to support the design of strategies to reach the target audiences.

Awareness-raising activities include two distinct stages:

(i) **Quick wins**: Identify and engage companies that have already demonstrated interest in DER and demand-side flexibility projects and/or have already undertaken energy audits but, for some reason, have not moved ahead, e.g. inability to provide sufficient collateral. These are expected to be quickly identified within ANDI's networks or leveraging contacts of existing ESCOs and energy consultants, and will be invited to participate in the programme. This stage is planned to last throughout the programme's first 3 years and is expected to generate the quickest returns in terms of requests for technical assistance loan support.

(ii) **Sustained demand for projects**: Identify companies based on their fit to the project's eligibility criteria and reach out to them via social media; direct contacts; relevant conferences; printed media; mailing lists, and specific workshops, to build demand for the programme's offering of energy efficiency measures, energy audits, DER technology funding and installations, and implementation assistance. This stage is planned to last throughout the entire project lifecycle.

8.2 Building and implementing a pipeline of high-quality and low-risk projects

An additional USD 3M will be used for capacity building to support the development of a pipeline of projects. The PMO will join forces with the academic sector to deliver a capacity-building programme that will upskill local independent consultants and ESCOs to standardise how energy audits are offered and energy efficiency and demand-side flexibility investment cases are built. Individuals and ESCOs who successfully go through the course and pass a test will be accredited by the PMO e.g. accredited by Organismo Nacional de Acreditación de Colombia (ONAC) and, as such, be able to use that accreditation in their favor by offering clients the benefit of accessing the guarantee mechanism, which will only be available for projects that have been built by accredited consultants.

End-users reached by the programme's Demand Generation component can either select consultants from a public list of accredited individuals/firms or request an energy audit of any such consultant via the programme's email disseminated in the marketing efforts. Accredited consultants will be ready to attend to energy audit requests as soon as such a demand appears, and will be free to identify projects proactively, especially quick wins, leveraging their networks from day 1.

The pipeline of projects is expected to be developed and implemented in three stages:

(i) **Capacity building to financial institutions**: Banks that are interested in financing end-users supported by this programme will be eligible to participate in capacity building sessions provided by the PMO free of cost to upskill bank management, risk and credit teams with regards to the aspects of financing such technologies. This will address the barrier of banks' risk perception, which relates to banks' excessive collateral requirements on such loans.

These sessions will happen throughout the programme and can be repeated upon demand. They will cover basic concepts of energy efficiency and demand-side flexibility projects, such as technical characteristics and combinations, costs and benefits (financial and environmental), as well as detailed assessments of cash flow in sample projects, internal rates of return, banks' environmental commitments (against the back-drop of SDGs, banks' existing commitments, SBTs, and Colombia's NDC) and risk exposures (against the back-drop of banks' TCFD-related ambitions).

(ii) **Delivery of subsidised energy audits and investment cases**: estimated to require roughly 100 hours of consultancy time per client; this includes the delivery of standardised energy audits (following sub-sector guidance provided in the capacity building programme) culminating in the delivery of standardised investment business cases that provide estimates for payback times, internal rates of return, project cash-flows, expected energy savings, and GHG mitigation potential. Energy audits will be partly funded by the programme but an investment/commitment will also be expected from users. These audits may also recommend the implementation of energy management systems e.g. ISO 50001. However, the programme would not cover the cost of these. Among proposed interventions, accredited consultants are expected to indicate the minimum investment required to achieve a minimum threshold of tCO_2e/$ invested, which will qualify such projects to receive the next stage of support.

Upon receiving investment cases, targeted end-users are guided to request loans or source alternative funding sources to implement recommended interventions. Accredited consultants will be able to provide clarifications if required by financial institutions.

(iii) **Delivery of implementation support**: target audiences that have been supported by stage (i) and effectively invest in one or more of the interventions proposed - as long as they meet the minimum requirements - are then eligible to request implementation support, whereby accredited consultants are estimated to spend roughly 100 hours per client in biweekly or monthly visits, supporting them to adequately install and operate newly implemented technologies to ensure optimal results are achieved.

8.3 Unlock finance

A third component is deployed in parallel to the ones above to enable a bigger group of end-users to invest effectively in proposed interventions by facilitating their access to credit. This component addresses the two major financial-related barriers: a perception of high risk amongst government and financial institutions; and high collateral requirements posed by banks vis-a-vis low capacity to provide collateral by end-users. It involves:

(i) **A guarantee mechanism**: The financial component of this programme includes USD 15M that acts as a guarantee for DER investments from commercial banks. It will be managed by an organisation tendered during the programme setup and covers up to 15% of the value of loans and therefore potential losses incurred by commercial banks, with specific conditions to be determined. Therefore, the guarantee mechanism's key objective is to lower the collateral requirements currently imposed by local banks on loans related to energy efficiency or demand-side flexible technology investments. End-users will be able to voluntarily choose to contract the guarantee mechanism (for a fee to be determined) when they are unable to provide the collateral initially requested by banks, and banks will only be allowed to benefit from this mechanism when their collateral requirement is reduced, as indicated above.

To mitigate the risk of banks providing risky loans at the expense of this mechanism and the risk of quick depletion, it: (i) will not cover 100% of losses – meaning banks will take part of risks themselves, as usual; (ii) will require banks to demonstrate their usual attempts to recover defaults; (iii) will count on a maximum leverage factor of 10 times worth amount available in the fund; (iv) will have a cap on coverage per end-user; (v) will have its cash-position invested in Colombia, in a safe option to be determined, which ensures it does not lose its value against inflation.

9 Eligible technologies

The programme will enable the deployment of the following:

- Electricity efficiency / energy efficiency measures e.g. smart meters
- Solar PV systems
- Battery Energy Storage Systems (BESS)
- Demand management resources e.g. Energy as a Service (EaaS) provided by aggregators

The programme, projects, and investments will cover energy efficiency measures and DER technologies including Solar PV and BESS; however, other demand management systems and approaches can be incorporated as part of offerings to users to provide demand-side flexibility.

10 Business and investment case

For the purpose of this proposal the Carbon Trust have prepared a bottom up business case and cashflow analysis to highlight how the guarantee mechanism funds could be leveraged, and what the expected outcomes would be, including cash savings for users and avoided carbon emissions. This analysis should be treated as a prudent forecast for what the programme could deliver, although careful consideration should be given to the assumptions used. The programme would leverage USD 15m from the guarantee mechanism to underwrite the value of commercial loans, and USD 5m to finance capacity building and technical assistance. This investment case has been forecasted out to 2030 with detailed outcomes across residential, commercial and industrial sectors outlined in Table 5 below.

The programme is expected to use USD 15M funding from the guarantee mechanism to unlock USD 139.4M of private finance for DER installations of BESS and Solar PV systems by 2030 across residential, commercial and industrial sectors. This will enable the installation of 44 MWh of BESS and 191 MW of Solar PV across sectors, leading to a total user saving of USD 22.2M and avoided emissions of 29,537 tonnes of C02e. The programme targets are separated by sector below (cumulative to 2030) and then annual figures are detailed by sector on the following pages.

Table 5. Headline figures from the programme, cumulative totals to 2030*

	Residential (100% AGG.) *	Commercial (50% AGG.)	Industrial (30% AGG.)
Total budget (per sector)	$7.5m	$3.75m	$3.75m
Total private investment leveraged	$75.1m	$32.3m	$32.0m
No. projects	35	76	45
Average installation size (solar PV /BESS)	2.4 kW/1.2 kWh	5 kW	75 kW
No. users (household/entity)	~17,600	~9,100	~435
Number suppliers/consultants	60	25	15
Installed capacity			
BESS (MWh)	44	NA	NA
Solar PV (MW)	88	44	59
Expected user savings	$13.5m	$3.7m	$5.0m
BAU emissions (tonnes C02e)	~27,000	~58,000	~91,500
Expected C02e savings (tonnes)	~17,800	~5,000	~6,700
Cost per tonne of C02e	TBD	TBD	TBD

*See Appendix B for details of calculations, rationale and sources

**AGG: % of users bought into the programme by aggregators vs independently engagement and investment

The programme relies on a scale up of projects targeting installations of eligible technologies for end users across residential, commercial and industrial sectors. This is indicative of what could be unlocked with the targeted funds of the guarantee mechanism and work by DER professionals through capacity building.

Table 6. Forecast for the residential sector

	2023	2024	2025	2026	2027	2028	2029	2030	Total
No. projects	-	-	2	4	5	6	8	10	**35**
No. users (household/entity)	-	-	100	800	1,500	3,000	4,800	7,437	**17,637**
Number suppliers/consultants for capacity building	60	60	60	60	60	60	60	60	**60**
Installed capacity									
Batteries (MWh)	-	-	0.1	1.1	2.9	6.5	12.2	21.2	**26.8**
Solar PV (MW)	-	-	0.2	2.2	5.8	13.0	24.5	42.3	**87.9**
Expected user savings ($)	-	-	36,875	331,875	885,000	1,991,249	3,761,248	6,503,526	**13,509,772**
BAU emissions (tonnes C02e)			126.4	1,061.9	2,090.5	4,390.2	7,375.5	11,998.2	**27,042.7**
Expected avoided emissions (tonnes C02e)	-	-	49	438	1,167	2,626	4,960	8,577	**17,817.2**
Cost per tonne of C02e	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Table 7. Forecast for the commercial sector

	2023	2024	2025	2026	2027	2028	2029	2030	Total
No. projects	-	-	6	10	11	13	16	20	**76**
No. users (household/entity)	-	-	162	460	930	1,500	2,420	3,673	**9,145**
Number suppliers/consultants for capacity building	30	30	30	30	30	30	30	30	**30**
Installed capacity									
Batteries (MWh)	-	-	-	-	-	-	-	-	-
Solar PV (MW)	-	-	0.3	1.3	3.4	6.8	12.1	20.2	**44.1**
Expected user savings ($)	-	-	26,903	112,349	287,471	572,742	1,022,476	1,706,968	**3,728,908**
BAU emissions (tonnes C02e)	-	-	850.6	2,536.0	5,383.5	9,117.3	15,444.7	24,611.8	**57,943.9**
Expected avoided emissions (tonnes C02e)	-	-	36	151	388	772	1,378	2,301	**5,027.1**
Cost per tonne of C02e	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Table 8. Forecast for the industrial sector

	2023	2024	2025	2026	2027	2028	2029	2030	Total
No. projects	-	-	5	5	8	8	9	10	**45**
No. users (household/entity)	-	-	22	28	52	67	112	154	435
Number suppliers/consultants for capacity building	20	20	20	20	20	20	20	20	**20**
Installed capacity									
Batteries (MWh)	-	-	-	-	-	-	-	-	**-**
Solar PV (MW)	-	-	1.4	3.0	6.0	9.6	15.4	23.4	**58.7**
Expected user savings ($)	-	-	115,902	252,108	505,062	808,776	1,306,224	1,976,222	**4,964,294**
BAU emissions (tonnes C02e)	-	-	3,874.7	5,178.0	10,097.0	13,660.1	23,976.5	34,670.1	**91,456.3**
Expected avoided emissions (tonnes C02e)	-	-	156	340	681	1,090	1,761	2,664	**6,693.6**

For a full list of assumptions and calculations, see Appendix B. However, critical assumptions used in the business case include:

- No electricity generated by users is sold back to the network
- User savings are calculated based on avoided grid import costs
- Batteries are charged and discharged once per day (365 times per annum)
- Commercial and Industrial users will not have BESS installed as users would require time of use tariffs to realise the benefits. These are not currently available, however, options for BESS installations can be explored during the programme on a case by case basis
- All residential installations are done through an aggregator
- 50% of commercial installations are through an aggregator and the other 50% through their own initiative
- 30% of industrial installations are through an aggregator and the other 70% through their own initiative
- 15% of CAPEX requirements will be underwritten by guarantee mechanism – USD 15M total with USD 7.5M for residential and USD 3.75M for commercial and industrial sectors
- USD 5M will be used for capacity building costs including marketing campaigns to cover the cost of >100 energy consultants

Additional assumptions and calculations made by sector include:

For the residential sector:
The programme would target a range of energy efficiency and flexible technologies, including demand management systems, and interrogate each residential users' needs through energy audits. However, the main capital expenditure is expected to cover the installation of solar PV and BESS. Current market costs per kW of solar PV for residential users is between USD 1,500 – 2,000 and USD 350 per kWh of battery storage. This equates to an average installation cost for solar PV at ~USD 3,800 and $420 for BESS (not including the battery inverter costs). The average installation size for solar PV is calculated based on the Carbon Trust's previous experience working in the sector and includes a 2.4kW solar PV installation to meet an annual average electricity consumption of 6,000 kWh. Analysis conducted by CT also assumed a load factor of 22.4% and assumed that the average user would consume 48% of their generation. This is calculated using an average electricity demand profile for Bogota. A 1.2 kWh BESS is also assumed to capture the additional generation not used, and discharged later in the day when average consumption for users would increase. The BESS is assumed to charge and discharge once a day (365 times a year) and have a technical life of 15 years (~5,500 cycles).

For the commercial sector:
Similarly with the commercial sector, the programme would target a range of energy efficiency measures and flexible technologies, including demand management systems, and interrogate each commercial users' needs through energy audits. However, the main capital expenditure is expected to cover the installation of solar PV. Current market costs per kW of solar PV for residential users is between USD 1,500 – 2,000. This equates to an average installation cost for solar PV between ~USD 2,900 – 9000 depending on the average energy consumption and size of installation. The average installation size for solar PV was calculated using the total generation for the sector (9,029 GWh per annum) divided by the total number of reported users in the sector (1,086,910) (Ministerio de Minas y Energía, 2019), ((SUI), 2023). This was used to create a small, medium, and large consumption profiles of 4,154 kWh, 8,307 kWh and 12,461 kWh per annum, respectively. Analysis conducted by CT also assumed a load factor of 22.4% and assumed that the average user would

consume 55% of their generation for a 1.8kW, 3.8kW and 5.0 kW solar PV installation per consumption profile. This is calculated using an average commercial electricity demand profile for Bogota.

For the industrial sector:
Finally, as with the other sectors, the programme would target a range of energy efficiency and flexible technologies, including demand management systems, and interrogate each industrial users' needs through energy audits. However, the main capital expenditure is expected to cover the installation of solar PV and BESS. Current market costs per kW of solar PV for residential users is between USD 1,500 – 2,000 and USD 350 per kWh of battery storage. This equates to an average installation cost for solar PV between ~USD 55,000 – 150,000 depending on the average energy consumption and size of installation. The average installation size for Solar PV was calculated using the total generation for the sector (25,073 GWh per annum) divided by the total number of reported users in the sector (89,982) (Ministerio de Minas y Energía, 2019), ((SUI), 2023). This was used to create a small, medium, and large consumption profiles of 139,322, 278,645 and 417,967 kWh per annum, respectively. Analysis conducted by CT also assumed a load factor of 22.4% and assumed that the average user would consume 32% of their generation for a 40 kW, 75 kW and 110 kW Solar PV installation per consumption profile. This is calculated using an average commercial electricity demand profile for Bogota.

11 Target audience

This programme targets four main groups: the public sector, commercial banks and other financial institutions; end-users in residential, commercial and industrial sectors; and energy consultants and technology suppliers.

11.1 Public sector

This target group includes at least three public sector organisations (UPME, Fenoge and Ministry of Mines and Energy) that will be involved in and responsible for promoting demand-side flexibility and energy efficiency across the three target sectors. In addition, these public institutions will receive training and guidance on international best practices in regulation and policymaking to accelerate flexibility deployment in the power sector.

11.2 Banks / Financial Institutions

This programme targets a selection of banks and financial institutions such as Bancolombia, Procredit, Bancamia, Banco de Bogota, Davivienda, Bancoldex, enhancing their understanding of how to measure and assess the risk of demand-side flexibility projects to require a more reasonable level of collateral. Bank employees will receive workshop training on assessing demand-side flexibility technology loans and how to employ/integrate these new skills in their line of work. The guarantee mechanism will increase access to loans offered by banks by underwriting and de-risking commercial loans offered for projects.

11.3 End-users

Aiming to be part of a just energy transition and to achieve the greatest energy savings and GHG mitigated per USD donated, this programme will explore the establishment of *energy communities* (residential or commercial) in which DER are a principal component of the systems. Another important focus will be medium-sized industries and commerce, where a major opportunity for energy efficiency and flexible technologies has been identified. This section dissects the Colombian industrial and commercial sectors to demonstrate the relevance of this target audience. It also lays out clear eligibility criteria for players to be within this programme's target audience.

The implementing partners will work with the companies and *energy communities* to develop the roadmap and implement energy efficiency measures and flexible technologies, ranging from technology identification to accessing finance, and project implementation support. To be eligible for the programme, users across sectors need to demonstrate:

- A proactive interest in adopting energy efficiency measures, flexible technologies, and participating in flexibility markets
- That they meet the technical criteria, set out by programme through training and deployed by consultants, including the right demand profiles, site specific considerations for installation and a stable grid connection etc.
- That they are unable to secure sufficient financing through conventional means
- They have previous expressed interest in energy efficiency or DER or have engaged with the programme through marketing campaigns as part of the 'generate demand' component

Residential users
The programme will target ~18,000 residential users by 2030, across Bogota, Cali, Medellin, Cartagena and Barranquilla. The majority of these will join the programme through aggregators. The programme expects that users will have a typical energy demand profile (higher load in the mornings and evenings) and have an average annual demand of 6,000 kWh per annum. The business case has assumed an average installation size of 2.4kW of solar PV and 1.2kWh BESS, however, these sizes are likely to vary and be site specific.

Commercial users
In the commercial sector the programme will look to engage with ~9,000 by 2030 with ~50% of these are expected to be engaged through aggregators. This includes 7,500 small, 1,300 medium, and 350 large commercial entities. The programme expects that users will have a typical energy demand profile (consistent throughout the day and lower at night) and have an average annual demand of 4,000-12,500 kWh per annum. The business case has assumed an average installation size of 1.8-5kW of solar PV, however, these sizes are likely to vary and be site specific.

Industrial users
Finally, ~430 industrial companies focused on 300 SMEs, 100 medium, and 30 large companies across the manufacturing industry, including the more energy-intensive sub-sectors of: (i) chemicals and pharmaceutical, (ii) food & beverage, (iii) pulp & paper, (iv) textile, (iv) basic metals, (v) non-metallic minerals and (vi) rubber and plastic. Beneficiary industries are located in following regions: metropolitan regions of "Bogotá-Cundinamarca " and "Valle de Aburrá " (which includes: City of Medellin and other 9 municipalities), Cauca Valley, and Caribbean coast (including: the cities Cartagena and Barranquilla). For more detailed assumptions on specific categorisations for small, medium and large entities see Appendix B.

11.4 Energy Consultants/Suppliers:

This target group involves ~100 energy consultants/suppliers that will be reached via local institutions working on energy efficiency, such as CCEE, CAEM, SENA, and technical universities in Bogota, Cali, Medellin, Cartagena and Barranquilla. The energy consultants will adopt international best practices to carry out energy efficiency audits and structure business plans to encourage decision-makers in organisations to move forward with energy efficiency and DER projects. Training will be provided to programme consultants and include:

- Energy performance contracting
- Energy auditing under the programme
- Public sector procurement
- Measurement, Reporting and Verification (MRV) requirements under the programme
- Access to other training
- How to become eligible/meet the eligibility criteria for users in each sector
- Accessing finance from financial institutions and other parties
- Project management
- Guaranteed savings contracting

In addition, a global energy efficiency and DER expert consultants will work with local partners to carry out training, leveraging the local network of CAEM, SENA, and technical universities. This knowledge and capability will be essential for accelerating energy efficiency and DER in Colombia, and this can continue to be leveraged by consultants and suppliers after the programme ends.

12 Impact

Key metrics to measure the impact and success of the programme include:

1. Emission reductions and C02e savings (MtCO2e) (against a BAU scenario)
2. Amount of private capital invested/unlocked by the guarantee mechanism and capacity building campaigns (USD M)
3. Number of users engaged across sectors (residential, commercial and industrial)
4. Increase in installed and generating capacity of BESS and Solar PV (MW/MWh)
5. End user savings (USD M)

12.1 Emissions reduction and CO2e savings

The business case suggests that a cumulative total of 29.5 MtCO2e can be saved over the course of the programme to 2030. This includes 17.8 MtCO2e from residential, 5.0 MtCO2e from commercial and 6.7 MtCO2e from industrial users. This can be achieved through a ramp up of projects, capacity building and leveraged funds to end users. This should be compared to a BAU scenario where users would have otherwise continued to import electricity from the grid with an average carbon intensity of 182g C02e/kWh. This reduction represents a 17% decrease from a BAU scenario and would make a significant contribution to Colombia’s NDCs and decarbonisation ambitions.

12.2 Amount of private capital invested/unlocked by the guarantee mechanism and capacity building campaigns (USD M)

The programme can potentially unlock USD 139.4M of private capital through its capacity building, developing a pipeline of demand-side flexibility projects, and de-risking commercial loans through the guarantee mechanism. It is these de-risking exercises that are expected to reduce the cost of capital and collateral requirements of commercial and local banks, to improve local access the finance and unlock this potential. Unlocking finance is critical to the success of Colombia's decarbonisation targets and for the energy sector to transform.

12.3 Number of users engaged across sectors (residential, commercial and industrial)

The three core components of the programme combine to allowed aggregators a route to market and a financially sustainable operating model to engage with end users while having access to the right finance. Generating demand will be crucial and it is expected that 100% of residential users, 50% of commercial users and 30% of industrial users will be engaged through aggregators. This will enable the programme to engage with ~17.8k users across sectors including ~11.8k from the residential sector, 5.5k from the commercial sector, and 0.3k from the industrial sector.

12.4 Increase in installed and generating capacity of BESS and Solar PV (MW/MWh)

One of the key metrics of the programme that will form part of the core KPIs will be the amount of installed capacity for BESS and Solar PV. This includes and estimated ~190 MW of Solar PV and 44 MWh of BESS by 2030. This is a significant contribution to Colombia's installed renewable energy capacity and an even more critical part of Colombia's growing DER capacity. This would include 44 MWh of BESS and 88 MW of Solar PV in the residential sector, 44 MW of Solar PV in the commercial sector and 59 MW of Solar PV in the industrial sector. In addition to installed capacity of these two technologies, energy consultants will also explore options for more flexible solutions for each user depending on site conditions of each such as Demand management resources, energy efficiency measures and smart meters.

12.5 End user savings (USD M)

Finally, for the overall success of the programme to be evaluated, it is essential to have a KPI related to the final energy savings for users across sectors. Estimates have been calculated by taking the average avoided grid import costs for each user and multiplying this by the % of DER generation consumed. This is forecasted to be USD 14.9M for the whole programme to 2030 including USD 8.2M for residential users, USD 2.6M for commercial users and USD 4.1M for industrial user

13 Sustainability

Long-term sustainability is a critical component and key output of the programme, and as such will be integrated throughout the three core components outlined in section 8. The programme has been designed to build on lessons learnt from similar guarantee mechanisms, as well as aligning to the Colombia context and the Colombian Government's targets for emission reductions and increased flexibility. Providing a clear delivery structure and training for public sector participants and energy consultants/suppliers will also be critical to ensuring long-term sustainability and will ensure that users continue to be engaged beyond the programme and new commercial and local banks are brought on board.

The success of the programme, in supporting the contracting of users through aggregators/ESCOs and financial institutions, to deliver increased flexibility, will be self-perpetuating. As savings are delivered and contractual obligations are fulfilled, confidence in financing such projects will increase. This will result in the opportunity to lower coverage rates and collateral requirements for the guarantee mechanism and encourage commercial financial institutions to participate during and beyond the programme.

As the programme grows, there will be a need for increased capacity within aggregators and ESCOs, and within flexibility markets. The programme will actively support and encourage emerging ESCOs and SMEs through its procurement processes and collaborating with other programmes and activities locally.

The involvement of the private sector, alongside applications to other funding sources for expansion and mainstreaming, all contribute to the long-term success and therefore sustainability of the programme.

14 Activities and timeline

The programme would go through a development and setup phase in its first year e.g. towards the end of 2023, to ensure the delivery structure is sound, donors, and delivery partners are onboarded and the guarantee mechanism is enabled. The entire programme is set to run to 2030, with the three main components or workstreams on the programme, generating demand, building a pipeline of projects and unlocking finance would then in tandem following the setup phase.

Figure 4. Programme timeline

15 Risks

Table 9. Programme risks and mitigation strategies

Risk Category	Risk Description	Probability (L/M/H)	Impact (L/M/H)	Mitigation strategy
Technical	Complications with installations and maintenance/ equipment not compatible with existing electrical systems.	M	H	Conduct thorough assessments of existing electrical systems and sites and consult with energy experts and consultants to ensure compatibility prior to installation.
Environmental	Weather conditions not conducive to solar panel efficiency in certain locations/lower capacity factors	M	M	Incorporate weather data analysis into project planning to identify the best locations for installation, as well as backup power sources for extended periods of low sunlight.
Financial	Fluctuations in the cost of solar panels and batteries	H	M	Maintain close relationships with suppliers to monitor price changes and include cost contingencies in project budgets.
Regulatory	Changes in government policies and regulations impacting DER incentives and initiatives	H	H	Stay informed of policy and regulatory changes through ongoing research and establish contingency plans to mitigate the impact of such changes. Maintain strong lines of communication with relevant government ministers.
Health and Safety	Accidents and injuries during installation or maintenance of equipment	L	H	Conduct thorough training for all consultants and suppliers, establish clear safety protocols, and provide personal protective equipment where required.
Stakeholder	Resistance or opposition from property owners or local communities	M	M	Conduct outreach and education efforts while generating demand for the programme to build support and understanding among stakeholders and seek input and feedback to address concerns and objections.
Project Schedules	Delays in equipment delivery or installation	H	H	Establish clear timelines and deadlines for all projects and monitor progress closely to identify potential issues to address them promptly.
Quality	Equipment malfunction or failure	L	H	Conduct thorough quality control measures throughout the installation process and establish clear protocols for ongoing maintenance and monitoring of equipment performance.

16 Next steps

Setting up a multi-year programme, as proposed within this document, is complex and will require strong organisation and alignment across interested parties from the outset. The following next steps are an outline of pragmatic actions required to set the foundations of the programme but should not be considered an extensive or comprehensive implementation plan. Additional consultations, discussions, agreements and feasibility studies will likely to require before this programme can be undertaken.

1. Engage with stakeholders, including businesses, aggregators, financial institutions, NGOs, and government agencies, to build a coalition of support for the programme. This can help to raise awareness and drive adoption of flexible technologies.

2. Tender and/or identify the PMO to facilitate the programme and identify and engage with relevant stakeholders including the guarantee provider, energy consultants, suppliers and a marketing provider.

3. Work with the new Colombian Government and key partners to identify and engage the right guarantee mechanism provider e.g. NAMA. Explore the best financing options for the guarantee mechanism. This will require engaging with local and commercial banks in Colombia.

4. Set up Programme Steering Committee (SC) by convening the main programme political and financial partners and sponsors including the PMO and financial institution that will provide the guarantee fund.

5. Work with relevant government agencies to develop a regulatory framework that promotes the adoption of BESS and Solar PV as well as other energy efficiency and demand management technologies and behaviours. This could include policies such as tax incentives, net metering, and renewable portfolio standards.

6. Work with selected energy consultants and suppliers to build capacity. Provide training and capacity building programmes for local businesses and contractors to install, operate, and maintain flexible technologies. This can help to build a local workforce with the skills needed to support the growth of the industry.

7. Develop a monitoring and evaluation framework to track the impact of the program on energy savings, carbon emissions, and flexible capacity. This can help to identify areas for improvement and guide future investments in DER technologies.

By implementing these initial steps, the foundations for the programme can be set in place and the likelihood of achieving the programmes aims, to help accelerate the adoption of energy efficiency and flexible technologies in Colombia, providing energy savings, reducing carbon emissions, and increasing flexible capacity, will be increased.

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Appendix

Appendix A – multi-stakeholder consultation exercise led by the Carbon Trust: Identificación de soluciones: Redes inteligentes

Temáticas

Colombia inteligente

El futuro es de todos | Minenergía | upme

NAMA Redes Inteligentes

+20 Temáticas

Tipo	CEO	EMCALI	ENEL	EPM/CELSIA	XM
MOU					
Convenio					
Contrato servicios					
Acuerdo confidencialidad					
Contrapartida					
Lo solicitado					

CEO (Compañía Energética de Occidente)

1. Comunidad energética con *microgrid* en municipio del CAUCA
2. Esquema de automatización avanzada en un circuito de distribución del SDL

CELSIA

1. Plan de incentivos para la vinculación de usuarios a programas RD

enel (codensa)

1. Cambio de red MT y BT por red trenzada
2. *Storage* La Unión
3. Urban *Futurabiliy* Fenicia - Modelo

xm

1. Metodología pronostico de DER en Dxn
2. Metodología análisis flexibilidad y resiliencia ante la integración de DER
3. Proyecto Operación Futura (PAO)

EMCALI

1. Integración MDM existente con sistema comercial y GIDI

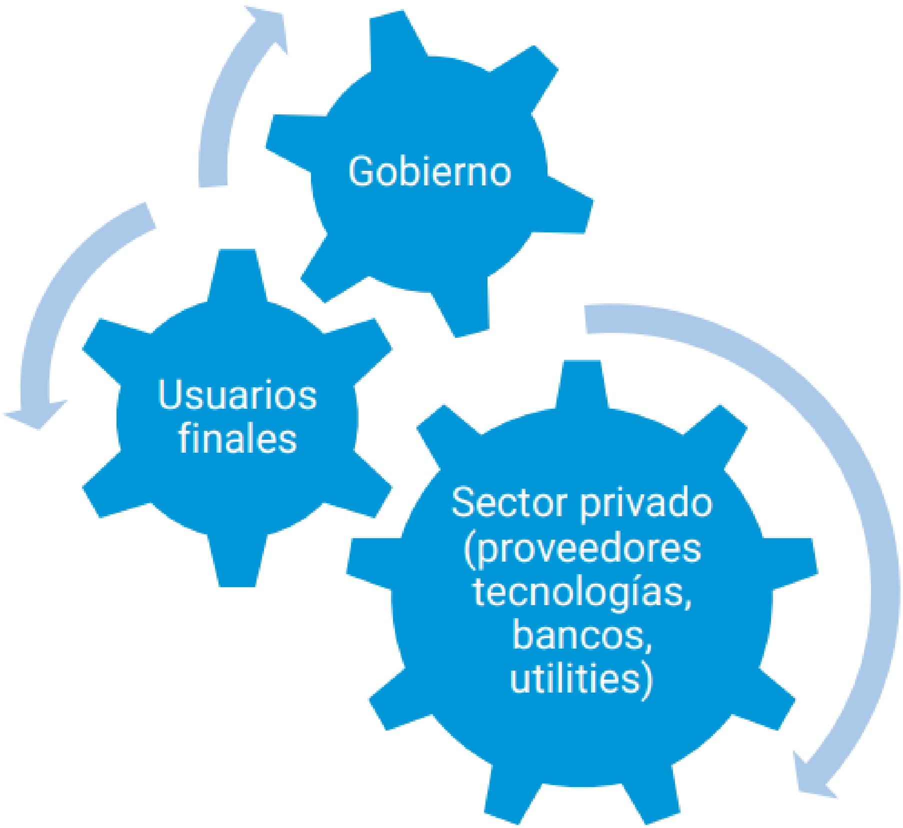
epm

1. Subestaciones digitales Fase 3
2. FACT distribuidos - Aplicaciones radiales
3. Centro *sandbox* de redes inteligentes
4. Centro Gestión de la Medida - Avanzado
5. Centro Gestión de activos - Tiempo real/Mntto Pred.
6. AMI - Arquitectura/Laboratorio/Modelo Negocio
7. Hoja de ruta Redes Inteligentes – Met. SGAM
8. Almacenamiento - Formación de capacidades
9. Autosaneamiento red - Estrategias de optimización
10. "*Energy as a service*" en ZNI - Modelo


CARBON TRUST
Identificación de soluciones: Redes inteligentes
Daniel Perdomo Rodriguez, Carbon Trust
21 July 2021

Soluciones

1. Regulatorias
2. Técnicas
3. Financieras
4. Conocimiento y Compromiso



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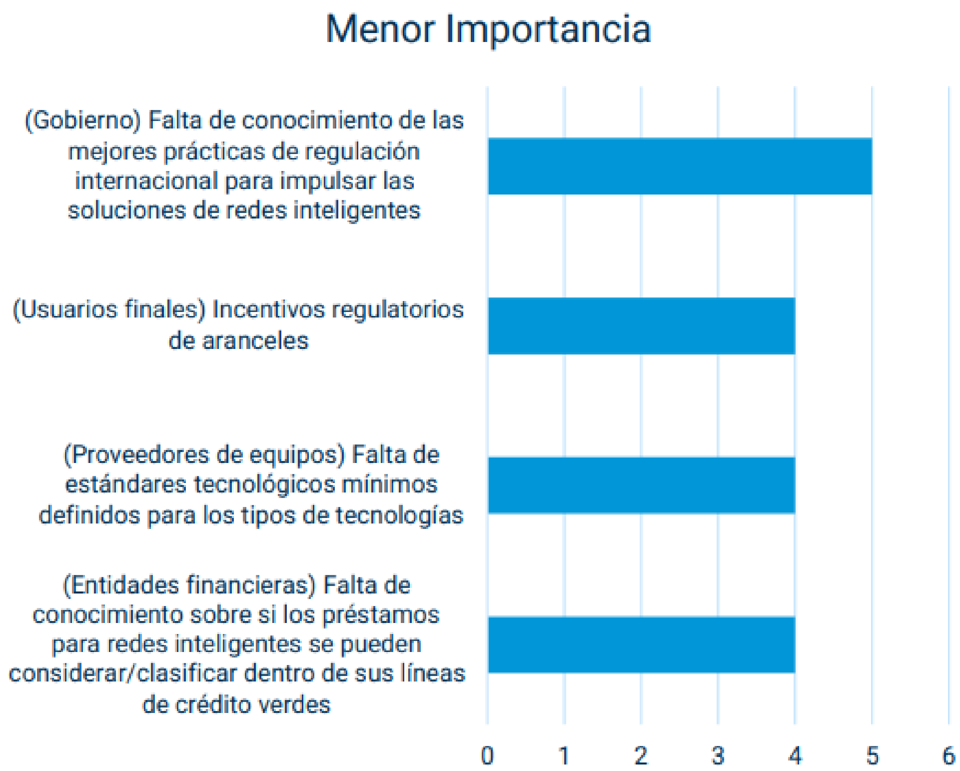
3

respuestas totales: 12

1a. Barreras regulatorias: resultados



1b. Soluciones regulatorias

<table>
<tr><th>Actores</th><th>Barreras</th><th>Soluciones posibles</th></tr>
<tr><td>Usuarios finales: sector industrial, comercial y residencial</td><td>Falta de incentivos regulatorios de mercado para la adopción de tecnologías de redes inteligentes

Falta de incentivos regulatorios financieros para la adopción de tecnologías de redes inteligentes

Falta de esquemas tarifarios (señales de precios) para la adopción de tecnologías de redes inteligentes</td><td rowspan="2">1. Transferencia de las mejores prácticas internacionales (incentivos regulatorios y financieros), incluyendo tarifas variables de energía

2. Una hoja de ruta para implementar mejores practicas internacionales adaptada a las condiciones locales</td></tr>
<tr><td>Gobierno / Responsables políticos</td><td>Falta de conocimiento de las mejores prácticas de regulación internacional para impulsar las soluciones de redes inteligentes</td></tr>
</table>

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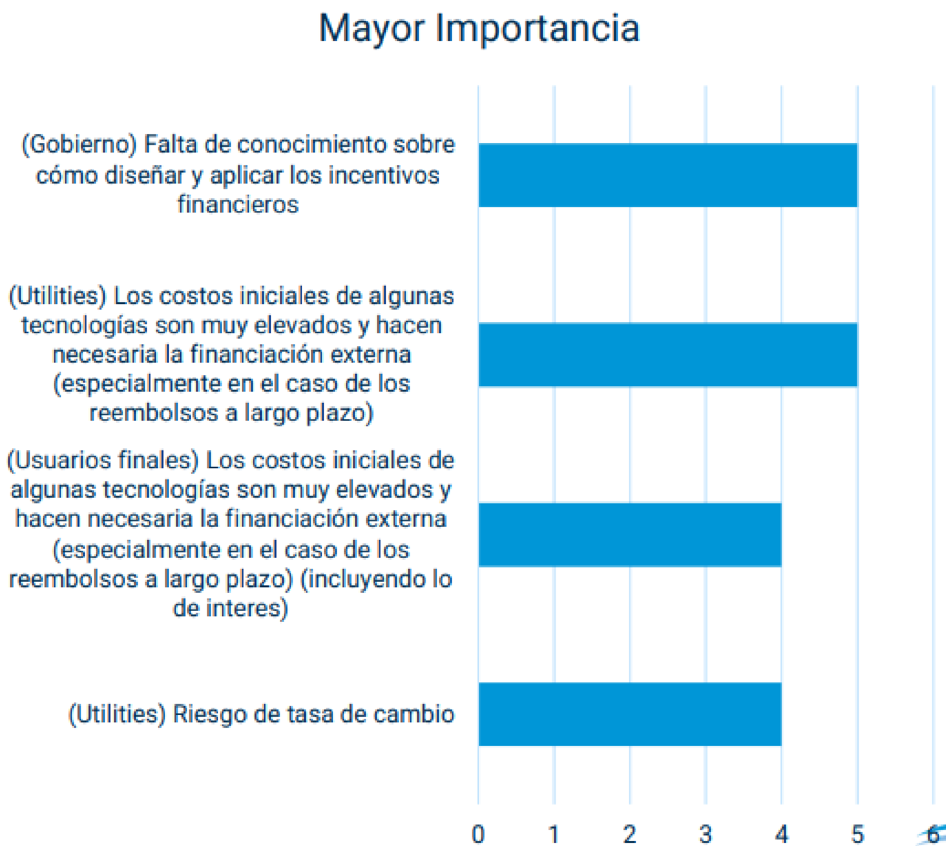
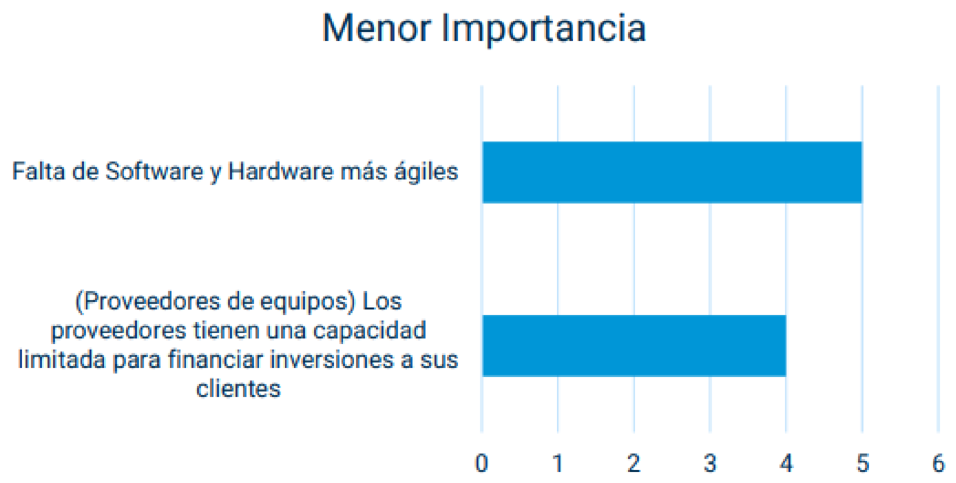
5

respuestas totales: 10

2a. Barreras financieras: resultados





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2b. Soluciones financieras

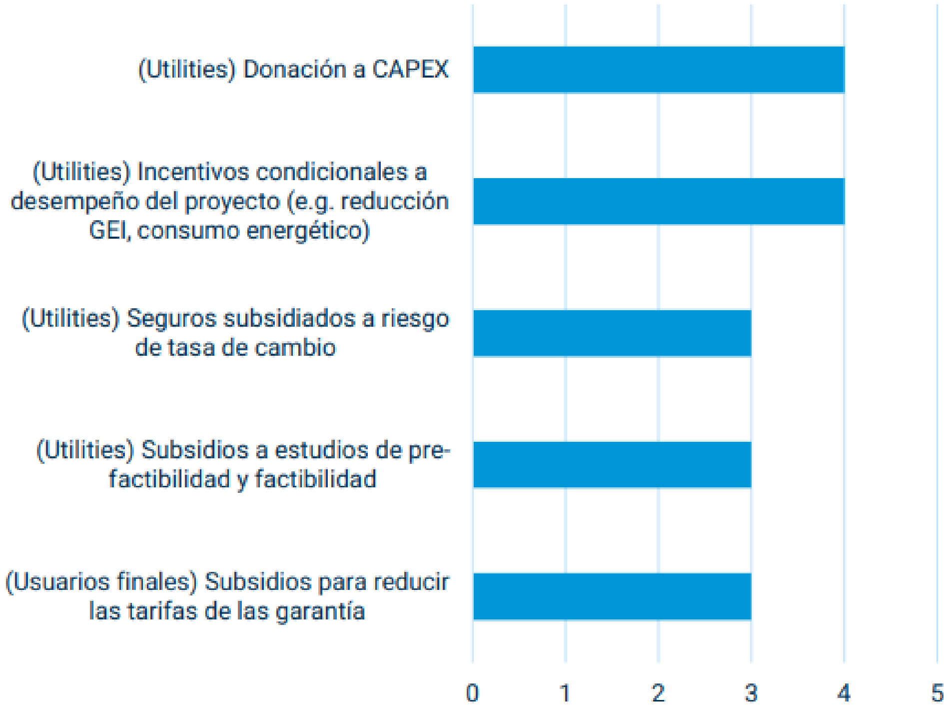
Actores	Barreras	Soluciones posibles
Usuarios finales: Sector industrial, comercial y residencial	- Los costos iniciales de algunas tecnologías son muy elevados y hacen necesaria la financiación externa (especialmente en el caso de los reembolsos a largo plazo)	- Donación a CAPEX - Mayor duración de los préstamos - Subsidios para reducir las tarifas de las garantía - Tasas de interés concesionales (subsidiadas) - Mayor periodo de gracia del préstamo - Leasing - Subsidios a estudios de pre-factibilidad y factibilidad - Incentivos condicionales a desempeño (e.g. reducción GEI, consumo energético)
Utilities	- Los costos iniciales de algunas tecnologías son muy elevados y hacen necesaria la financiación externa (especialmente en el caso de los reembolsos a largo plazo) - Riesgo de tasa de cambio	- Donación a CAPEX - Mayor duración de los préstamos -Seguros subsidiados a riesgo de tasa de cambio - Subsidios para reducir las tarifas de las garantía - Tasas de interés concesionales (subsidiadas) - Mayor periodo de gracia del préstamo - Leasing - Subsidios a estudios de pre-factibilidad y factibilidad - Incentivos condicionales a desempeño del proyecto (e.g. reducción GEI, consumo energético)
Gobierno / Responsables políticos	Falta de conocimiento sobre cómo diseñar y aplicar los incentivos financieros	Transferencia de las mejores prácticas internacionales y apoyo en el asesoramiento para su implementación

7

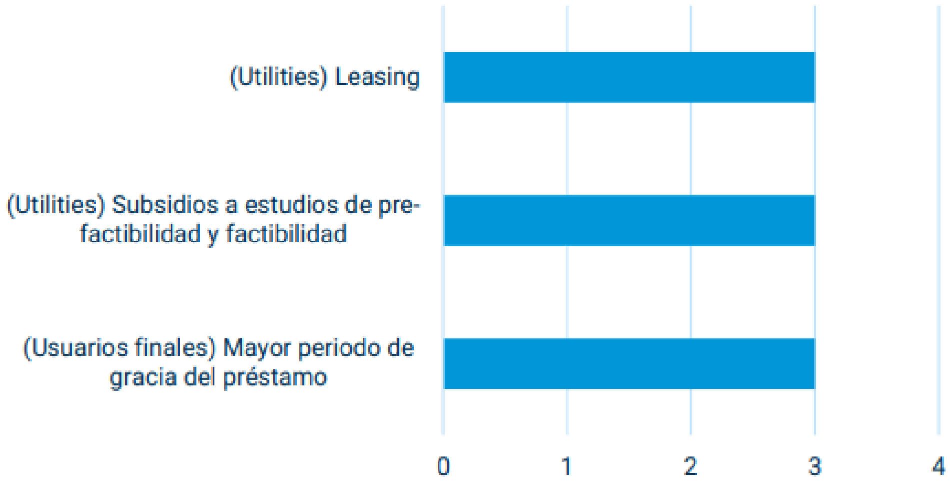
respuestas totales: 10

2c. Resultados soluciones financieras

Soluciones de mayor importancia



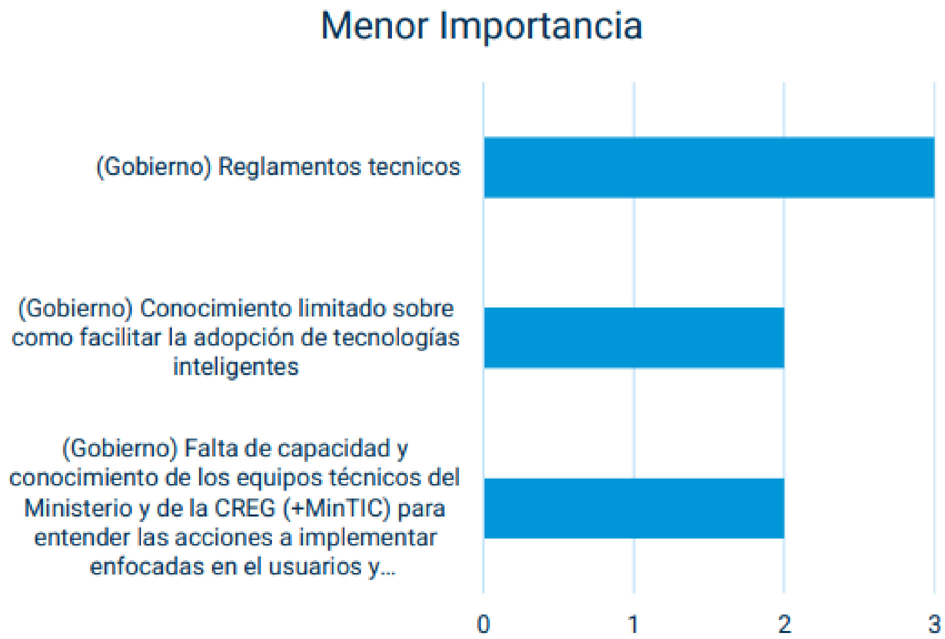
Soluciones de menor importancia



8

respuestas totales: 8

3a. Barreras técnicas: resultados



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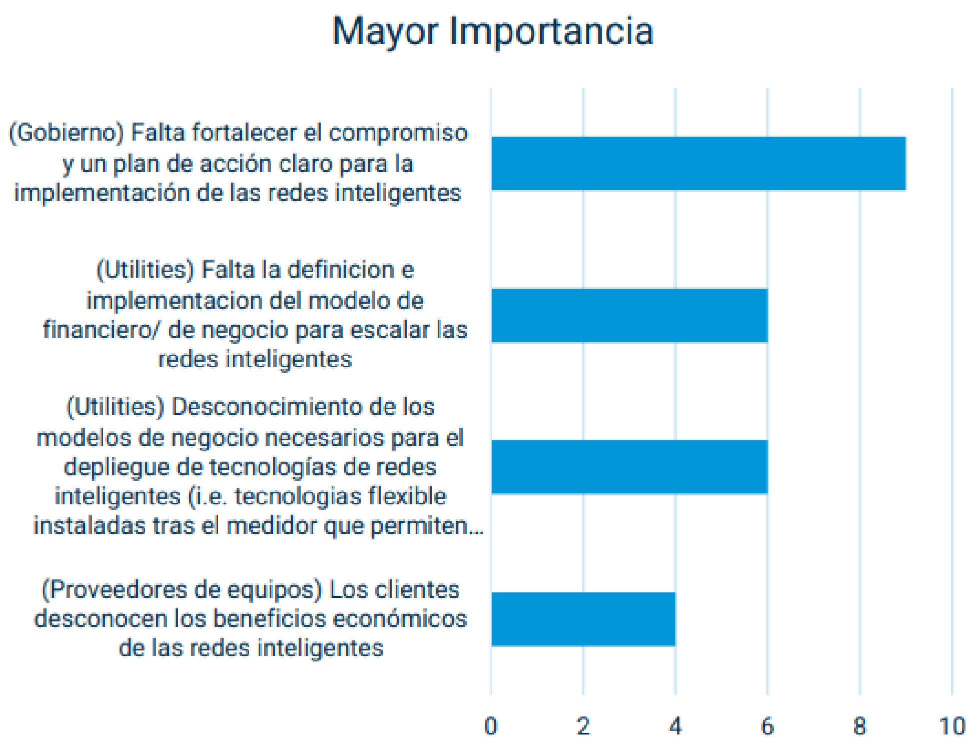
3b. Soluciones técnicas

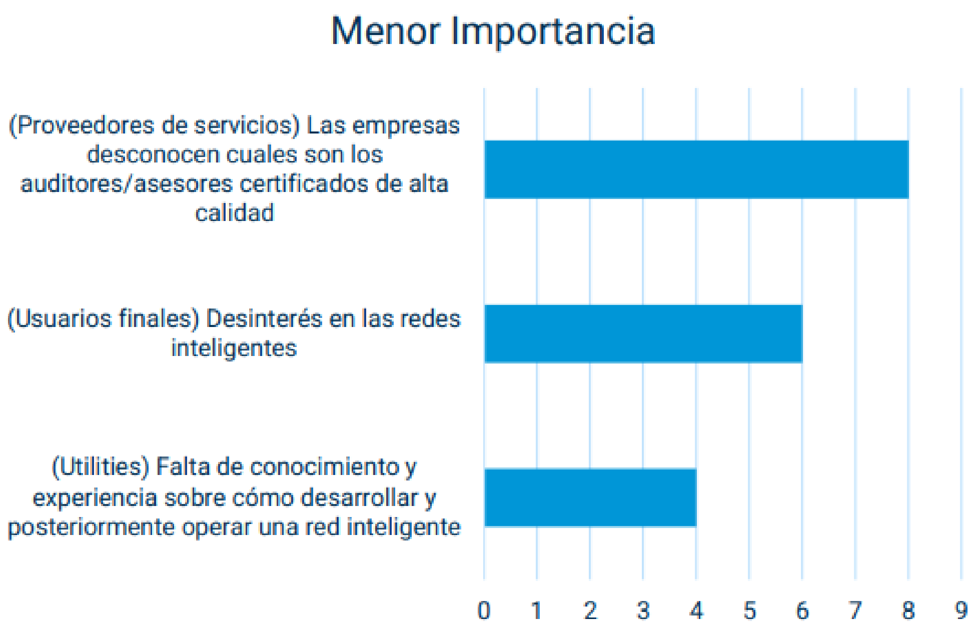
Actores	Barreras	Soluciones posibles
Entidades financieras	- La falta de estandarización y simplicidad conduce a un alto coste de transacción para dar servicio a muchas empresas individuales.	Desarrollo de capacidades
Proveedores de servicios: auditores, consultores, instaladores	- Falta de competencias para realizar las auditorías, evaluaciones, instalaciones, seguimiento y verificación exigidas por los financiadores y clientes	Directorio de empresas verdes (programa de certificación) Desarrollo de capacidades
Gobierno / Responsables políticos	- Conocimiento limitado sobre como facilitar la adopción de tecnologías inteligentes	- Formación para el desarrollo de capacidades - Asistencia técnica para realizar estudios de mercado que permitan cuantificar los bloqueos de comportamiento

10

respuestas totales: 13

4a. Barreras de conocimiento y compromiso: resultados





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4b. Soluciones de conocimiento y compromiso

Actores	Barreras	Soluciones posibles
Proveedores de equipos y tecnologías de redes inteligentes	- Los clientes desconocen los potenciales proveedores, equipos y tecnologías - Los clientes desconocen los beneficios económicos de las redes inteligentes	- Plataforma 'Green Technology Selector' para identificar equipos y proveedores - Proyectos piloto/mejores estudios de casos para generar confianza y demostrar los beneficios comerciales
Utilities	- Desconocimiento de los modelos de negocio necesarios para el despliegue de tecnologías de redes inteligentes (i.e. tecnologías flexible instaladas tras el medidor que permiten proveer servicios de red y flexibilizar la demanda) - Falta la definición e implementación del modelo financiero para escalar las redes inteligentes - Falta de conocimiento y experiencia sobre cómo desarrollar y posteriormente operar una red inteligente	- Proyectos piloto/mejores estudios de casos para generar confianza y demostrar los beneficios comerciales
Gobierno / Responsables políticos	Falta fortalecer el compromiso y un plan de acción claro para la implementación de las redes inteligentes	Acompañamiento en la actualización de la hoja de ruta de las redes inteligentes en Colombia

Appendix B – business case assumptions and calculations

Business case assumptions for Solar PV

Assumption	Residential	Commercial	Industrial	Rationale
Average annual electricity consumption (kWh) – small	NA	4,154	139,322	50% of mean annual consumption
Average annual electricity consumption (kWh) – medium	6,000	8,307	278,645	Total electricity consumption by sector divided by total electricity users in the sector (Energía), 2021) ((SUI) S. U., 2022)
Average annual electricity consumption (kWh) – large	NA	12,461	417,967	150% of mean annual consumption
Average installation size (kW) - small	NA	1.8	40	50% of average
Average installation size (kW) – medium	2.4	3.8	75	Average calculated from total consumption/consensus number of entities and Calculation based on average yield and demand profiles for different sectors. Assumes no power is exported.
Average installation size (kW) - large	NA	5.0	110	150% of average
Load factor	22.4%	22.4%	22.4%	Carbon Trust assumption based on prior work in Colombia
Generation consumed (%)	48%	55%	32%	Calculation based on average yield and demand profiles for different sectors. Assumes no power is exported.
Expected $ saving ($ per kWh) – grid cost	0.138	0.135	0.135	(GlobalPetrolPrices, 2022)
Expected emissions saving (g per kWh)	182	182	182	(OurWorldinData, 2022)
Cost per MW	1,600,000	1,600,000	1,370,000	Values include equipment, installation and network interconnection. UK average data for 2021-2022 for installations 0-4kW and 10-50kW converted to USD. ((DESNEZ), 2022)
Assumed Opex (as % of CAPEX)	1%	1%	1%	General assumption

Business case assumptions for BESS

Assumption	Residential	Commercial	Industrial	Rationale
Average annual electricity consumption (kWh) – small	NA	4,154	139,322	50% of mean annual consumption
Average annual electricity consumption (kWh) – medium	6,000	8,307	278,645	Total electricity consumption by sector divided by total electricity users in the sector (Energía), 2021) ((SUI) S. U., 2022)
Average annual electricity consumption (kWh) – large	NA	12,461	417,967	150% of mean annual consumption
Average installation size (kWh) – small	NA	NA	NA	NA
Average installation size (kWh) – medium	1.2	NA	NA	50% of solar installation
Average installation size (kWh) – large	NA	NA	NA	NA
Round trip efficiency	95%	95%	95%	Current technology average from Carbon Trust analysis
Generation consumed (%)	100%	100%	100%	General assumption
Expected $ saving ($ per kWh) – grid cost	0.138	0.135	0.135	(GlobalPetrolPrices, 2022)
Expected emissions saving (g per kWh)	182	182	182	(OurWorldinData, 2022)
Cost per MWh	350,000	350,000	350,000	Prices adapted from NREL (NREL, 2022)
Assumed Opex (as % of CAPEX)	1%	2%	2%	General assumption

Business case technical calculations

Technology	Metric	Calculation
Solar	Total installed capacity (MW)	Number of projects x Number of users per project x Average installed capacity **(e.g. 2.4kW) / 1000**
	Average annual MWh	Total installed capacity (MW) x load factor (**22.4%**) x hours per annum (**8760**)
	Expected avoided emissions (converted to tonnes of C02e)	Average annual MWh x expected grid carbon intensity (**182g per kWh**)
	Total expected user saving ($)	Average annual MWh x cost of electricity from grid **($0.135 per kWh**) x generation consumed **(residential 48%/commercial 55%/industrial 32%)**
Batteries	Total installed capacity (MWh)	Number of projects x Number of users per project x Average installed capacity **(e.g. 1 kWh) / 1000**
	Average annual MWh	Total installed capacity (MWh) x round trip efficiency (**95%**) x number of cycles per year (**365**)
	Expected avoided emissions (tonnes of C02e)	Average annual kWh x expected grid carbon intensity (**182g per kWh**) / 1,000,000
	Total expected user saving ($)	Average annual MWh x cost of electricity from grid **($0.135 per kWh**)
Other	BAU emissions	Average annual electricity consumption per user (kWh) x grid carbon intensity (**182g per kWh**) x number of users x annual increase of **5% per annum** / 1,000,000

Business case financial calculations

Metric	Calculation
CAPEX	Cost per MW installed **($1.5m)** x average number of MWs installed per annum
OPEX	Cost per MW installed x average number of MWs installed per annum x assumed percentage (e.g. 1%)
Technical assistance costs	Number of team members including energy consultants/suppliers (includes contracted marketing team for demand generation) x average cost per team member per annum ($5,600)
Total cost to facility	(CAPEX + OPEX + technical assistance costs) x **% covered by guarantee mechanism (15%)**
Discounted cash flow	Total annual cost / (1 + discount rate **(6%))** ^ year
Guarantee loan balance	Net cumulative discounted cash flow (2024-2030)

UK PACT