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The power of bottom-up and multi-stakeholder approaches to improving the uptake of sustainable household energy technologies in non-OECD economies

Abstract

Energy efficiency and renewable energy technologies in households have a key role for the achievement of the Paris Agreement and to contribute to various SDGs. In pursuit of these objectives, multilateral funds, in conjunction with local governments, design and implement different technology transfer policies. However, the results are very different. In this article we explore recent cases of energy policies to increase the use of renewable and energy efficiency technologies and practices in households in some countries of Latin America, with the aim to identify the key means to closing the gap between technology needs and implementation. We identify two key aspects that determine the impact and result of technology uptake: the elaboration of policies with a bottom-up and multi-stakeholder perspective. With this in mind, we offer some policy recommendations.

Introduction

Energy efficiency and renewable energy technologies in households have a key role in achieving the Paris Agreement goals and the clean energy transition, with significant co-benefits for socioeconomic development, especially for developing regions. However, there is a significant unrealised potential in household energy efficiency measures, across the world. This means that the amount of energy used to fulfil different energy services (e.g. heating, cooling, lighting, transportation, producing goods) could, and should, be lower than it is today. Similarly, there is still a huge potential to increase the use of renewable energy technologies at the household level.

In order to close these gaps, multilateral funds, in conjunction with local governments, have to convert the political rhetoric on the transfer of clean or environmentally sound technologies (EST), into reality before 2030. Key to achieving this will be government-driven policies, based on a combination of push and pull instruments, to enable and incentivise investment at the household level. To date, the results of such actions have been mixed.

Within the academic and grey literature, there is a wide consensus regarding the importance of local context in determining the success, or not, of the policies implemented. There is a long list of boundaries or enabling conditions that may improve (or reduce) the technology capacity to penetrate local markets. For example, the existence of a latent demand for renewables or energy efficiency technologies that generates a suitable niche market and the capacity of technologies to meet an existing local need. It is equally important to understand the market conditions for this need to be satisfied by economic goods, the competitiveness of the technology and the payment capacity of the population. Other factors include the availability of other resources and goods which are necessary for the technology to meet a need, and the existence of technical and economic capacity to deploy the technology at national or regional level. These are some of the key issues that policy makers need to consider and address when designing national strategies to accelerate the uptake of household energy efficiency and renewable energy technologies.

Framed by these issues, we explore recent cases of energy policies to increase the use of renewable and energy efficiency technologies and practices in households in some countries of Latin America. In doing so we aim to identify the key aspects to close the gap between technology needs and implementation. Specifically, we aim to answer two questions:

1. What are the key aspects to be considered during the design phase?

2. Which of these aspects is most relevant in the implementation phase, to accelerate local technology adoption?

We attempt to answer these questions by reflecting on real-world case studies from across Latin America.

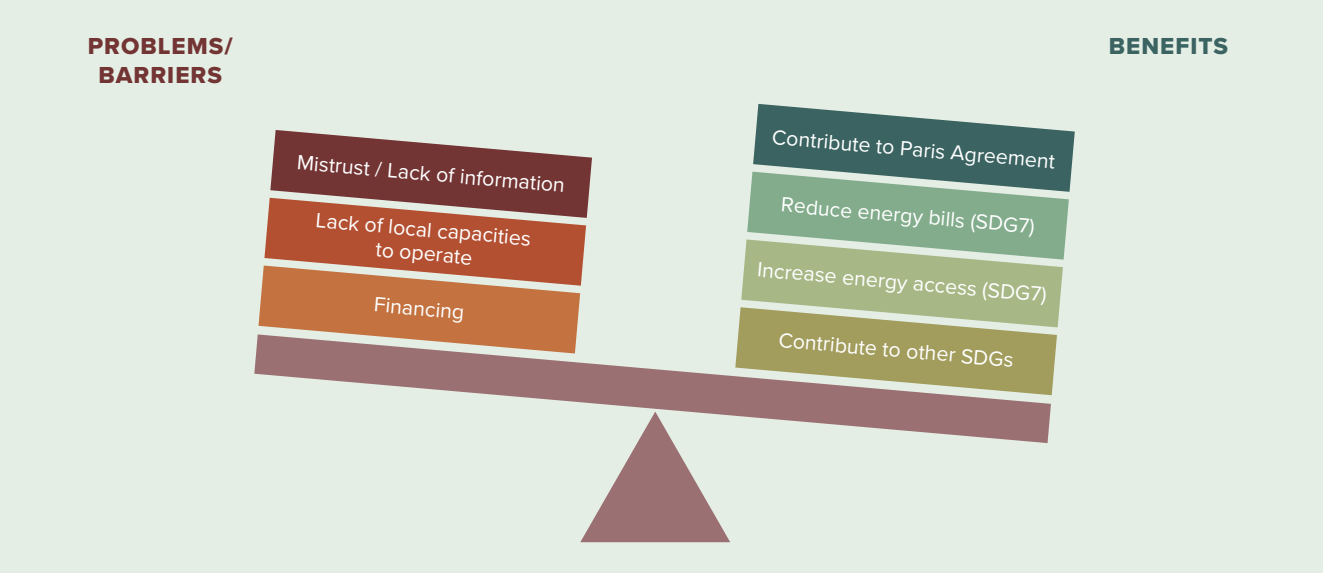
Household energy efficiency and renewable energy technologies: an opportunity for developing regions to meet the Paris Agreement and SDG7

The household sector accounts for the needs of private domestic consumers to meet different energy services, such as space heating and cooling, water heating, cooking, lighting, electricity for appliances, among others. All these services are crucial for individual welfare and development. Access to electricity and other modern energy sources improves health and education conditions, with the consequent impact on human capital, as well as direct welfare impacts from the financial cost of energy supply.

The household sector is one of the largest end-use sectors worldwide. Household energy consumption is driven by different variables, such as geography, weather, building structure, energy prices, appliances prices, availability of energy sources, cultural aspects, population growth, per capita and household income, among others.

Energy policies focused on the household sector in developing regions are very important, both for their contribution to Sustainable Development Goals (SDGs), and the contribution to the Paris Agreement objectives. Indeed, SDG7 states *"Ensure access to affordable, reliable, sustainable and modern energy for all"* by 2030, where energy efficiency actions, as well as renewable energy, have a clear impact. Renewable energy and energy efficiency may also be a good way to complement other SDGs in developing regions, such as SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), SDG 5 (Gender Equality), SDG 10 (Reducing Inequality), among others. Despite these clear benefits, technology uptake has been slow and erratic across

Figure 1. Barriers and benefits for renewable and energy efficiency technology adoption in developing regions



most developing countries, especially in Latin America, for diverse reasons that are important to explore.

A commonly cited definition of environmental technologies classifies them in terms of hardware, software and 'orgware', referring to the mix of material components, know-how and systems to manage technologies, once installed.[i] This is the case of medium to low-income households, in which actions related to the phasing-out of inefficient technologies and promotion of new efficient alternatives are as relevant as behavioural changes in using the technologies and resources.

For instance, in the case of the adoption of energy efficient technologies in households, in general, the most important barriers, particularly in low-income homes, are:[ii, iii, iv]

- Lack of access to modern energy sources
- Low-income households tend to live in old and low-quality buildings with low energy efficiency standards
- Lack of access to affordable finance for retro-fitting technologies, even if they offer short pay-back periods
- Energy efficiency is not seen as a priority given competing basic needs
- Most vulnerable and low-income communities have lower levels of trust in local authorities, policy makers, companies, and other stakeholders
- These homes usually do not have access to reliable information and knowledge required to evaluate the energy efficiency opportunities
- The frequent use of second-hand markets to purchase appliances
- Magnified perception of upfront costs in comparison to the cost of energy bills

Technology transfer strategies in low to medium income homes in developing regions need to be designed carefully, taking into consideration all these issues.

Designing interventions bottom-up

Challenges to the success of technology transfer in developing regions mostly emerge from a methodological perspective, in the design phase of the policy or intervention. Many strategies are conceived from a universal deterministic and top-down viewpoint, without considering the enabling conditions for technology implementation, diffusion, and uptake.

The universal deterministic point of view means extrapolating successful policies from one region or another, which usually fails. Top-down interventions tend to fail because they lack a careful evaluation of context and case particularities. This standpoint ignores the relevance of context (border) conditions. Either for energy and socioeconomic systems, as well as for the implementation of energy policies, both context and history influence the current and future outcomes and evolution. Energy services and energy demand in households, for instance, depend on environmental and geographical characteristics such as climate

and geography, but also the economy, culture, habits, etc. There are numerous examples of otherwise successful experiences that have failed, when 'imported' top-down in the LAC region.

Ecuador's strategy to introduce induction stoves in low-income households is an example of this policy perspective and its results. Ecuador implemented a program with the aim of installing 3 million induction stoves. These stoves were installed in border areas, characterized by high LPG consumption levels and LPG smuggled to Colombia and Peru, as a result of the low price of this fuel in the country. Due to the lack of State control, commercial companies forced marketed induction stoves to low-income homes. The buyers incurred unpayable debts, in addition to heavy investments from the State, which had to extend the 220-volt distribution networks which, in some cases, a year after receiving the stoves, remained unused. Electricity bills in these households increased, in some cases up to ten times. Furthermore, even though the program was supposed to be a boost to the national industry, the stoves were imported from China at prices that were not competitive for the incipient national industry, with the opposite desired impact on the national economy. The failure of this policy was mainly due to the way it was designed, without considering all policy dimensions and local context.

A similar example of the failure of top-down policies can be found in the case of the GEF program to place 15,000 PV panels to provide electricity to isolated residents in the Peruvian Amazon, very close to the border with Ecuador. The project faced multiple difficulties and had to be abandoned due to the lack of a comprehensive evaluation of the location, socio-cultural realities and complexity of the technology. The main obstacles faced by the project, were, firstly, the selection of the region that was very difficult to access and very far from urban centres that could provide support to the users and with changing water courses. Secondly, most of the inhabitants of the region were nomadic, they abandoned their precarious dwellings when the rivers changed their course. Thirdly, all the equipment remained under the property of the State because of national regulations. This legal framework prevented the transfer of property to the users, and the State also had to take care of project maintenance costs (which were very high due to location). In short, only a few devices were installed, and the project could only be partially completed by choosing other regions of the country to install the equipment. Once again, an inadequate evaluation of reality and a geopolitical decision resulted in an unsuccessful and costly project.

There are also successful cases in which a technology is perfectly adopted, even without policy intervention. This is the case of the adoption of windmills for water pumping in the Argentine Humid Pampa. Argentina had natural resources to produce millions of cattle, which, in addition to rich pastures, required water that could be obtained from the ground, to support the beef export program to the United Kingdom. The technology to pump water was already known in the USA, since the 19th century. In this context, private actors began to import these mills from the USA, though they soon realised these machines were easy to manufacture. This kick-started a process of import substitution and technology improvement, where the mills began to be made of metal and gave rise to a new industrial and market niche. Simultaneously, in the small towns of the rural areas, a new opportunity arose and the development of skills, often in a totally self-taught way, of the so-called Molinero (miller). This last element implied a huge education and training strategy in a few decades that produced excellent results in very early times. This is an excellent example for the technology uptake without specific policies linked, thanks to a combination of elements: a product (meat) demand, that generated a derived demand, abundant natural resources to produce it in large quantities and the existence of technology that allowed access to one of the resources that the productive activity required. This was complemented by the existence of capacities to adapt, improve and disseminate the technology and, finally, the capacity to operate and maintain the technology in the dispersed places where it was located.

Top-down interventions are meant to fail in most of the cases, particularly for policies targeted at the household level. In contrast, bottom-up policies have proved to be more successful in many circumstances in developing countries. This, however, does not mean that learnt lessons are not useful, but they need to be adapted. For the case of renewable and energy efficiency technology in households this implies, at least: 1) a careful evaluation of the household demand, and the energy service that needs to be fulfilled; 2) the best technology option (hardware, software and orgware) to be used in the specific case, and 3) the barriers for the technology uptake. Steps 2 and 3 are the most relevant in terms of pursuing a bottom-up approach. In the case of technology selection, Franco et al. (2017)[v] and Schmukler

(2018)[vi] stress that socio-technical adequacy is extremely relevant for the local adaptation and incorporation of a technology. This means that the technology needs to adapt to the socio-demographic context in which it is transferred. This aspect, therefore, reveals the importance of local participation during the design process, avoiding a reliance on assumptions or ideas defined top-down. Then, during the implementation phase, flexibility is key. Technology adoption barriers are clearly case dependent, and so must be the policy instruments.

The value of multi-stakeholder perspectives: the role of local organizations to improve the design and impact of projects

Participants in technology transfer include not only those involved in the direct transactions (private firms, state-owned companies and individual consumers), but also many others who play important roles "behind the scenes" (financiers, aid agencies, national governments, international institutions and local community groups). Results are positive when all stakeholders communicate and actively participate. As stressed by UNEP, a multi-stakeholder partnership and the existence of local partners seems to be crucial to accelerate and consolidate changes in consumption patterns.

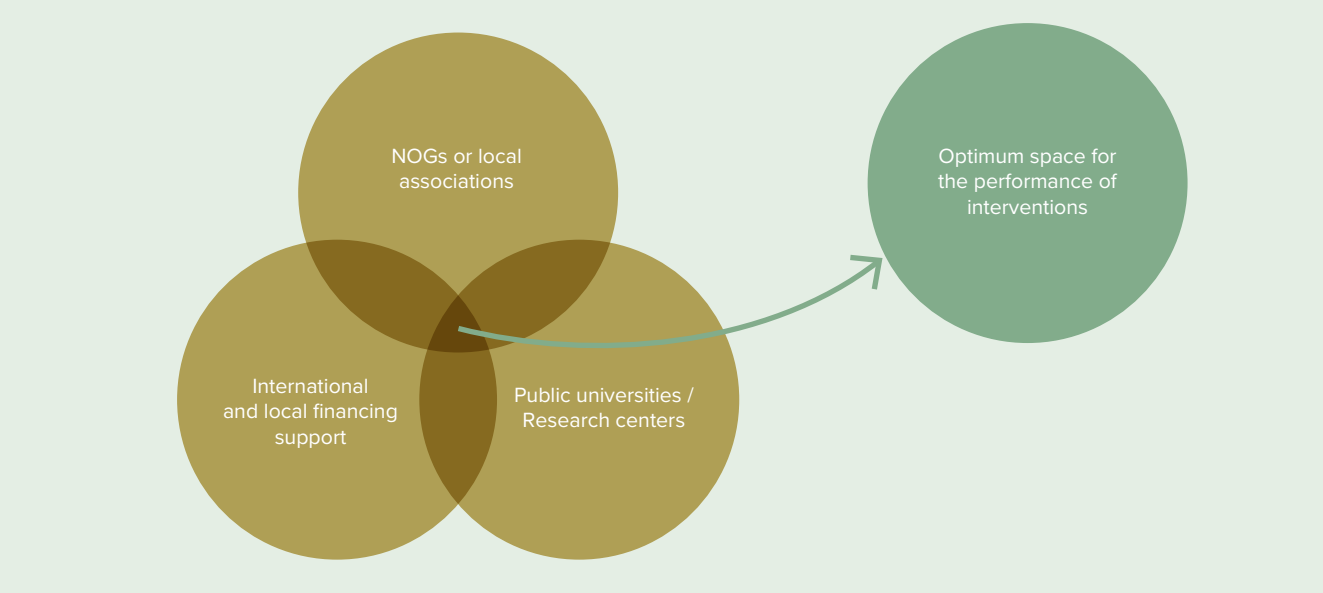
Figure 2 shows the best space for technology uptake at the household level during the implementation step. Firstly, interventions need to be designed, co-designed or/and implemented by local institutions /organizations with good knowledge of the local context. This aspect helps to remove the social barrier related to the low levels of trust in local authorities, policy makers, companies, and other stakeholders that implement the policies (which increases in the case of international interventions).

Secondly, the lack of access to reliable information and knowledge on energy technologies is a characteristic of many homes in developing regions. This barrier should be, mostly, addressed in advance to any other barrier. There is a significant amount of information delivered by international institutions or organizations (and even by national governmental departments), but this information does not always reach the target end users. An approach to tackle this problem is to provide specific capacity building programs during the transfer process. This key process could be developed by public universities, research centres or academic institutions. Thirdly, regarding the financial barrier, local and international funds may be needed. In this case, an alternative may be to establish a financing strategy with electricity and natural gas utilities, particularly in the case of energy efficiency actions.

A bottom-up and multi-stakeholder experience for energy efficiency actions in low and medium-income neighbourhoods in Argentina

There are numerous examples of projects designed by local organisations, bottom-up, offering valuable insights and

Figure 2. Strategies for involving diverse stakeholders and institutions



lessons. Here we focus on a recent Argentinean program to increase energy efficiency in low- and medium-income houses in the Metropolitan Area of Buenos Aires (AMBA in Spanish): Neighbourhood Energy Focal Points. This project, implemented by the Non-Governmental Organization (NGO) Fundación Pro Vivienda Social (FPVS in Spanish)[1] and the School of Science and Technology (ECyT in Spanish) of the Universidad Nacional de San Martin (UNSAM in Spanish), provides training to residents of the target neighbourhoods on how to manage their energy resources and adopt energy efficient practices. In words of Salvador Gil, director of Energy Engineering at UNSAM and project manager "…with efficient energy use (low-income homes) can also save the physical effort and transportation costs of buying firewood or LPG…."[vii, viii] Therefore, this project aims at reducing GHG emissions and improving quality of life. As such, the idea is to transfer knowledge about efficient managerial procedures on energy use to households in the lower-income category. To 2020, more than 15 neighbourhood leaders were trained, who have advised more than 100 households on how to save energy.

In this project, the neighbourhood energy focal points carry out energy audits, measure the consumption of all appliances in participating homes and identify the most important aspects of domestic energy consumption.[vii] The work has two key connected purposes:

1. To train students of the Energy Engineering career at UNSAM and related courses on how to conduct household energy audits and efficient energy management.

2. Train neighbourhood energy focal points through a program of virtual classes, where the participants were originally members of the FPS. The training focuses on carrying out energy diagnostics of homes in different neighbourhoods in the peripheral and marginal areas of the greater Buenos Aires – generally low-income – and provide guidelines for the efficient use of energy in their homes.

Based on these evaluations, the neighbourhood energy representatives provide practical advice on energy management actions that can be implemented by the households in order to reduce energy consumption. Some are very simple, other more complex, such as:[vi, vii]

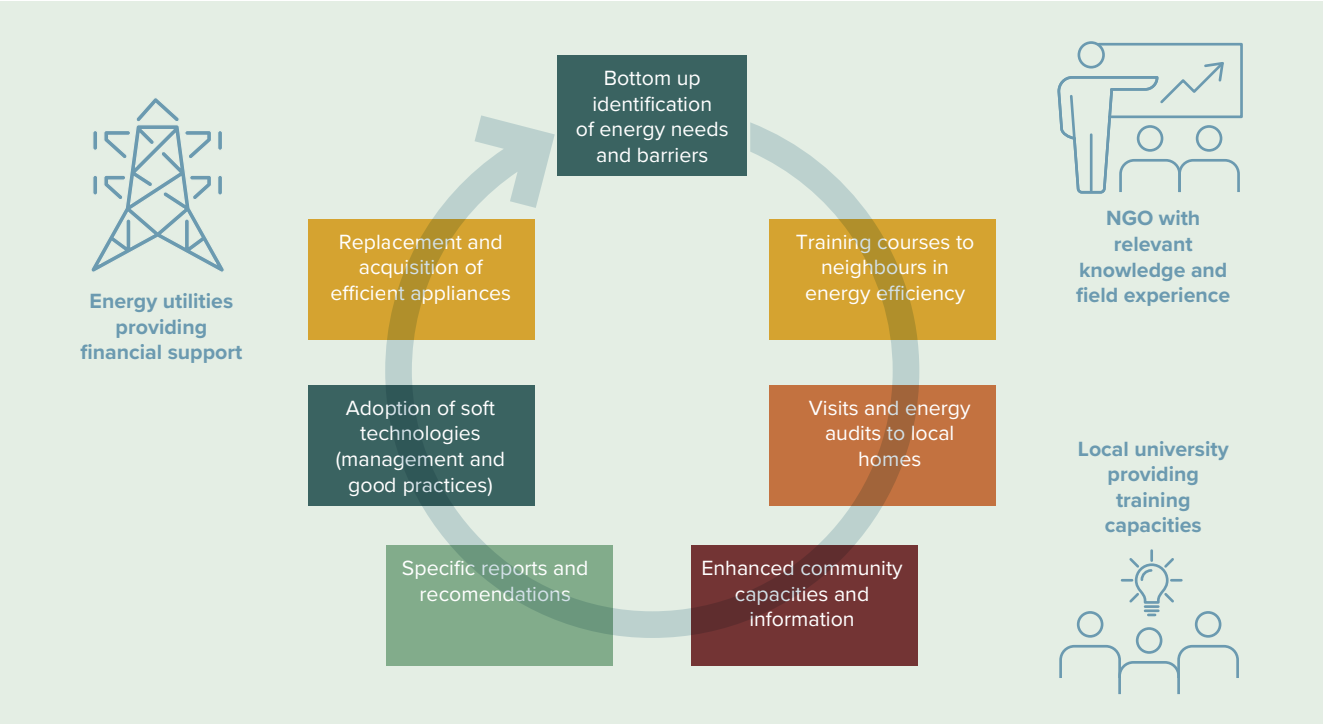
- Reduce air infiltrations, with carpenter's tape and nylon
- Regulate the heating and cooling temperature with a simple wall thermometer or by regulating the thermostats of some equipment
- Choose or opt for an adequate and efficient heating system
- Heating only the places that need it
- In refrigeration, use as much as possible evaporative fans and air conditioners, which consume 10% less than an air conditioner, especially when temperatures do not exceed 30 °C
- Purchase domestic hot water heating systems (DHW) with an energy efficiency label
- Choose refrigerators class A (or better) in energy efficiency
- Replace old light bulbs with LED technology

The last four actions mentioned focus on low-cost technology options (mostly managerial actions) need to be accompanied by more costly actions including the replacement of hardware and appliances, which may require additional supply-side support, where leadership from national Energy Authorities is needed.

A notable aspect about this experience in terms of technology transfer, is the integrated and inclusive approach in which it has been designed. In this case, this multi-stakeholder partnership has included the three dimensions mentioned in Figure 2. Firstly, the UNSAM, which provides most of the capacity building for the program. Secondly, as stressed by Gil (2020)[vi] the FPVS is a NGO that has been working for more than 20 years with low-income neighbourhoods in the AMBA. During that time, it has contributed not only to the construction of natural gas networks, which offer a more economical and reliable service, but also to the participation of neighbours in the laying of networks and internal installations. This experience was crucial to increase local acceptance. The participation of a NGO with longstanding experience in the region is very important to remove the barriers related to the confidence of the community, their willingness to engage with external stakeholders. Thirdly, the electricity utility, EDENOR, that has the local responsibility for electricity distribution in the area, provided financial and technical support. The participation of the electricity company in this type of project reflects their enlightened self-interest, as the efficient use of electricity among end users helps reduce distribution losses and

[1] http://fpvs.org/eficiencia-energetica/

Figure 3. Successful elements and stakeholders of the "Neighbourhood Energy Focal Points" project in the AMBA



increase the quality of supply, by minimising periods of peak demand.

A key aspect that seems to have increased the performance of the project is that it was built with a bottom-up perspective. Indeed, the idea of the project emerged from people with long-term experience in the local community, who are familiar with the real needs, information and capacities of the local households. This is extremely relevant, as many technology transfer experiences tend to fail due to low levels of community uptake, reflecting interventions designed top-down that fail to meet local needs and circumstances. As mentioned by Gil this project emerged from the existing knowledge of FPS in the area, which contacted the UNSAM to look for a way to reduce energy consumption in homes in these neighbourhoods, as a result both institutions created the training course for neighbourhood energy managers.

A third relevant aspect of this project is that it focuses on removing the information and capacity barriers prior to other interventions, which is commonly cited as a fundamental barrier to the adoption of energy efficiency technologies. In this case, the remarkable aspect is the implementation of the capacity building strategy, which combined a theoretical and practical approach. Firstly, the UNSAM developed a group of theoretical classes to educate the local energy focal points. Then the focal points of each neighbour visited homes equipped with electricity consumption meters and surveyed their consumption. All this information was evaluated with the university, and specific case reports were prepared, which included personalized recommendations to reduce their consumption.

Figure 3 illustrates the successful elements identified from this experience, and its interrelation with the multi-stakeholder approach (shown by the green squares). As shown the virtuous circle starts with the bottom-up identification of needs (a project born from the people´s necessities), in which the role of the NGO is crucial. Then there is a capacity and information instruments built in conjunction between the NGO and the university, which includes training actions, audits and detailed reports on energy efficiency options for each home. These instruments are very important to remove the most important barriers in low-income homes and are (somehow) an enabling condition to promote energy efficiency throughout replacement of appliances. Finally, the role of energy utilities has been highly important to finance all these actions. This is a very important and novel aspect from this project.

Policy recommendations

The experience of technology transfer and adoption in developing regions shows that providing the technology (even for free), does not guarantee its adoption from a sustainable long-term perspective. The end-user uptake of technologies is fundamental, and requires a good knowledge of the technology and/or willingness to embrace new ways of producing or consuming energy, which in turn requires policy interventions. Based on observed experience in Latin America, the following are key questions that could be useful to guide the design and implementation of renewable and energy efficiency technologies transfer, particularly in low-income homes:

1. What are the country specific conditions in which the technology will be transferred?

2. What are the real energy needs, existing technologies and barriers to their uptake?

3. What are the existing institutions or local organizations that could increase the willingness to adopt the technology in the target group?

Regarding the first aspect, in the case of technology transfer, there are initial *conditions or enabling conditions* that need to be met or considered, for example:

- The existence of a national strategy and plan, including renewable sources and energy efficiency
- A careful evaluation of the most appropriate niche for renewable technologies, according to national circumstances and other factors
- Adequate institutional and legal frameworks that enable and incentivise renewable energy and energy efficiency actions
- Reliable data on electrification rates among the local population, including the share of the legal vs. illegal access in the most deprived urban and peri-urban areas
- The structure of electricity markets (how are decisions made including on prices, the role of private vs. public entities and their respective levels of accountability)
- The scope and content of laws and regulations regarding the role of foreign investors and actors in the energy market for both products and services at the household level
- It would be useful to create specific financial support funds, so that these types of initiatives could be replicated in other regions or countries

Related to the aspects that should be considered during the *design phase*, one of the clearest aspects arising is that technology transfer and adoption at the household level is more successful when it follows a bottom-up perspective instead a top-down one. The implementation of existing successful policies requires careful evaluation and adaptation to local circumstances. This means, on the one hand, that all the technologies need to be adequate in terms of scale, availability of resources, climate, local knowledge, culture, practices and customs. On the other hand, it is important to consider the difference between regions, also within one country there may be a broad diversity of social situations that determine the reaction to the technology to be adopted.

The end-user's perspective is key, regarding their problems and needs and their approach the solutions. This standpoint is contrary to a techno-deterministic view, which predominated among international organizations and national governments, which in the past have tended to predetermine the technologies to be transferred prior to any analysis of needs, problems and barriers. In contrast, during the design process, a multi-stakeholder perspective has proven to be a good practice. Including different views in the evaluation of the needs, problems, barriers and potential solutions is key, especially during the initial phases.

Focusing on the third dimension, the *implementation phase*, experience shows that the best way to remove some of the social barriers is to include local organizations or NGOs, which usually have strong knowledge of the problems and characteristics of local communities, including the capacities of households, attitudes and preferences. This aspect also relates to the importance of the multi-stakeholder approach, i.e. to include different views (especially local stakeholders), in the implementation of the policy, as much as possible. It is important to have key actors participating in the process in a committed way, both in the elaboration and implementation of the process.

As mentioned, the uptake of energy efficiency and renewable energy technologies faces various barriers. Therefore, they require a battery of instruments to promote their adoption, including financial instruments, economic incentives, capacity building, among others. It is advisable for communication and awareness actions to focus on the economic impact of the technologies, including long-term cost savings for households, rather than environmental benefits. It is very important to implement capacity building strategies

in conjunction with the technology transfer policies. Long term sustainability of the technology depends upon local capabilities in the target community, regarding operation, installing and repairing the technology. It is also useful in some cases to develop demonstration projects at the community level, to increase the awareness among household consumers about specific technologies and their benefits.

Acknowledgments

Authors would like to thank Salvador Gil for the information provided during the meetings and his opinions on this article.

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