Chapter 9
Solar Water Heating System Codesign and Do-It-Yourself Approach for Appropriate Technology Diffusion: The Médina Case Study (Dakar, Senegal)

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Abstract In order to develop an effective method for appropriate technology diffusion, as in the solar water heater (SWH) case, the technical aspects (appropriate technology) and the planning aspects (stakeholders participation, training, and skills transfer, etc.) are both fundamental. Appropriate technologies must always take into consideration many aspects beyond the purely technical so that they can provide beneficial social, economic, and environmental impacts on the local context. This paper examines a multi-stakeholder participative approach that is focused on SWH technology diffusion and application. The integration of multiple stakeholder roles in the local context has been proposed and applied to the "Centro di Formazione Médina" (CdF Médina) or the "Médina Training Center" project and extended to the Médina neighborhood in Dakar (Senegal). The introduction of a codesign method involving engineers, engineering students, local stakeholders, and migrants, coupled with the Do-It-Yourself (DIY) technique, has been tested and recently implemented locally to permit the start-up phase of diffusion and local repeatability among trained artisans. Furthermore, with the involvement of local partners, stakeholders, and Senegalese migrants, the idea of creating a local and artisanal enterprise of SWHs has been developed, and a feasibility analysis has been carried out.

9.1 Hot Water Needs and Solar Water Heater Technology

Energy access is strongly linked and interconnected to environmental, economic, and social sustainability issues at both global and local levels. This role has been recently highlighted through different programs and initiatives such as the Sustainable Energy

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for All UN program (SE4A 2011) and the Sustainable Development Goals discussed in Rio+20 (SDG 2012). Access to energy is, indeed, not guaranteed for billions of people worldwide, and the way most of the energy is currently produced and used is not sustainable, thus increasing the need to have clean, efficient, affordable, and reliable modern energy, especially in developing countries (DC) and emerging countries (EC) where specific policies are often not implemented (AGECC 2010; Brew-Hammond 2010).

The use of renewable energies into the actual mix, especially for distributed generation in rural or limited energy access areas, has become an important supply method promoted by both local and international institutions and organizations in order to satisfy these requirements. Nevertheless, the intermittent nature of some renewable sources requires the development of specific energy system designs, while even combining renewable technologies with traditional ones in order to guarantee the reliability of the system and the supply of energy (Mandelli and Mereu 2013).

In this framework, both the electricity supply and the use of modern sources for cooking, heating, and lighting purposes are deeply investigated and supported in order to achieve a sustainable production system that limits the use of traditional biomass and oil (Mapelli and Mungwe 2013).

Among the energy needs mentioned above, hot water supply is not considered a basic need in many DC due to their warm climates, and solar water heater (SWH) use is not considered the ideal technology to enhance the living conditions of the poor population in these contexts (Langniß and Ince 2004). Despite that, hot water is increasingly regarded as a fundamental aspect of modern hygienic and healthy life in contemporary societies and, in some cases, has a key role in artisanal productive processes, thus incentivizing the demand. Furthermore, SWH actually represents an economic competitive alternative in countries with high energy costs and sufficient irradiation, therefore contributing to the introduction of possibilities for sustainable socioeconomic development (Sitzmann and Langenbruck 2003). For these reasons, many representatives of the international community believe that the SWH system is one of the most simple yet effective renewable energy technologies, which is characterized by the ability to be constructed using locally available materials by technicians without high expertise and skill (Milton 2007).

From the environmental, social, and health (i.e., local pollution) viewpoint, SWH systems reduce dependence on conventional water heating fuels such as fuelwood, propane, or fossil fuels that provide power for electric water heating systems. From a technological viewpoint, SHW systems are characterized by different typologies of collector, layout, and circulation systems. All these characteristics obviously influence the performance, technological complexity, and cost of the installed SWH system (Vanek and Albreight 2008), and the choice of the most adapted configuration is based on the analysis of the specific context.

As mentioned above, hot water supply is not a basic demand in many countries because of their warm climates, and as long as the supply of more essential goods and services is insufficient, the supply of hot water is regarded as a luxury (McEneely 2000). This is confirmed by the main use of SWH in Africa by high-income households, institutions, and large commercial establishments such as hotels and game lodges (Karekezi 2002). SWHs can be used as complementary systems in clinics, laundries, food treatment (vegetables, meat, milk, etc.), textile industries, etc.

Large worldwide penetration has occurred in some DCs, and projects on SWHs have already shown successful implementation and stable market conditions as in Zimbabwe (Weiss and Schwarzlmüller 2002) and Puerto Rico (Headley 2000). Another example is the Botswana experience in terms of the role of the quality of the installation. The project shows that even a good SWH product, when installed incorrectly, cannot work. As a result, the Botswana Bureau of Standards has developed a test method to check SWH installations on site (GEF 2005).

The aspects highlighted above show that SHW system diffusion actually requires an effort to bring the technology to an economical sustainable level (reduced costs), social role (diffusion of its availability and definition of the right target), and local technological sustainability (presence of local skills).

9.2 Design and Participative Method

An appropriate technology can be seen as one that evolves or is developed in response to a particular set of needs, in accordance with prevailing circumstances, and has been developed or adopted as the result of a rational process of decision-making with the vital participation of all the stakeholders during all the processes (Practical Action 2012). Hence, appropriate technologies must primarily enhance human capabilities through technology advancement and economic development (UNDP 2005) and achieve a social transformation (Garniati et al. 2014). Considering the characteristics of the appropriate technology mentioned above, and reported by Schumacher (1973), SWH can be evaluated as a good candidate. In fact, an SWH can be produced locally with raw materials and does not require high skills. Moreover, it presents positive environmental impacts with no pollutants or CO_2 emissions, it can be adapted to different locations with different boundary conditions, and its small scale and modularity permit its use by individual families or small groups of families.

SWH technology is further characterized by the opportunity for building by a Do-It-Yourself (DIY) approach that is labor-intensive but more productive than many other traditional processes. This approach offers the opportunity for local people to get involved in the processes of change and innovation and the use and development of the technology in small villages or small laboratories. In accordance with the context characteristics, the SWH can be designed with different layout complexities and materials that add to different solutions and costs. Though appropriate technology has been historically considered to consist more of elementary techniques that do not prioritize growth (Kaplinski 2011), the SWH DIY approach attempts to overcome this vision, thus also creating economical values within the society through the opportunity to activate small artisanal enterprises of SWH production. In this case, the repeatability of the technology becomes a feature that is even more important in the process of diffusion of the same. The possibility to start income-generating activities of artisanal construction of SWH interfacing with the market implies in itself an even stronger analysis of the local context. The identification of the target beneficiaries, their needs and their resources, and the involvement of all local actors and their desires become, in fact, essential and require a thorough participatory process.

In order to ensure the sustainability of the project's activities and the repeatability of its results, a participative methodology is essential throughout the project's duration. In a technology transfer project, the correct individuation of the community needs and the available resources is essential in order to define the most appropriate solution, and it requires a careful involvement of all stakeholders. It must be understood that the technology integrates itself in a cultural and social context with specific environmental and economic conditions that influence and are influenced at the same level by the new conditions. If the aim is to make the communities autonomous, self-organized and independent, and/or guarantee the repeatability of the impacts, technology and innovation alone are not sufficient, but must be driven by human factors and be coupled with the principle of participation and direct community involvement.

The entire process is schematically reported in Fig. 9.1, which indicates the participative methodology in the energy access framework. The development technology process is carried out by different stakeholders—locals, migrants, engineers—each of whom brings personal background and competencies as inputs to the decision-making process. As in the case of the SWH development with the DIY approach, the participative context analysis supports the development of an appropriate technology with innovative solutions and real transfer skills.

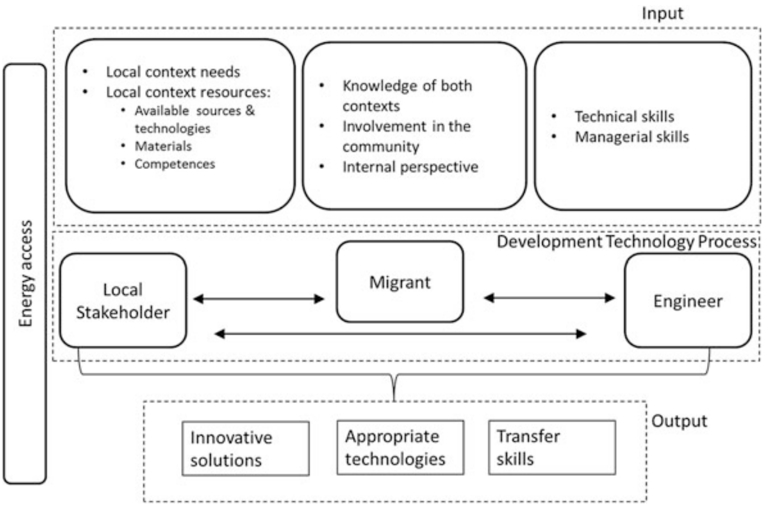

Fig. 9.1 Participative energy access framework

The figure of the engineer has to focus not only on the appropriate technology and innovation but also on human promotion. In this framework, the facilitator has a key role in the participation process. His or her main function is to facilitate communication between the involved parties; this includes explaining the scope of the debate and guaranteeing that it will not be polarized or monopolized, and providing help with difficulties related to the use of technical language (Ramirez et al. 2010).

In this process, the migrants can represent a key figure and serve as the bridge between local and external contexts to integrate the figure of the facilitator and aid worker. The migrant's role in this kind of project represents an extension of its classical role in migration and development projects, which can be considered as a field between cooperation and local development. The aim of migration and development processes is not only to promote development in countries of origin but to also create synergies between migrants' participation in cooperation projects and their integration in countries of destination. For this reason, migration and development strategies are innovative policies to foster trans-local spaces of solidarity where migrants play a key role as links between governments, civil society, and populations, both in countries of origin and destination (Acebillo-Baqué and Østergaard-Nielsen 2011). In addition to remittances and other types of financial transfers, migrants stimulate the development of countries of origin and destination with the transfer of know-how and knowledge. In fact, people, as they move, take with them ideas and knowledge and acquire new skills and ideas while in abroad (IOM 2010). While the Declaration of the High-level Dialogue on International Migration and Development states that "emigration is not an alternative to accelerated development efforts at home, but mobility can facilitate access to ideas, knowledge and resources that can complement and in some cases enhance progress" (UN 2013), migrants can propose themselves as active stakeholders in North–South development projects because of the context knowledge of both countries and can assume the fundamental role of dialogue facilitators during the analysis phase and in the problem-solving and decision-making steps.

9.3 The Médina (Dakar, Senegal) Case Study

Presented here are the application of the approach described in Sect. 9.2 and related results carried out in the project "Centro di Formazione Médina" (CdF Médina) or "Médina Training Centre" and its extension to the neighborhood of Médina in Dakar (Senegal). The process phases and roles of the involved stakeholders are highlighted and schematically shown in Fig. 9.2.

CdF Médina The project CdF Médina, which began in 2007 and was based on the Médina of Dakar (Senegal), had the purpose to improve the living, health, and economic conditions of weavers working in the sphere of fair trade, the students at the CdF Médina training center, and the community in which they operate through a

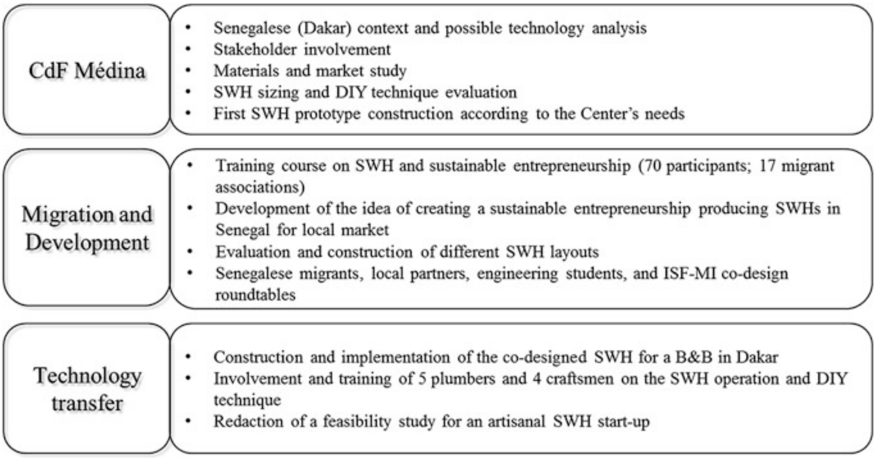

Fig. 9.2 Approach and results of the CdF Médina Project

qualifying training scheme, and real support for the concrete development of sustainable economic activities. The CdF Médina is part of the wider Senegalese textile chain that has witnessed a growing effort to enhance the national product through the promotion of organic cotton and the rediscovery of traditional techniques for weaving and fabric dyeing. The project has involved qualified partners in fair trade (Karibuny), textile craftsmanship, local nongovernmental organization (Yaakaar G. I.E and Domû Africa), and Engineering Without Borders—Milan (ISF-MI) for the technological transfer and training.

The ISF-MI role was to face and cope with the energy access issue that was present in the training center and atelier for both electricity and heat supply. Hot water for textile production (dye fixing) and for domestic use (showers, cooking, etc.), led to an analysis of the local context to determine the needs and resources, available technologies, and proper introduction of new ones into the context.

Different resources and technologies have been considered and studied in order to evaluate the most appropriate solution to guarantee good social, economic, and environmental impacts in the Center. With this aim, the preliminary design of a DIY SWH system as an alternative to previous biomass (fuelwood) and gas use has been carried out. In this phase of the project, a context analysis was carried out on the field by ISF-MI to focus on the possible craftsmen concerned in the DIY activity and on the locally available materials and skills. Local artisans have been involved and the available materials and skills have been defined. The analysis revealed the presence of good logistics to supply materials in Dakar and the presence of technical skills (welding, glass production, etc.), but at the same time, it underlined the need of the training for a not yet well-known technology. Furthermore, the same training requirement for the installation and maintenance of the SWH system emerged from the study of the local SWH commercial market, which is entirely composed of imported solutions and is still not well developed. Finally, a prototype of the DIY SWH system that fits the Center's needs has been built.

Migration and Development The activities carried out in the local context have been integrated with training courses that are focused on the topic of sustainable entrepreneurship in DC in the energy sectors. The case study of CdF Médina has been presented in the courses based on the preliminary analysis carried out by ISF-MI and local partners. The courses have been attended by 17 migrant associations from different origin countries and 32 students of Politecnico di Milano for a total of approximately 70 participants. This environment, where different cultural and technical backgrounds have been mixed, permitted the development of the theme of the SWH as a possibility of artisanal production through the DIY approach. Hence, the theme has been thoroughly analyzed and a joint planning at both the technological and managerial level has been codesigned involving Politecnico di Milano students, Senegalese migrants, and ISF-MI. In this phase, owing to the active participation of Senegalese migrants and through their contact with local associations, it has been possible to provide continuity to the idea of creating a local and artisanal enterprise of SWH panels.

The first possible beneficiaries for the SWH have been identified as tourist accommodation businesses, hospitals, clinics, laundries, textile and food production activities, and households. Consequently, they have defined the main systems' characteristics: they have to be lasting but simple, market competitive, and guarantee a good efficiency. A system with an open thermosyphon configuration and a glazed flat plate panel has been chosen in accordance with the mentioned features, materials, and resources.

Technology Transfer As an application of the previous analysis, a codesigned system has been built and implemented in a bed and breakfast (B&B) of a local cultural association in Dakar. The construction and implementation have been completed with an on-the-job training course that involved five plumbers and four craftsmen who were previously identified with the local partners. During the three-week course, both the theory of SWH and the practical implementation of the system have been treated. The implemented system cost has been approximately half of the average commercial systems present in Dakar retailers. Finally, two of the plumbers and the four craftsmen who were involved in the construction offered their availability to work together and start running a business in order to investigate the opportunity to develop an even lower cost solution for different beneficiary targets that are actually under investigation.

A feasibility analysis for the artisanal SWH entrepreneurship has been carried out. The concept of the business model developed, based on the value chain model (Porter 1985), is shown in Fig. 9.3, where the key primary and support activities of the potential artisanal enterprise are reported. In addition to this, target market segments and foreseen social impacts are presented in order to provide a more complete view of the social business idea. The artisanal enterprise will be structured in the form of a cooperative with the presence of the previously trained craftsmen to

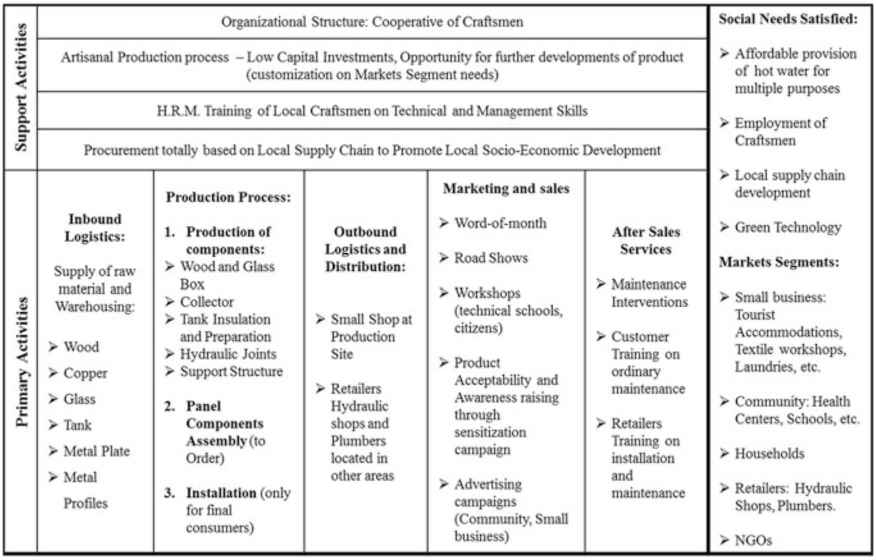

Fig. 9.3 Business model concept. Inspired by the value chain model (Porter 1985)

ensure adequate technical and management skills. The production process, comprising three phases, is totally based on the use of local manpower and materials in order to maximize local socioeconomic development.

9.4 Conclusions

The introduction of a codesign method involving engineers, engineering students, local stakeholders, and migrants, coupled with an appropriate technique (DIY), has permitted the identification and implementation of an appropriate energy system. The codesigned system has been tested and locally implemented to permit the start-up of the phase of diffusion and local repeatability among trained artisans. Furthermore, with the involvement of local partners, stakeholders, and Senegalese migrants, the idea of creating a local and artisanal enterprise of SWH panels has been developed, a detailed feasibility analysis has been created, and it will be ready for implementation in the near future. Finally, the DIY construction technique proposed in the project represents a valid example of appropriate technology where all the dimensions of sustainability are taken into account; at the same time, this approach guarantees environmental (increasing the reuse and recycling of waste materials), economic (investing in a local market where there is a constantly growing demand), and social sustainability (recognizing the value of and enhancing local skills and guaranteeing independence from external subsidies), which, coupled with entrepreneurship initiatives, can represent a means of economic development for local stakeholders.

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