INVESTING IN SUSTAINABLE ENERGY TECHNOLOGIES IN THE AGRIFOOD SECTOR (INVESTA)

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BACKGROUND AND INTRODUCTION

The FAO project "*Investing in Sustainable Energy Technologies in the Agrifood Sector"* (INVESTA) supports innovative and sustainable approaches to accelerate the uptake of clean energy solutions in agri-business in developing countries and emerging regions. The project developed a methodology to analyse energy interventions in the agrifood sector. The main purpose of the methodology is to assess costs and benefits associated with renewable energy and energy efficiency practices, and to highlight hidden socio-economic and environmental impacts of such interventions. This is important for decision-making, to better target investments that will result in a net benefit to the society. The cost-benefit analysis (CBA) has been applied to specific energy interventions in the milk, vegetable, rice and tea value chains in Kenya, the Philippines, Tanzania and Tunisia.

This paper summarizes the results of the INVESTA methodology applied to three cooling technologies in the milk and vegetables value chains:

- domestic biogas-powered milk chillers,
- solar milk coolers,
- solar cold storage for vegetables.

METHODS

The project is divided into two phases. In the first phase, costs and benefits of clean energy technologies are assessed at intervention level (e.g. for the entrepreneur, farmer or food processor). The methodological approach highlights hidden environmental and socio-economic costs of interventions, such as government subsidies to fossil fuel, which are often borne by non-economic operators. Such costs and co-benefits are therefore included in the analysis and compared to a simple financial analysis to inform about the "real" impacts of the investments.

In financial analyses, all costs and benefits are valued at market prices, since the main goal is to examine the financial returns to the individual agents performing the investment. Instead, economic analysis is undertaken from the perspective of the overall economic system and it deals with the (economic, social and environmental) costs and benefits for the society. The main differences between financial and economic analysis are three:

- The economic analysis attempts to quantify "externalities", such as GHG emissions, water savings, and other environmental and social impacts resulting from the project;
- The economic analysis removes transfer payments, such as subsidies (economic costs for the society) and taxes (economic benefits for the society);
- The economic analysis makes use of "shadow prices" that eliminate market distortions and reflect the effective opportunity costs for the economy.

After having assessed the impacts at the single intervention level, in the second phase the technical potential of a technology is estimated for a given country. The INVESTA CBA for the country case studies highlights the initial investment required (at country level), the investment horizon (the expected lifetime of the technology), the financial attractiveness—in terms of internal rate of return (IRR) and net present value (NPV)—and the economic NPV, which includes socio-economic and environmental costs and co-benefits. Depending on the country conditions and on the benchmark choice, the impact of the same energy intervention can be significantly different (see example 2).

RESULTS

Example 1. Cost-Benefit Analysis (at intervention level) of a Domestic Biogas-Powered Milk Chiller

The domestic-scale biogas digester and milk chiller is a technology suitable for smallholder dairy farmers with few dairy cows, since it can only cool up to 10 litres of milk per day (FAO and GIZ, 2018). The milk chiller requires about 1 thousand litres of biogas per day (with a heat value of 25 MJ/l) to cool 10 litres of milk. Another cubic metre of surplus biogas is available to fuel one or more cookstoves for 1 to 2 hours per day. The commercially available SimGas system used for the analysis (costs and performance detailed in FAO and GIZ, 2018) includes digester, milk chiller and cookstove. It has a capital cost of US$ 1,600 and a lifespan of 20 years (lifetime of the digester, while the milk chiller lifetime is less than 10 years).

Costs and benefits of the technology over its lifetime are summarized in Figure 1. It shows that the benefit from investing in a milk chiller are: financial revenues from additional milk selling, more value added along the value chain, the production of slurry and digestate that can be applied on farm, and the biogas cookstove (which reduces indoor air pollution and allows savings on traditional fuelwood and charcoal, thus reducing GHG emissions).

Variable costs are for maintenance, replacement of spare parts and labour. Maintenance starts from year three of adoption, costing on average US$ 20 per year. The main cost of the system is the additional work needed to feed the digester with cow manure every day. Non-monetized benefits (improved soil quality and access to energy) and possible negative impacts (increase in water consumption and impact on time saving) are represented by the circles.

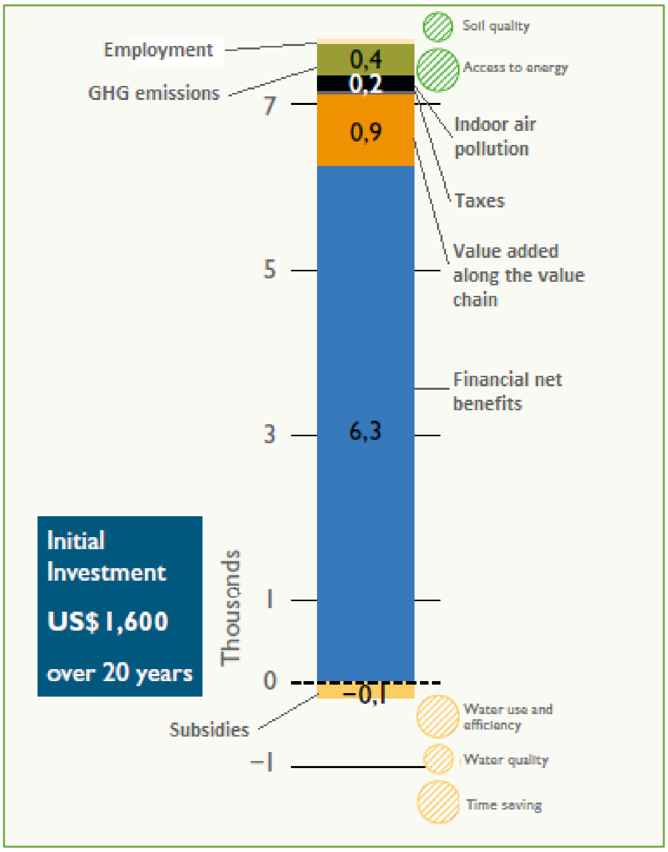


Figure 1. Financial and non-financial benefits (positive) and costs (negative) for a domestic biogas milk chiller

Example 2. Cost-Benefit Analysis (at national level) of Solar Milk Coolers

The technology and performance of the solar milk cooler is based on the “MilkPod” system that has been operated in Kenya since 2015 (FAO and GIZ, 2018). Manufactured by FullWood Packo, a Belgian company, it can chill and store 500 to 2,000 l of milk per day, relying just on solar power. The system is a complete milk collection and chilling station, including a milk receiving and testing section, a rapid milk chilling section and a milk storage section.

The cost of one MilkPod with a capacity of 600 litres, imported from Belgium, is US$40,000. The system includes a cooling unit with ice bank (US$ 15,200); a 6 kW solar PV system (about 20 panels of 250 Wp); four 24 V, 3,500 Ah batteries; an inverter and a controller (US$ 19,290). The system is built in a shipping container with insulated walls and roof, LED lighting, a stainless steel wash sink with hot and cold water connections, a water heater and a stainless steel table (US$ 5,510). The system is shipped and installed by the manufacturer who also trains the future operators. Expected life of the cooling tank, ice bank, PV panels, water heater, waste heat recovery unit from the compressor (using a plate heat exchanger) and the other steel components in the container is 20 years. It is assumed the batteries will be replaced every 10 years for a cost of about US$ 3,000. Routine maintenance includes washing the tank once a day and cleaning the solar panels six times a year. The ice bank capacity can cool 2,500 l of milk, and can chill and maintain milk at 4 °C for 3 to 5 days with no solar input.

Costs and benefits of the technology depend on the benchmark situation. Therefore they are different in different countries (Figure 2).The solar milk cooler can be a greenfield investment (e.g. in Tunisia and Tanzania) or it can replace an existing regular 100 kWh/year refrigerator powered by a diesel-fuelled generator (example of Kenya) (FAO and GIZ, 2019). Monetized financial, economic, social and environmental costs and benefits in different situations are shown in Figure 2. In particular, the milk coolers reduce milk waste and spoilage and add value along the value chain.

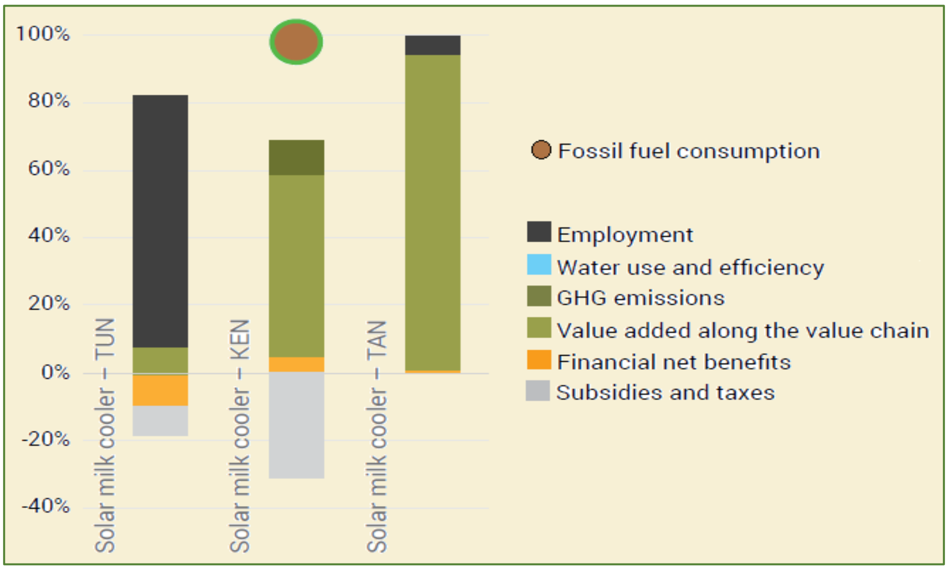


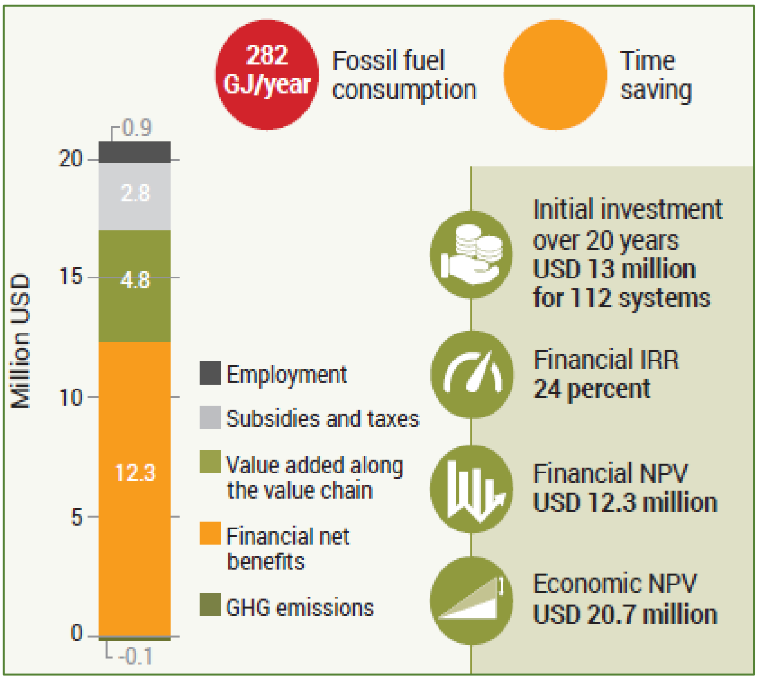
Figure 2. Costs and benefits of the 3 solar milk cooler case studies in Kenya (KEN), Tunisia (TUN) and Tanzania (TAN), as percentage of the investment capital cost

Note: the shares reported take into account only the monetized impacts. The non-monetized impact on fossil fuel consumption is reported above the bars and is positive (green outline).

Example 3. Cost-Benefit Analysis (at national level) of Solar Cold Storage for Vegetables

The 25 m^3 refrigerated cold storage system, designed for tomatoes and green beans, is powered by electricity from a 11 kWp solar PV array. The system is built in a 20 feet shipping container (6.1 m x 2.4 m x 2.4 m). The analysis is assuming the costs and technical performance of refrigerated container systems such as those commercialized by SunDanzer. These systems are suitable for refrigeration in locations with an intermittent grid as they are equipped with batteries for energy storage and (optionally) a PV system.

The capital cost of a refrigerator of 35 m^3 with an internal refrigeration capacity of 25 m^3 ranges from US$ 90,000 to 110,000, plus around US$ 25,000 for the solar system. For larger systems with several units, the capital cost per unit of refrigeration capacity slightly decreases.



In Kenya, the tomato and green beans value chains are analysed since they are two important perishable crops, with growing markets. At the national level, there is potential for about 112 grid-connected solar cold storage systems for tomatoes and green beans that could be installed to serve farmer groups or associations at collection points. Figure 3 summarizes costs and benefits associated to the technology.

Figure 3. Financial versus economic attractiveness of solar cold storage for vegetables at national level

DISCUSSION

Barriers to technology adoption and support interventions

During field visits in the case study countries and meetings with national stakeholders, specific national data and information on the energy technologies and the value chains under analysis were collected. For each clean energy intervention assessed in a specific value chain, the main barriers to technology adoption and possible solutions were presented and discussed in each country. The following categories of barriers to technology adoption have been identified:

- knowledge and information;
- organization/social;
- regulations/institutions;
- support services/structures;
- financial returns;
- access/cost of capital.

Possible support interventions to overcome each barrier, led by governments, donors, private sector actors, investors, international financial institutions (IFIs) and NGOs, were subsequently identified and classified as: target setting; regulatory schemes based on legal responsibility and jurisdiction; financial incentive schemes including guarantees; and knowledge and education schemes. Table 1 provides an example of barriers to technology adoption and support interventions for the solar milk cooler technology. Other examples can be found in the FAO/GIZ report (2019).

Table 1. Policy support interventions to overcome barriers to deployment of solar milk coolers.

	Possible support intervention	Barriers to be tackles	Responsible actors
Target setting	Setting of minimum milk quality standards	Lack of incentive for a farmer to improve milk quality and hygiene	Ministry of Agriculture
Regulatory schemes based on legal responsibility and jurisdiction	Enforce stricter quality check at collection points	No strict milk quality check at the collection stage reduces incentives for farmers to improve the hygiene and cool their milk	Ministry of Agriculture Dairy Board
Knowledge and education scheme	Programs for educating and training technicians Use public extension services, associations, private sectors and local NGOs to educate users on the benefits and effective use of the technology Initiate informative programs to promote the technology	Lack of awareness of the technology Shortage of qualified technicians in rural areas to install and maintain the system.	Private sector companies Local Government Authority (LGAs) Livestock extension officer at LGA Local NGOs Sector associations
Facilitate access to finance	Financial incentives to make technology more affordable The incentives should be in terms of low interest subsidized loans or loan guarantees Introduce a price premium for refrigerated quality milk	Low financial returns High initial investment costs for dairy smallholder groups Lack of financing solutions for dairy smallholder groups Lack of incentive for a farmer to improve milk quality and hygiene	Ministry of Agriculture, Livestock and Fisheries Ministry of Finance Commercial Banks MFIs IFIs Dairy Board Dairy companies

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