

## Principles for design of projects introducing improved wood-burning cooking stoves

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### Abstract

Projects introducing improved stoves that save firewood and reduce emissions and indoor smoke address real needs but have often not succeeded as expected. One of the reasons may be that lessons have not been learned effectively. We reviewed the only available comprehensive list of principles for stove project design. We modified it, and added more principles based on literature and our own experience. Our list consists of 20 principles covering the areas of awareness creation of multiple benefits, stove design and variety, participation of the beneficiaries, production modes, role of subsidies, and the necessity of accurate assessments and reporting.

Keywords: Aid effectiveness; Monitoring and Evaluation; Methods; Region: Sub-Saharan Africa

### Need for principles of stove project design

Numerous initiatives to introduce improved stoves that save firewood and reduce emissions and indoor smoke have been implemented in many countries. The improved stoves have the potential to bring economic, health and environmental benefits to users. However, a recent World Bank report states that “...many approaches to introducing improved stoves (in developing countries) have been tried, with some successes and many failures” (World Bank 2011). There are many reasons why these projects have been less effective than they could be. These are related to the project design, the performance of the stove itself, consumer research and knowledge of their location, and marketing.

‘Best practice’ has become a catch word in proposal writing, but do project planners systematically assess the alternative practices or conduct a systematic evidence-based evaluation of technical solutions and from these select those to try? Donors do not often require this. A more common approach is to find an example that has ‘worked’ and base design on that. However, these approaches may be location and culture specific. A large knowledge base on both the project concepts and the technical solutions exists in project

reports, scientific papers and expert knowledge. Yet this knowledge is very fragmented and hence difficult to use as a basis for stove project design.

Project designs need to be adapted to local context but general principles are essential as guidance for both the project concept and the building of high quality stoves. A report by the World Bank (WB) from 18 years ago (Barnes et al 1994) is still the most comprehensive synthesis of principles for design of projects introducing improved stoves. It was based on a systematic review of a large number of projects. Much has been learned since then. A newer WB report (World Bank 2011) gives an overview of the development of stove projects over the past 30-40 years. It provides many examples of successes and failures and ideas for new approaches and funding sources, but is much vaguer on giving advice on what does and does not work, and it does not state principles. The report 'Cookstoves and Markets' (Rai and McDonald 2009) provides an excellent compilation of information on what has enabled the creation of markets for stoves in the different parts of the world. The Global Alliance for Clean Cookstoves (GACC), launched in 2010, is currently the best single source of information, as it actively collects and gives access to all the relevant new literature. There are also many studies of adoption motives in one or several projects and these provide information on what leads people to use or reject improved stoves (e.g. Jan 2011; Lambe and Atteridge 2012; Levine and Cotterman 2012; Lewis and Pattanayak 2012; Person et al 2012). But these do not attempt to provide a comprehensive list of principles for project design.

This paper is based on experiences as documented in literature and our own field experience with improved stoves from two small projects by the NGO Liana ([www.liana-ry.org](http://www.liana-ry.org)) in 12 poor villages in Mwanza District in Northern Tanzania. We used the WB (Barnes et al 1994) principles when planning these projects.

The aims of this paper are to 1. Review principles of the WB report, suggesting modifications to those principles that were not supported by our experiences or recent literature, and 2. Add new principles that literature and experience suggest need to be included in such a list.

## Principles for better stove projects

Barnes' et al (1994) principles of reasons for success and reasons for failure for stove projects are listed in Table 1 as points 1- 16. Points 1, 3, 7, 8 and 11 were found to be problematic and are discussed further and modified. We then discuss four further principles that we base on our own experience and literature. These are added as Points 17-20 in Table 1.

### Modified Principles

Table 1. Principles according to Barnes et al (1994) for reasons for success and failure of stoves programmes. Points 1, 3, 7, 8 and 11 were found problematic and are further discussed in the text and modified (Bold). Points 17-20 are added to the list based on literature and our own experience.

|   | Reasons for success   | Reasons for failure   |
|---|---|---|
| 1 | Original: Programme targets region where traditional fuel and stove are purchased or fuel is hard to collect<br><br>Modified: <b>As people choose to adopt a stove for multiple reasons, project builds motivation and awareness on</b> | Original: Programme targets region where traditional fuel or stove are not purchased or fuel is easy to collect<br><br>Modified: <b>Project motivates people mainly by firewood savings (as suggested by a popular name for improved stoves</b> |

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|----|--|---|
|    | <b>multiple benefits and especially on benefits that matter in that particular region or group of people</b>   | <b>'firewood-saving stoves')</b>  |
| 2  | People cook in environments where smoke causes health problems and is annoying   | People cook in the open, and smoke is not really a problem  |
| 3  | Original: Market surveys are undertaken to assess potential market for improved stoves<br><br>Modified: <b>Project ensures that it can offer options that can be built by people themselves without any money, if possible</b> | Original: Outside 'experts' determine that improved stoves are required<br><br>Modified: <b>Project picks up the option(s) and tries to create markets for selling them</b>   |
| 4  | Stoves are designed according to consumer preferences, including testing under actual use  | Stove is designed as a technical package in the laboratory, ignoring customer' preferences  |
| 5  | Stoves are designed with assistance from local artisans  | Local artisans are told or even contracted to build stoves according to specifications  |
| 6  | Local or scrap materials are used in production of the stove, making it relatively inexpensive.  | Imported materials are used in the production of the stove, making it expensive   |
| 7  | Original: The production of the stove by artisans or manufacturers is not subsidised<br><br>Modified: <b>Project chooses the level of subsidy or cost sharing carefully by location.</b>                                       | Original: The production of the stove by artisans or manufacturers is subsidised<br><br>Modified: <b>Inflexible ideas about using subsidies</b>   |
| 8  | Original: Stove or critical components are mass produced<br><br>Modified: <b>Project chooses building locally or mass production according to the area</b>   | Original: Critical stove components are custom built<br><br>Modified: <b>Inflexible ideas about what production mode would be best</b>  |
| 9  | Similar to traditional stove   | Dissimilar to traditional stove   |
| 10 | The stove is easy to light and accepts different-sized wood  | The stove is difficult to light and requires the use of small pieces of wood  |
| 11 | Original: Power output of stove can be adjusted<br><br>Modified: <b>Stoves should support local cooking and firewood usage practices</b>   | Original: Power output cannot be easily controlled<br><br>Modified: <b>Stoves may be designed according to sound design principles and be very sophisticated, but do not support local cooking and firewood usage practices</b> |
| 12 | The government assists only in dissemination, technical advice and quality control   | The government is involved in production  |
| 13 | The stove saves fuel, time, and effort   | The stove does not live up to promise economy or convenience under real cooking conditions  |
| 14 | Donor or government support extended over at least 5 years and designed to build local institutions and develop local expertise  | Major achievements expected in less than 3 years, all analysis, planning and management done by outsiders   |

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|----|--|--|
| 15 | Monitoring and evaluation criteria and responsibilities chosen during planning stages according to specific goals of project               | Monitoring and evaluation needs are not planned and budgeted, or criteria are taken uncritically from other projects or not explicitly addressed                         |
| 16 | Consumer payback of 1 to 3 months  | Consumer payback of more than 1 year   |
|    | <b>Added reasons for success</b>   | <b>Added reasons for failure</b>   |
| 17 | <b>Project bases the choice of stoves and principles for design on reliable evidence and if needed adapts it to local user preferences</b> | <b>Project copies (maybe inaccurately) models from other projects without proper knowledge of the models, user preferences or the general principles of stove design</b> |
| 18 | <b>Project introduces multiple stove designs</b>   | <b>Project introduces only one model</b>   |
| 19 | <b>Project concentrates on stove models with chimneys</b>  | <b>Project relies on literature listing many chimneyless stoves as 'improved' or 'advanced' stoves even if kitchens cannot be made smoke free with them</b>              |
| 20 | <b>Project assesses the project approach and the stoves, and reports accurately</b>  | <b>Project does not assess the technologies it promotes, nor the project concept (no learning)</b>   |

***Principle 1 modified: As people choose to adopt a stove for multiple reasons, project builds motivation and awareness on multiple benefits and especially on benefits that matter in that particular region or group of people.*** We claim that a stove programme can be successful in regions which are not necessarily “regions where traditional fuel and stove are purchased or fuel is hard to collect”. And conversely a stove project does not necessarily fail because it “targets a region where traditional fuel or stove are not purchased or fuel is easy to collect”. This is also supported by a large systematic review of stove adoption by Lewis and Pattanayak (2012) in which they found that the influence of fuel availability and prices (and household size and composition, and sex) is unclear. An improved stove provides multiple benefits. The willingness to obtain a stove depends on several things.

Studies have found that lack of awareness of the multiple benefits of improved stoves is one of the main factors hindering adoption, in addition to affordability and education level, the latter being linked to knowledge about the benefits (e.g. Levine and Cotterman 2012; Lewis and Pattanayak 2012; Mobarak et al 2012). Knowledge about the multiple benefits thus deserves attention, with investment in in-depth awareness raising to improve adoption. This naturally assumes the project has a high quality product that can deliver these multiple benefits and suits the local cooking and firewood usage habits. Further, it is essential to ensure that people learn to use this high quality product correctly in order to reap the benefits. This requires good follow-up mechanisms within the project.

We conducted village meetings to raise awareness. In these meetings a local committee was selected for each village to assist in activities. During the first of our awareness raising village meetings we explained and discussed the following benefits of changing from the traditional 3-stone fire to an improved stove:

- Decrease smoke hazards to health (respiratory diseases, eye problems, premature deaths, still-born and low-weight children, weakened immune system, probably cancer), especially hazards to women and children who spend time in the smoky kitchen.
- Labour savings for those collecting firewood (often women and girls).
- Environmental benefits when less firewood is used and tree resources are conserved. These include:

- Local benefits of soil and water conservation and a cooler micro-climate
- Global benefits of climate change mitigation
- Benefits of biodiversity conservation
- Trees conserved as sources of non-commercial and commercial medicine
- Aesthetic benefits of a more attractive living area
- Safer for small children who often get burned by open fires

This is a very impressive and convincing list. Few technologies can bring such a range of different benefits. In the evaluation of the project 42 users were interviewed about one year after they had obtained a stove. Thirty-three mentioned firewood saving as a benefit, no smoke in the kitchen was mentioned 24 times and quickness to cook was mentioned 20 times. In addition, ease of lighting, the benefit of enabling two pots to cook at the same time, and heat preservation were also mentioned. In addition, women reported that an improved stove is attractive as it makes their kitchens look more modern and sophisticated.

***Principle 3 modified: Project ensures that it can offer options that can be built by people themselves without any money, if possible.*** In the poorest areas only cost-free stove options will be attractive to and adopted by the majority. If completely free options are not possible, then very cheap ones need to be included. Markets and market surveys (of the original Principle 3) are not the central issue in the very poorest areas due to the limited cash in circulation and low development of markets for products such as stoves.

Many studies show that household income or affordability is amongst the factors that play an important role in stove uptake (e.g. Rai and McDonald 2009; Jan 2011; Lambe and Atteridge 2012; Lewis and Pattanayak 2012). Person et al (2012) finds that cost appears as the single most significant barrier to adoption. Lewine and Cotterman (2012) arrive at the conclusion that both liquidity constraints (consumers find it difficult to come up with the entire purchase price) and imperfect information (about the benefit and the durability) were the barriers to uptake in Uganda. A study from Bangladesh (Mobarak et al 2012) describes how households placed stove orders weeks ahead but cancelled their orders at delivery due to lack of cash to pay. Their study also revealed how most of the households prioritise other family needs (doctors, schools, electricity, clean water, latrines, seeds for planting, and flood protection structures) over stoves.

There is a trend in current initiatives to support more refined cookstoves which are necessarily more expensive. What the WB now classifies as ‘advanced’ biomass cookstoves are technologically better designs with “...grates, insulation, induced draft or forced air flow, and more durable materials to provide a cleaner burning, more efficient device” (WB 2011). However, given the fact that income in the world’s poorest countries and among the poorest is not increasing, free self-built models or very cheap models will be needed for a long time to come. Of course a self-built stove with no cash requirement comes at a cost of labour. However the opportunity cost of labour for many rural people is low except at peak farming times and stoves can be built at almost any time. In addition, stove building can be a collective activity and the time spent may be considered a social benefit rather than a cost.

Self-built models may, however, pose a risk. Builders may purposefully change the design or the material, or the design may gradually change when the skill is transferred from person to person. Further, for any stove, in the absence of any guidance, maintenance may be poor and the stove may not be used correctly. These may totally negate the expected benefits in fuel saving, cooking time or emissions (Academy for Educational Development 2007; WB 2011; Hanna et al 2012). Yet adoption and long term usage is

dependent on the trade-off of the cost of the product and the benefits it offers (Jeuland and Pattanayak 2012).

The counter side of the original Principle 3 that, “*outside ‘experts’ determine that improved stoves are required*”, is often a practical necessity. The poorest areas are rarely initiators of a new practice. It is often an outside organisation, such as the local government in the district centre, an NGO or a business that decides that stoves should be ‘offered’ in a certain area. It is difficult to distinguish between ‘determine’ and ‘deciding to offer’. Most of the products in today’s world come from outside the immediate scope of our lives. Yet we do make use of the things and adopt those that we feel we need. However, an often repeated mistake is that the project selects the model(s) and tries to create markets for them without realising how poorly stoves compete with other cash needs when there is always the free alternative of a 3-stone fire.

In our case the free model was a two-pot mud stove with a chimney. We called it Lorena and it is very similar to the Lorena model of Gitonga (1995). Mwanga District’s high quality clay that makes durable mud stoves, and the fact that expertise was available from nearby Usambara mountains, where it is widely used, enabled us to include this model in our selection. It was the most popular stove in both projects. A locally constructed burned clay stove without a chimney (Upesi) could not compete with the mud stove (stove names as in Mäkelä 2008). This was due to both the chimney and the price. The chimney was valued highly by women once they understood the health hazards of smoke. They saw no point of buying a stove, even if a cheap one (Tsh 4500=€2.2) when they could get a good one with a chimney for free (with the additional benefits of cooking two pots at once). As in Mobarak et al’s (2012) case, some families placed an order for the metal Vita stove thinking it would be a superior model due to its durability and no maintenance. But when the time came to collect the stoves, many tried to withdraw their order as the price (Tsh 30,000=€14) was considered too high.

***Principle 7: Project chooses the level of subsidy or cost sharing carefully by location.*** The original list of priorities states subsidising the production of the stoves or the stove purchase price is likely to lead the project to failure. It has been widely believed in the development circles that “*people just do not value things that are given to them*” (Barnes et al 1994), though the WB and other development players have not always followed this principle. Many stoves have been subsidised and many have been given for free.

Bensh and Peters (2012) give a good literature review of empirical evidence that challenges this deep-rooted belief that usage intensity increases if people pay a positive and real price. Their own study from Senegal found that 96% of the households that had received improved stoves for free were still using them after one year.

Unless the project is a fully commercial business, with all costs covered by sales, subsidy will be inevitable and necessary. The essence of a development project is to use public funds in order to do something beneficial that would not happen purely as a result of commercial considerations. However, the level and nature of subsidies needs to be adjusted to local conditions. Rai and McDonald (2009) say that “*...indirect subsidies for product development and promotion, producer training and awareness creation play an essential role in supporting sustainable markets for cookstoves*”. Subsidies can also be used for other aims, such as promoting the development of a new sector. Markets can, however, be badly distorted when different players introduce different levels and types of subsidies. Rai and McDonald (2009) give an example of this when GTZ used indirect subsidies only, but the World Bank subsidised the stove price as well.

As we were able to offer a free model, we did not subsidise the price of other stoves. However, all training on other models was free and during training participants could often build a stove for themselves and thus obtain a free stove through learning to build them. As we took the approach that all stoves should be built locally either in villages or in nearby towns, training to build stoves formed a central part of our project. We think that training should be free to participants, and small payments can be introduced gradually as skills are acquired. However, paying beginner trainees for taking part in training, as practiced by some NGOs, reduces self-drive. We also initially transported Upesi stoves from where they are made to other villages so that people could try them, but the markets did not take off due to competition from the free stove. We also experienced conflicting subsidy levels. Our school stove programme used a cost-sharing approach. But another NGO came to the same area after us and offered totally free school stoves, prompting schools to delay their decision with us in the hope of getting a totally free stove instead of paying part of the cost.

***Principle 8: Project chooses building locally or mass production according to the area.*** This means either 1. Building *local* (e.g. village level) capacity in technical skills and social structure to allow continued availability of stoves in poor and remote areas, or 2. Aiming at mass production if people have monetary capability and distribution is practical (e.g. transporting is convenient). Both options aim at continued impact by changing thinking and practice beyond the length of the project.

Mass production is practical in larger centres with existing markets to which stoves can be added without much capacity building. Consistent quality and lower production prices are benefits of mass production. The vision of the current global cookstove community led by the Global Alliance for Clean Cookstoves (GACC) is to create a global market for high quality and low cost stoves. This can be done by joining the forces of private, governmental and non-governmental channels (WB 2011). However, currently most mass-manufactured cookstoves are made in China. Much work is needed to expand this trend elsewhere. Such mass produced cookstoves would also need to satisfy a multitude of cooking styles.

Remoter areas might never be able to obtain the product from these production centres. People's sphere of life can be very small and trips to towns and bigger villages rare and cumbersome with limited transport on bad roads. Further, local markets are tiny (often providing the most essentials only such as sugar, salt, tea, soap) when people have very limited amounts of cash. Transport costs from distant production centres are already high and likely to increase sharply in the near future. Providing the remote and cash poor areas with a locally built model ensures stove uptake and continuity. Examples of successful state wide projects include those that involve local potters at village level. The fact that the stoves are produced by local artisans in their village and the artisans are available to provide user training is often appreciated by the customers (World Bank 2011).

In our projects, the locally built two-pot mud stove with chimney took off well and stoves are being built in new homes after the project has finished, though not at a fast rate. With the aim of making the activities continue and to assist the trained builders in marketing their skills, we arranged 'marketing meetings' in each village at the end of the project. Builders gave a detailed descriptions of the models they are capable of building, and test results of their performance was reported.

Stimulating a marketing system for a locally produced Upesi burned clay stove or a high quality Vita metal stove was extremely difficult and we failed in it. We tried to motivate several shop keepers and the stove builders themselves. Despite there being a constant low demand for Upesi stoves in the villages surrounding their building place, no one took up the business of distributing them. Vita was considered expensive (Tsh 30,000=€14), so it had an even lower chance of getting distributed by local means. First,



establishing a supply chain to reach the end consumers is a long process and would need a project of its own. Second, the area would need to have a larger cash economy to support such a market.

***Principle 11 modified. Stoves should support local cooking and firewood usage practices.*** Many past projects have failed because the stove they promoted did not support local cooking habits (WB 2011). A successful improved stove supports these habits, but due to scientific design principles, delivers the promised additional benefits (see more in Added Principle 17).

Adjustable power output of stove (of the original Principle) does not seem to be an important factor. Adjusting power output is very little referred to in literature. It is of course listed in more technical literature concerning stove performance (e.g. Baldwin 1986) but it is not a feature demanded or specifically appreciated by local customers, at least in East Africa.

We originally did demonstrate a model, the Finnish produced Turbo stove, that comes with a double layer grate. Air inlet holes can be closed and opened by rotating the two layers against each other in order to adjust burning. Everyone seemed to think it was clever, just like the double layer walls that let in preheated air (also found in Baldwin 1986). But these were not the things local people base their selection of a stove on. Having double walls and double grate doubles the price of the stove, which is much more significant to the customers. The traditional way of adjusting the heat by pushing in or withdrawing long firewood is, however, one of the critical design factors that makes a stove acceptable and the stove must accommodate it. That is why doors for the fire chamber are not acceptable (or not kept closed) and neither are fire chamber openings that do not allow long firewood to lie horizontally outside the chamber.

## **Added principles**

The last four principles in Table 1 are reasons for success and reasons for failure additional to those listed by Barnes et al (1994). They are based on current literature and our own experiences of how stove projects work.

***Added Principle 17. Project bases the choice of stoves and principles for design on reliable evidence and if needed adapts it to local user preferences.*** A very large range of so called firewood-saving stoves exists. How does one know how they perform? A project designer has the choice of either systematically evaluating the evidence on different stoves or simply doing what another project has done. Unfortunately, the latter is common because very little comparable information can be found on the stoves and their performance as so few systematic studies have been conducted.

Naming of stove models can vary from project to project and area to area, so it is not always clear which stove is being described in a report. Our two-pot mud stove with a chimney ended up being called a Lorena. However, we do not recognise it from the WB (2011) description of a stove with that name, originally developed in Guatemala, and which lasted for only about a year. The type of Lorena we built is made from the best clay (or termite hill soil) one can find, or from burned clay bricks masoned together with clay or termite hill soil. If it is built of high quality clay and maintained weekly (by smearing by manure, clay and ash mixture) it has been recorded to last for over 30 years.

There are also projects that promote designs that are clearly poor, with design details misunderstood or changed over time due to unintentional modification. The worst example found was yet another so called Lorena in Uganda that took an hour to bring 3 litres of water to boiling (Academy for Educational Development 2007). This is also not the Lorena we built.



There are several examples in the literature of stoves that do not unambiguously perform better than the traditional stove and further problems are caused by incorrect usage (e.g. WB 2011; Bailis et al 2012; Hanna et al 2013).

The most important aspect in the selection of the stove model is to understand that stove design needs to follow known stove design principles. When local artisans and users are engaged in the design process, it is important to ensure they understand these design principles. In addition, they need to understand that local preferences and material options need to be accommodated within the basic limits of good stove design. If women are the ones who cook, as in many traditional societies, it is essential to involve them in this process. Modification of existing models is wise only after understanding these principles. Several sources of stove design information exist for this (Baldwin 1986, Gitonga, 1995; Bryden et al 2005).

We did an internet based study of available stoves and their characteristics before planning our stove projects. As only a small number of stoves have been documented properly, only a small number ended up described in our report (Mäkelä 2008). However, the exercise provided us with a large enough number of stove models (plus 2 local ones) to start with in our initial awareness raising training. But we did also make an initial mistake of modifying the Vita stove by adding a chimney to it (Soini and Coe 2011). This considerably increased fuel consumption. However, adding a door to the fire chamber corrected the problem.

***Added Principle 18. Project introduces multiple stove designs.*** Many projects promote only one stove model. This is a strategy with two clear risks. First, families and women have different preferences, priorities and needs. If the one stove being promoted does not meet their needs they will stay uninterested and not adopt it. Secondly, there is a chance that introduction of one inferior model will reduce or remove opportunities for later introduction of better designs, leaving users locked-out of access to superior technology. This phenomenon of 'path dependency' is well known in economics (e.g. Foray 1997). In areas where mass production and commercialization is viable, competitive markets may solve the problem. However, development projects have still a long way to go in understanding that customer preferences vary within the same locality, and a one-size-fits-all approach often does not work.

We decided to introduce twelve models from which beneficiaries could select the ones they were interested in. The first narrowing down to the most promising models was done in the theory trainings. Participants were asked individually (without consulting others) to list the two models they were most interested in trying for themselves. This process was not ideal. First, it required people to make an initial choice on the basis of theory and demonstrations, not on using each stove themselves. Secondly, some models considered to be interesting needed to be dropped as no trainer for that model could be sourced. Our criteria was that it should be possible to build all models locally and not create dependence on outside resources.

From 12 models initially introduced, the project was left with four main models. Two modified versions were added, one modified by project personnel's initiative and the other through a user's initiative. The four selected were an on-site built two-pot mud stove with a chimney (our Lorena), the portable Upesi burned clay stove, the portable Vita metal stove (together with a version with a chimney) and a large Brick and Cement two-pot stove with two fire chambers. The prices range from the free mud-stove to Upesi at 4500Tsh (2.2€) and Vita at 30,000Tsh (15€) to the most expensive Brick and Cement stove at 100,000Tsh (50€). The last one was taken by only very few, and limited to families in which one member had a regular job. Some women selected more than one type, using different stoves for different tasks. The initial criteria

for choice were often driven by cost and the attractiveness and the status that goes with it. When the stoves were built, women started to see more clearly the different benefits and what really matters to them (Table 2).

Table 2. Benefits of four stove models reported by women who used them. ✓ indicates benefit reported.

| Benefit  | Lorena | Upesi | Vita | Brick and Cement |
|--|--------|-------|------|------------------|
| Smoke-free kitchen   | ✓      |       |      | ✓                |
| Reduced smoke  |        | ✓     | ✓    |                  |
| Two pots at the same time by the same fire                         | ✓      |       |      |                  |
| Two pots at the same time, fire can be adjusted to both separately |        |       |      | ✓                |
| Saves firewood   | ✓      | ✓     | ✓    | ✓                |
| Can be built by anyone (no special skills or tools needed)         | ✓      |       |      |                  |
| Free of charge or cheap  | ✓      | ✓     |      |                  |
| Preserves heat in its structure                                    | ✓      | ✓     |      | ✓                |
| Pots stay clean (compared to 3-stone fire)                         | ✓      | ✓     | ✓    | ✓                |
| Quick to cook  | ✓      | ✓     | ✓    | ✓                |
| Functions as a table for food preparation                          | ✓      |       |      | ✓                |
| Safe for children  | ✓      |       |      | ✓                |

**Added Principle 19. Project concentrates on stove models with chimneys.** Many models of improved stoves still come without chimneys. For example, MacCarty et al (2010) tested 50 stoves, which is commendable, as such test results are very rare. But only 12 stoves had a chimney. The paper does make it clear that several other factors other than chimneys contribute to the reduction of the emission. These include rocket stove design, pot skirts, gasifier stoves, forced air stoves and liquid fuels. Yet, if smoke is not removed almost completely via a chimney it is harder for a project to claim benefits of smoke reduction as it is unclear whether the level of reduction is enough to induce health improvements. We do, however, recognise that in some urban environments it may not be possible to vent out smoke by a chimney, and thus a stove that considerably reduces emission would need to be the choice.

Once the awareness-raising, including awareness about smoke hazards to health, has been done effectively the majority of women would like to have a stove that makes their kitchen smoke free. From our project experiences, smoke hazard to health was really the issue that stirred the audience more than discussion of environmental problems cause by tree cutting. No one had been aware of the serious health problems smoke causes. Women always mention eye irritation (teary eyes), coughing and headache as impacts of being in a smoky kitchen. They really woke up for action when they heard of kitchen smoke being responsible for 1.5 million premature deaths per year, still-born and underweight babies, doubling (this may be even six times) a child's risk of getting a serious respiratory disease and smoke ranking as number four in the list of serious threats to health, and probably causing cancer.

**Added Principle 20. Project assesses the approach and stoves used and reports accurately.**

Monitoring and evaluation has moved a long way forward from simple input-output focused approaches to results-based approaches. Good result-based monitoring systems help the project to continuously assess its progress and thus adjust and improve. Result-based approaches also gradually build knowledge of what

works, what does not, and why. These can be drawn on by others. Useful guides are available on how to create such a M&E system (e.g. Kuzek and Rist 2004). In addition, a paper by GTZ and ITDG (1995), though 17 years old, is still the most instructive and comprehensive information package on stove project M&E.

In addition to M&E of project activities, a stove project needs to assess stove performance. The minimum that needs to be known about each stove is:

- How does this model perform (firewood usage compared to e.g. 3-stone by standardized tests and as reported by users)?
- What do users think about it (what do they like and do not like about it)?
- Where has it been used (in what kinds of conditions or by what kind of users)?
- How is it built (accurate building instructions with measurements and list of materials)?

Testing stoves is not easy, this being one reason why there is so little accurate information available about different models of stoves. Testing firewood usage of stoves by boiling point tests or standardized cooking tests is laborious but possible without any special equipment. However, many questions arise about the reliability and the comparability of such tests due to the many choices concerning the test site, the details of the procedure and the quality of the firewood. Getting accurate information on firewood usage from the users is tedious for the users when all firewood needs to be weighed and recorded for long periods of time. However, user interviews are easy to conduct and they give the opportunity to hear the customers' view of the product on performance along with possible problems and suggestions for improvement. Testing emissions requires special equipment and skills and is out of reach of most of the smaller stove interventions.

We performed boiling point tests and standardized cooking tests for all stoves within our projects (Soini and Coe 2011). This also gave us the opportunity to learn about the modifications we had made. In addition, interviews were conducted to get user feedback on each model. Information was obtained about what the users think is good and bad about each model. Any ideas for modification were also recorded. By these interviews we also learned how the technology has started to spread from the persons initially trained.

If, collectively, we are to improve the performance of projects introducing improved stoves, each project must itself do two things: carry out credible evaluations and publish the results of those evaluations. A 'tick the box' approach to monitoring project activities is not sufficient as no learning takes place.

## Other project design considerations

The principles elaborated here are necessary but not sufficient for designing effective stove projects. In common with development work in other sectors, there are at least two further groups of considerations. First, there are general principles for planning interventions such as the mode of participation, gender awareness and sustainability. These are documented in many sources. Secondly, there is a myriad of practical questions concerning strategy and approach that need to be answered. For example, will the project organise training to allow everyone to construct their own stove? Or is it better to develop a group of artisans who can make a business of stove building? If the latter, what skill level is required from the artisans to allow them to join the training? And how these should be assessed? The answers to these questions will depend on local context.

## Conclusions

It might be expected that introducing the apparently simple and needed technology of improved wood-burning cook stoves would be straightforward. However years of experience suggests that is not the case. We have used literature and our own project experience to document 20 principles for stove project design. These cover areas of awareness creation of the multiple benefits, requirements for stove design and variety of models and the participation of the beneficiaries in the design, production modes, role of subsidies, and the necessity of accurate assessments and reporting. These are not new: many projects have used several of these. However few projects have used all of them.

Awareness raising lays the foundation for the project and builds the motivation to adopt. It is necessary to know the project area and its needs very well in order to do this properly. Improved stoves bring multiple benefits and it is necessary to know which benefits are most important in each area of operation. Raising awareness of stove benefits that people are concerned about creates demand for the stoves.

Only stoves that are desirable will be acquired and used. A stove has to conform to design principles to perform well. Hence these principles need to be understood by local users and artisans participating in finalising the design. Participation of users and local artisans is essential for the creation of models that are acceptable – for example, models that support traditional cooking habits and are easy to use– and feasible to construct locally. As families have different requirements and priorities, several models are needed to fulfil the needs of the whole community. The project is responsible for testing the performance of the stoves. If readymade models are to be selected by the project, it is necessary to base the selection on reliable evidence of their performance and acceptability. As smoke is one of the major problems that stove projects should address, it makes sense to concentrate on models with chimneys.

Projects need to be flexible in decisions on which production mode to facilitate. There is currently a general strong trend to mass production. However, many areas are still so poor with limited cash economies that they will be left out if free and locally constructed models are not introduced.

An aim of development projects is to use public funding to provide services and products to people who cannot easily afford to pay the full price for these and their development and design. Subsidies and cost-sharing will thus always play a role in development projects. The level of subsidy and the type of subsidy (indirect or direct) needs determining according to the needs of each project location. It might also be needed to develop markets to a new sector. However, it has been found that the involvement of the local government should be only in dissemination, technical advice and quality control, not in production.

Compilation of these principles has been possible because some projects and researchers have systematically evaluated their project successes and failures, and then carefully documented and published their findings. It is necessary to assess both the project design and the stoves and then report accurately and in detail. This open approach to generating evidence and learning from it is essential if we are to make projects more effective and allow these beneficial technologies to reach more people. We hope our list of principles will also be used, evaluated and revised as learning continues.

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