ANALYSIS OF AVAILABLE MODELS OF IMPROVED COOK STOVES (ICS) AND THEIR SUITABILITY IN DIFFERENT ECOLOGICAL ZONES IN NEPAL

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SUMMARY

Approximately 90% of Nepal's total energy requirement comes from biomass, which makes it the most important source of energy. Nearly two thirds of this fuel is used for cooking, mostly with traditional cooking stoves that are inefficient and defective.

In recent times, various programs for promoting Improved Cook Stoves (ICS) have been implemented, resulting in the installment of over 700,000 ICS in rural households across the country. However, the available models of these stoves and their suitability in different ecological zones had not been analyzed prior to this research, and household needs in light of family sizes and cultural practices had been ignored. Programs or manufacturers have created new models in the laboratory and sent them directly to the field without feedback from potential users. Hence, this study was carried out with the objective of compiling information on efficient and appropriate designs for ICS, with the ultimate goal of conserving forests and reducing greenhouse gases that result from deforestation/forest degradation.

In the course of compiling this report, various individuals and organizations involved in the development, promotion, and Distribution of ICS were interviewed as primary sources using structured questionnaires. The secondary sources included published and unpublished reports, research articles, journals, technical manuals, and bulletins.

The results from our study indicate that the suitability of a cooking stove for a given populace depends on innumerable factors like geography, climate, and socio-economic factors. In the high hills, for instance, locals prefer portable metal stoves because these stoves also function as space heaters—a critical requirement in cold places. In the mid-hills, mud ICS with two or three potholes and fixed rocket stoves are most appropriate. Rocket stoves are able to achieve the efficient combustion of fuel at high temperatures by ensuring a good supply of oxygen, controlled burning of fuel, complete combustion of volatiles, and efficient use of the resultant heat. This technology is cheap, efficient, and easy to build using local materials. In the Terai, several models of mud ICS are suitable. Portable rocket stoves are also preferable because many houses have thin walls and thatched roofs, and people often cook outdoors.

Although new models of ICS made by international manufacturers have been introduced in Nepal, we cannot recommend these stoves now due to socio-economic considerations such as the potential unemployment of local stove promoters, and the distortion of prices in local manufacturing, etc.

CHAPTER ONE: BACKGROUND

1.1 Energy Scenario in Nepal

Nepal has the highest consumption of traditional biomass fuels in Asia because of its dependency on firewood and other supplements such as charcoal, plant residues, and animal wastes (Bhattarai 2003). Biomass refers to living and recently dead biological materials than can be used as fuel (AEPC/ESAP, 2012). However, it excludes organic material transformed by geological process into substances such as coal or petroleum.

Approximately 90% of the total energy requirement is satisfied with biomass. Nearly two thirds of this energy from biomass is used for cooking (AEPC/ESAP, 2012). Overall, firewood meets about 77% of the national demand, which makes it the largest contributor of energy. Agricultural residues and animal excrement provide about 4% and 6% respectively.

Almost all of the firewood used as fuel is consumed for domestic purposes (WECS, 2010). The cutting of trees from public and community forests as well as private farms for household consumption is depleting the forests of Nepal at a fast rate, and causing ecological and environmental degradation.

In the context of energy consumption at the household level, cooking is the most significant activity. Most cooking stoves in rural areas use biomass, especially firewood. The type of traditional stoves most frequently used in rural households is simple in design: a metal or clay tripod over an open fire. Such stoves have inherent defects, however. In addition to being highly inefficient, they produce lots of smoke and leave soot on utensils and other household items (CRT/N, 2014). Furthermore, open fires are dangerous. They are not advisable for households that have little children.

1.2 Improved Cook Stoves

Improved Cook Stoves are cooking devices designed to improve the combustion and efficiency of biomass. They consume less fuel, increase convenience, and reduce cooking time as well as emission (AEPC/ESAP, 2012). Additionally, they improve their users' quality of life by maintaining a cleaner household environment and reducing

workload in terms of firewood collection. According to the AEPC, some of the direct and indirect benefits of ICS include:

Impact on environment

- Firewood consumption is halved.
- Indoor air pollution is reduced by 30 to 90 percent.
- Greenhouse gas emission decreases by approximately 2.5 tons of CO_2 per year per stove.

Impact on health

- The risks associated with various respiratory problems decline — particularly for pneumonia among children and chronic obstructive pulmonary disease among women.
- Eye irritations and other health problems decrease.
- Fire hazard is reduced.

Impact on gender

- Women spend less time collecting firewood, cooking, and washing dishes.
- Women's disproportionate exposure to smoke declines.
- Men's participation in the kitchen increases with a cleaner household environment.

1.2.1 The history of ICS in Nepal

The history of ICS in Nepal dates back to the early 1950s, when Indian models such as Hyderabad and Magan stoves were introduced (Joshi 2004; AEPC/ESAP 2012). In the 1960s, the Department of Agriculture developed its own model and used molds to manufacture and disseminate this stove into the 1970s. About this time, various governmental and non-governmental organizations became involved in developing and distributing such stoves: the Peace Corps, the Women Training Centre, the Research Centre for Applied Science and Technology, the United Nations Children's Fund, etc. (Joshi, 2004). Overall, the efforts to distribute Improved Cook Stoves were sporadic until the National Rural and Renewable Energy Program (NRREP) was implemented under the AEPC in 2012 to systematically promote and disseminate ICS and similar technologies (APEC/NRREP, 2012).

1.2.2 The present status of ICS in Nepal

By 2014, more than 740,000 ICS had been distributed throughout the country. Additionally, 14,000 metallic ICS (high hills) and 1,500 Institutional ICS (IICS) had been installed. Mud ICS had been distributed in 2,655 Village Development Committees (VDC), 33 municipalities, and 63 districts, and over 8000 promoters and stove masters had been trained (AEPC/NRREP, 2014).

Improved Cook Stoves are becoming increasingly popular by the day with the involvement of INGOs including World Wildlife Fund Nepal (WWF-Nepal), International Centre for Integrated Mountain Development (ICIMOD), the Netherlands Development Organization (SNV), and the International Union for Conservation of Nature (IUCN); NGOs including and private-sector entities like Practical Action Nepal.

1.3 Rationale for the study

Overexploitation of resources for energy is driving deforestation and forest degradation in Nepal. Since more than 60% of the households in the country use firewood as their main source of fuel for cooking, the inefficiencies inherent in traditional cooking stoves should be taken seriously (AEPC/NREP, 2014). In order to reduce the pressure on our forests from the energy demand, the Government of Nepal and other initiatives like the Hariyo Ban Program have been promoting energy-saving technologies. Improved Cook Stoves like rocket, metal, and mud stoves, for instance, have been distributed or promoted in recent years.

However, the available models of these stoves and their suitability in different ecological zones had not been analyzed prior to this study, and household needs in light of family sizes and cultural practices had been ignored. Hence, the collection of information on the available models of ICS, with regard to factors such as convenience, efficiency, and cultural acceptability, was necessary to ensure that the most appropriate designs are distributed.

1.4 Scope of the study

The scope of the study, as per the terms of reference, has been outlined below:

i. Collect information on the available models of ICS, including brief descriptions of their designs, energy efficiencies, fuel consumptions, applicability in various ecological contexts (taking into account family sizes, heating needs, culinary practices, etc), and upcoming designs.

ii. Analyze the findings to evaluate the effectiveness, constraints, and prospects of the available models.
iii. Present a draft report with the key findings, issues, and recommendations to the Hariyo Ban Program and other stakeholders for comments and suggestions.
iv. Prepare the final report after incorporating the comments and suggestions.

1.5 Objectives

The general goal of the study was to identify the most efficient designs of ICS so that this information could be used to support the broader objective of conserving forests and reducing greenhouse gas emissions.

The specific objectives were:

i. To collect information on the available models of ICS and their utilities in different ecological zones.
ii. To recommend appropriate models of ICS for the various ecological zones where the Hariyo Ban Program is currently active—taking into account factors such as family sizes, culinary practices, women's workloads, etc.

CHAPTER TWO: METHODOLOGY

In the course of compiling this report, various individuals and organizations involved in the development, promotion, and distribution of ICS were interviewed as primary sources using structured questionnaires. The secondary sources included published and unpublished reports, research articles, journals, technical manuals, bulletins, and brochures. The following methods were used to compile all the required information:

i. Desk review of relevant literature.
ii. Analysis of photographs and sketches.
iii. Consultations and interviews with stakeholders (the government, I/NGOs, the private sector, promoters, manufactures, academic institutions) that have been involved in the development, promotion, and Distribution of ICS. A list of the organizations that were contacted (with the names of respondents) is attached as an annex to this report.
iv. Direct field observations.

CHAPTER THREE: FINDINGS

Depending on the geographical location, climatic condition, and socio-economic indicators in the area of distribution, several programs have distributed a wide variety of ICS models in Nepal. In the Terai, several models of mud-brick ICS and portable rocket stoves are common. A two-pothole stove with a grate in the combustion chamber is widely used by the people in the Terai since they burn a substantial amount of agricultural residues. In the mid-hills, mud-brick ICS have been distributed as they are cheap, efficient, preferred by the locals, and can be easily built using locally available materials. However, the backfiring of smoke due to incorrect assembling of the chimney and the longer cooking times associated with the second pothole are some of the commonly reported drawbacks for this type of technology. In the high hills, portable metal stoves are most appropriate due to the colder climate of this region.

The models of ICS currently being distributed have been instrumental in saving firewood and providing many other benefits. However, newer and more efficient models made by international manufacturers are increasingly available. The details regarding all of these models have been presented below:

3.1 ICS models in Nepal

3.1.1 Mud-brick ICS

i. One-pothole ICS

Region of Distribution	The mid-hills and the Terai. Although accepted in the Terai, this model should be modified slightly. Most houses in the region have thin walls and thatched roofs due to people's poor economic situation. The chimney used with this stove is not suitable for such houses. However, in those districts, especially in the Terai, where it is common to cook outside, this model is suitable without any modification.
Cost	NRs. 150 to 200 (with some variation depending on the size and base construction)
Quantity Distributed	20,000 plus
Description	Simple design
Efficiency[1]	25-30%
Advantages	Cheap; flexible design, which allows bigger stoves to be constructed to cook for larger groups; efficient removal of smoke; suitable for making animal feed.
Disadvantages	Requires training for its construction; generally unavailable in the market; longer cooking time (single pothole); unsuitable for space heating.

Source: AEPC, CRT/N, and Practical Action Nepal

[1]Efficiency, in this context, refers to thermal efficiency, which is a measure of how effectively the heat generated by the stove is utilized in boiling water or cooking food (Akpootu et al., 2014).

ii. Two-pothole ICS

Region of Distribution	The mid-hills and the Terai. This model is quite popular in the mid-hills. Although accepted in the Terai, it should be modified slightly for the region: Most houses have thin walls and thatched roofs due to the poor economic condition of the people. The chimney used with the stove is not suitable for such houses. Additionally, people in the Terai burn lots of agricultural residues, so designs that include grates are highly recommended**.**
Cost	NRs. 150 to 200 (with some variation depending on the size and base construction)
Quantity Distributed	20,000 plus
Description	This stove has only one fuel inlet below the first pothole. A baffle is placed at an angle of 60 degrees from the horizontal plane in order to direct the flame towards the second pothole. The design is shown in the figure below. The efficiency of combustion in two-pothole stoves can be improved by using grates, which allows air to heat up before reaching the fuel. The use of grates is also more suitable for burning agricultural residue. Additionally, it facilitates the collection of ash. Metallic chimneys can also be used with this stove. By placing a tin structure over the second pothole, the stove can double as a space heater. In order to conserve energy, whenever the rear pothole is not being used for cooking, it is advisable to use it to boil water or to cover it as shown in the figure below:
Efficiency	25-30 %

Advantages	Cheap; flexible design; efficient removal of smoke; reduction in cooking time (compared to the one-pothole model).
Disadvantages	Requires training for its construction; generally unavailable in the market; unsuitable for space heating unless a metal chimney or a tin box is used (which can be expensive); prone to back drafts from the chimney; not portable.

Source: AEPC, CRT/N, and Practical Action Nepal

iii. Two-pothole ICS (with the second pothole raised to waist height)

Region of Distribution	**The mid-hills and the Terai**
Cost	NRs. 150 to 200 (with some variation depending on the size, base construction, and local wage rates).
Quantity Distributed	Few
Description	
Efficiency	15-25 %
Advantages	Cheap; flexible design; efficient smoke removal; reduction in cooking time (compared to the one-pothole model); easy to repair and maintain; less conducive to back pain (due to the elevated design).
Disadvantages	Requires training for its construction; generally unavailable in the market; unsuitable for space heating.

iv. Three-pothole multipurpose ICS

Region of Distribution	**The mid-hills and the Terai**
Cost	NRs. 150 to 200 (with some variation depending on the size, base construction, and local wage rates).

Quantity Distributed	Few
Description	Simple design
Efficiency	25-30 %
Advantages	Cheap; flexible design; efficient smoke removal; greater efficiency in terms of cooking time; reduces the use of firewood by up to 40 percent (compared to traditional stoves).
Disadvantages	Requires training for its construction; generally unavailable in the market; unsuitable for space heating.

Source: AEPC, CRT/N, and Practical Action Nepal

v. Three-pothole institutional ICS

Region of Distribution	**The mid-hills and the Terai**
Cost	NRs. 150 to 700 (with variation depending on the size and base construction).
Quantity Distributed	1,000 plus
Description	A grate is placed on the first chamber, and two horizontal bars serve as top grates and support pots that are smaller in diameter. In order to use pots that are large, pot rests are recommended.
Efficiency	15-25%
Advantages	Highly efficient; suitable for businesses and institutions (barracks, hostels, restaurants, hotels, etc.); reduces the use of firewood by 20 to 30 percent (compared to traditional stoves)
Disadvantages	Requires training for its construction; generally unavailable in the market; unsuitable for space heating.

vi. The ESAP model (two-pothole institutional ICS)

Region of Distribution	**Schools in four pilot districts (Jajarkot, Surkhet, Salyan, and Makawanpur)**
Cost	NRs. 7,000
Quantity Distributed	175
Description	This stove is constructed using a special type of mud-brick. Iron pot rings are placed on both potholes to fit the cauldrons tightly. The holes are 56 and 33 centimeters in diameter. Heat is distributed between them at a 4 to 1 ratio. The height of the chimney is between 2.4 and 2.7 meters. A grate is placed over the fuel bed, and an iron gate is used to regulate the draft.
Efficiency	Information not available
Advantages	Highly efficient; saves fuel; allows the fire to be extinguished at will.
Disadvantages	Extremely expensive; unavailable in the market.

vii. Lapsi stove

Region of Distribution	**Sanga (Bhaktapur) and Kavre district because of the abundant production of Lapsi (Nepali hog plum).**
Cost	NRs. 1,000 to 1,500
Quantity Distributed	10
Description	The dimensions of the stove are 41 x 39.2 x 18 inches. The design uses bricks, cement, sand, an iron tripod, a grate, and an iron pipe. A metallic grate is used at the fuel bed to facilitate the frequent removal of ash. Mud plaster is used inside the combustion chamber to repair cracks. The fuel is fed into the chamber through a hollow

	metal tube.
Efficiency	Information not available
Advantages	Highly efficient; saves fuel.
Disadvantages	Unavailable in the market; uses Lapsi seeds as fuel (it might not be suitable to use with other fuels)

viii. Mud rocket stove

Region of Distribution	**The mid-hills and the Terai**
Cost	NRs. 300 (approximately)
Quantity Distributed	Only demonstrations have been conducted so far (in Makawanpur, Dhading, and Nuwakot).
Description	This model was built by the CRT/N with technical assistance from C. Kellner. It is made using mud-bricks. The combustion chamber is insulated using a refractory brick liner. The dimensions of the combustion and fuel insertion chambers are 12 x 12 x 30 cm and 10 x 12 cm respectively.
Efficiency	25%
Advantages	Does not require a chimney; produces less smoke.
Disadvantages	Requires firewood (or other fuel) to be supplied in small chunks; lacks multiple potholes; unsuitable for smaller pots.

ix. Matribhumi Chulo

Region of Distribution	**Lalitpur (Lele, Champi, Chapagaon, and Lamatar)**
Cost	NRs. 2,500 (approximately)
Quantity Distributed	1000

Description	Simple Design A three-watt fan feeds air into the burner. A chimney cap is kept at the outlet. As the smoke exits from the chimney, the cap insulates the house from the fire.
Efficiency	29%
Advantages	Affordable; easy to use; durable; reduces the consumption of firewood by 65.5%.
Disadvantages	Requires training for its construction; unavailable in the market; unsuitable for space heating.

x. Beehive briquette stove

Region of Distribution	Information not available
Cost	NRs. 700 (approximately)
Quantity Distributed	1000
Description	Simple design This type of stove is designed for the efficient burning of beehive briquettes. The combustion is completely dependent on the airflow through the main chamber, which can be controlled using a sliding door at the bottom. In clay stoves with metal rings, the welded metal reinforcement provides strength to the stove and acts as the potholder. In double-walled metal stoves, the space between the walls is insulted with rice husk, clay, ash, etc.
Efficiency	20-30%
Advantages	Easy to handle; portable; reduces smoke by 80%; suitable in all geographic areas of Nepal.
Disadvantages	Requires training for its construction; unavailable in the market; unsuitable for space heating.

3.1.2 Metallic ICS

i. Jumla design (smokeless metal stove)

Region of Distribution	**Jumla, Humla, Dolpa, and the mid-hills of Kaski.**
Cost	NRs. 7,500 (but it has been made available to farmers at a subsidized cost of NRs. 2,500)
Quantity Distributed	4,500
Description	Only one manufacturer, located in Nepalgunj, produces this stove. Its wall and cooking surface are made from 1.5mm and 4mm MS sheets. Each stove weighs about 40kg and has three potholes as well as a compartment for baking roti. A nine-liter stainless steel tank is attached to the chimney. It can be used to heat water. The bottom of the stove is filled with mud to prevent heat loss. An adjustable air vent on the main door allows the regulation of draft and a damper in the fuel pipe ensures the efficient transfer of heat. A new stove is expected to last 15 years. This design is suitable for places that are 2000 meters above the sea level.
Efficiency	14-22%
Advantages	Suitable for large families; reduces cooking time; serves multiple purposes (water and space heating); reduces the consumption of firewood by 40 percent; takes the local availability of resources and eating habits in high-altitude communities into consideration.
Disadvantages	Heavy; expensive; and difficult to manufacture.

Source: AEPC, CRT/N, and Practical Action Nepal

ii. Bayupankhi stoves

Region of Distribution	**Urban and semi-urban areas**

Cost	NRs. 600 to 5,000 (depending on the size and construction materials). The smallest stove, which is adequate for a family of 5 to 6 members, costs between NRs. 600 and 1,650.
Quantity Distributed	60,000
Description	Sindhu Urja Kendra manufactures these cylindrical stoves using metallic sheets. They are double-walled with a 3 cm air gap in between the cylinders. The inner wall has perforations to allow air into the combustion chamber. The stove is 23 cm in height. Its internal diameter can be 10, 15, or 18 cm depending on whether the stove is classified as small, medium, or large. A low voltage electric fan is fitted at the bottom of the stove or on an extended pipe—18 cm away from the body. If the fan is fitted at the bottom, glass wool is used to insulate it from the heat. Due to its efficient combustion, this stove consumes less than 1 kg of fuel wood to prepare a meal for five to six persons. A large sized 'Jumbo bayupankhi stove' is suitable for larger institutions.
Efficiency	25-30 %
Advantages	Highly efficient; portable; reduces smoke significantly.
Disadvantages	Requires firewood (or other fuel) to be supplied in small chunks; requires a power supply to operate the fan.

Source: AEPC, CRT/N, and Practical Action Nepal

iii. CRT/N metal stove

Region of Distribution	**Jumla, Humla, Dolpa, and Kalikot -- colder regions where metal stoves also function as space heaters.**
Cost	NRs. 4,500 (15 years ago)
Quantity Distributed	
Description	This stove has three potholes, one in the front (28 cm in diameter)

	and two in the rear (15 cm each). The wall and the top surface are made using 2mm and 4mm mild steel sheets. The chimney creates draft and provides an outlet for the smoke.
Efficiency	14-22%
Advantages	Doubles as an effective space heater; reduces cooking time (three potholes)
Disadvantages	Heavy; expensive; difficult to manufacture.

Source: AEPC, CRT/N, and Practical Action Nepal

iv. The KU2 design (metal stove)

Region of Distribution	**The high hills and mountainous regions.**
Cost	NRs. 3,700 to 4,500
Quantity Distributed	Very few
Description	This stove has two potholes in the primary chamber and a third pothole in the secondary chamber. An eight-liter water tank is attached to the primary chamber. The stove weighs 37 kg. This is the improved version of the KU1 model. However, it is still in a trial phase.
Efficiency	Information not available
Advantages	Highly efficient; clean combustion of fuel.
Disadvantages	Expensive; difficult to manufacture.

Source: AEPC, CRT/N, and Practical Action Nepal

v. CRT/N DK model

Region of Distribution	**The high hills and mountainous regions**
Cost	NRs. 2,500

Quantity Distributed	Few
Description	Two potholes and a water jacket are retrofitted into a metallic chimney. The stove weighs 12 kg.
Efficiency	25%
Advantages	Doubles as a water heater; comparatively light.
Disadvantages	Expensive; difficult to manufacture only in metal workshops which are usually not available locally

Source: AEPC, CRT/N, and Practical Action Nepal

vi. CRT/N RT model

Region of Distribution	**The high hills and mountain regions**
Cost	NRs. 1,000
Quantity Distributed	Few
Description	This metallic stove has a grate and an insulation liner inside it. It is based on the same principle as that of the rocket stove.
Efficiency	22-24%
Advantages	Less cooking time; doubles as a space heater; suitable for burning agricultural residues and briquettes; accommodates pots of various sizes.
Disadvantages	Requires firewood (or other fuel) to be supplied in small chunks); difficult to manufacture only in metal workshops.

Source: AEPC, CRT/N, and Practical Action Nepal

vii. Rocket stove

Region of Distribution	The **High hills**

Cost	NRs. 1,200 to 1,500
Quantity Distributed	Few
Description	This ash-insulated double-walled metallic stove can be built using a tin can or a metal bucket. The elbow, a key feature in the design, can be constructed using a metal pipe or ceramic. The combustion chamber is 12 cm in diameter and 30 cm high and has an insulated skirt around the pot. To increase convective heat transfer, a narrow gap is maintained between the pot and the skirt.
Efficiency	25-30%
Advantages	Portable; low emission; good combustion of fuel.
Disadvantages	Requires firewood (or other fuel) to be supplied in small chunks); expensive; difficult to manufacture in metal workshop.

Source: AEPC, CRT/N, and Practical Action Nepal

viii. WWF and SNV model

Region of Distribution	**Karnali and Sagarmatha zones**
Cost	Information not available
Quantity Distributed	12 in Dolpa and 12 in Solu Khumbu.
Description	This stove has two potholes, one larger and one small. Their diameters are 25 cm and 20 cm respectively. The wall and the top are 2 and 3 mm thick. The design includes a chimney for letting out smoke.
Efficiency	29-39%
Advantages	Multiple potholes; doubles as a space heater; easy to assemble and take apart (comes with a manual); light; cheap.
Disadvantages	Difficult to manufacture

Source: AEPC, CRT/N, and Practical Action Nepal

ix. Ujelii chulo (stove)

Region of Distribution	Dolpa and Solu Khumbu
Cost	Information not available
Quantity Distributed	12 in Dolpa and 12 in Solu Khumbu.
Description	This design integrates a thermoelectric generator with a fuel-efficient, low-emission wood stove. Two-finned heat sinks are used to generate a temperature gradient across the stove, which is used to generate electricity with the help of thermoelectric cells. The net peak output produced with this mechanism is 16 watts, so only low-wattage appliances can be used. This module produces 2 watts to drive a fan and 3 watts to power a low power consumption but high intensity light emitting diode (LED), which is capable of illuminating the entire room.
Efficiency	Information not available
Advantages	Generates electric power; low emission; low fuel consumption.
Disadvantages	Expensive to maintain and operate.

Source: AEPC, CRT/N, and Practical Action Nepal

x. Rice husk stove

Region of Distribution	**Rural Terai**
Cost	NRs 612-1,200
Quantity Distributed	Information not available
Description	This stove consists of an inner cone where the fire is ignited and an outer cone where rice husks are burned. The cones are separated by a heat shield, and they are both perforated with small holes at the bottom. At the base of the inner core, are two burners that provide a steady supply of oxygen.

Efficiency	Information not available
Advantages	Easy to use; very economical; uses agricultural residue as fuel.
Disadvantages	Can only be used where rice husks are available; incompatible with fuels other than rice husks; services of a metal workshop are needed for repair and maintenance.

Source: AEPC and NEW Initiatives

3.2. New ICS models

Recently, several new models of ICS manufactured by international companies have been introduced in the Nepali market. Most of these stoves claim to portable, highly efficient, and environment-friendly, but they are still being tested at the Renewable Energy Test Station (Nepal Academy of Science and Technology) to see if they live up to their claims. For the time being, we do not recommend these new models because importing them might distort prices in the local market and discourage local manufacturers. Furthermore, because these models come in readymade packages, they have the potential to take away the jobs of over 8000 promoters and stove masters, trained for ICS building (AEPC/NREP, 2014). According to CRT/N (2014), the women who work as ICS installers might suffer from unemployment. However, details on some of these models are given below.

i. CM-10-2/ CM-10-R (metallic stove)

Targeted Distribution Region	**Mountains**
Cost	NRs. 10,000 (two-pothole); NRs. 5,000 (rocket type)
Unit Weight	25 kg (two-pothole); 5-7 kg (rocket type)
Efficiency	Information not available
Durability	5 years
Description	Simple design
Advantages	• Reduces fuel consumption by 50 percent

	• Doubles as a space heater • Uses fiber glass insulation for safety

ii. Double burner wood stove (Prakti)

Targeted Distribution Region	**All regions**
Cost	NRs. 9,240
Unit Weight	8 kg
Efficiency	35%
Durability	5 years expected lifetime (one-year warranty)
Description	Modified design that allows the user to assemble the stove, can make local women responsible for stove assembly, bringing out the empowering potential of clean cook stoves. Flexible pot rests to fit pots of multiple sizes. Removable tops and bottoms for cheap and easy maintenance.
Advantages	Reduces fuel consumption by 40 percent. Cuts pollution of dangerous smoke by 80% Multiple potholes for simultaneous cooking.

iii. Double burner wood stove with chimney (Prakti)

Targeted Distribution Region	**All regions**
Cost	NA

Unit Weight	8 kg
Efficiency	NA
Durability	5 years expected lifetime (one-year warranty)
Description	Modified design that allows the user, local women, to assemble the stove. Flexible pot rests to fit pots of multiple sizes. Removable tops and bottoms for cheap and easy maintenance. The addition of a chimney reduces air pollution further.
Advantages	Reduces fuel consumption by 40 percent. Lowers pollution by more than 80 percent. Multiple potholes for simultaneous cooking.

iv. Single burner charcoal stove (Prakti)

Targeted Distribution Region	**All regions**
Cost	NRs. 5040
Unit Weight	8 kg
Efficiency	Information not available
Durability	5 years (one-year warranty)
Description	Easy to clean. Durable finish. Sliding doors to reduce pollution and charcoal consumption, and for easy removal of ash. Handles for convenience and portability.

Advantages	Reduces fuel consumption by 43 percent, a family of 8 people saves 0.5 kg of charcoal per day. Less time spent purchasing fuel and building a fire. Lowers air pollution by 80%.

v. Single burner wood stove (Prakti)

Targeted Distribution Region	The **Terai**
Cost	NRs. 5145
Unit Weight	5 kg
Efficiency	Information not available
Durability	5 years (one-year warranty)
Description	Durable grate to reduce pollution and wood consumption.
Advantages	Reduces fuel consumption by 50 %, saves a family of five people 2 kg of wood per day. Lowers air pollution by 80 %. Less time spent purchasing fuel and building a fire.

vi. G-3300 wood stove (Envirofit)

Targeted Distribution Region	**The h**ills
Cost	NRs. 7,000
Unit Weight	5.7 kg
Efficiency	32.6 %
Durability	Information not available

Technological Description	Information not available
Advantages	Information not available

vii. M-5000 wood stove (Envirofit)

Targeted Distribution Region	The hills
Cost	NRs. 7,000
Unit Weight	4.2 kg
Efficiency	29.7 %
Durability	Information not available
Technological Description	Information not available
Advantages	Information not available

viii. PCS-1 premium cook stove (Envirofit)

Targeted Distribution Region	**All regions**
Cost	NRs. 7,000
Unit Weight	5 kg
Efficiency	32.6 %
Durability	Two-year warranty
Technological Description	Argon welded 1 mm thick body. Top plate made with heavy cast iron.

	No riveting (except for branding and serial no).
Advantages	80% reduction in smoke and toxic emissions Less time is spent purchasing fuel and building a fire. 50% reduced cooking time 60% reduced fuel consumption. Durable design.

ix. Agni Star

Targeted Distribution Region	**All region**
Cost	NRs 9,500
Unit Weight	6.7 kg stove and 2.5 kg combo controller for total of 9.2 kg
Fuel	Rice husks
Efficiency	34 %
Durability	Information not available
Technological Description	Information not available
Advantages	Information not available

x. Agni Sun

Targeted Distribution Region	**All region**

Cost	NRs 10,500
Unit Weight	Information not available
Fuel	Rice husk
Efficiency	31 %
Durability	Information not available
Technological Description	Information not available
Advantages	Information not available

xi. Annapurna chulo

Targeted Distribution Region	**Annapurna circuit**
Cost	Information not available
Unit Weight	5 kg
Efficiency	35- 37%
Durability	Two-year warranty
Description	Argon welded 1mm body. Top plate made with heavy cast iron. No riveting (except for branding and serial no).
Advantages	50 % less consumption of fuel. Lowers smoke emission by 70 %. Cuts cooking time by almost half

xii. Orka institutional stove (Pratki)

Targeted Distribution Region	**All regions**

Cost	Information not available
Unit Weight	8 kg
Efficiency	Information not available
Durability	5 years expected lifetime (one-year warranty)
Technological Description	Portable. Improved combustion using a new fuel inlet and grate design. Optimal size and weight.
Advantages	Reduces fuel consumption by up to 80% and cooking time by up to 70% Reduces harmful emissions by 80%.

xiii. Smart chulo

Targeted Distribution Region	**All regions (urban institutions)**
Cost	NRs. 50,000 to 60,000
Unit Weight	Information not available
Efficiency	Information not available
Durability	5 years (one-year warranty)
Technological Description	Simple design. Portable. Uses biomass pellets as fuel.
Advantages	Optimum fuel consumption for large-scale cooking.

3.3. Appropriate models of ICS for different ecological zones

i. Mountain regions

The mountain regions occupy 35% of the total land but only about 6.75% people live in this region (CBS, 2011). Improved Cook Stoves made from metals are most appropriate for the mountains, which is why they have been preferred for distribution by various governmental and non-governmental organizations in this region. These stoves ensure fuel efficiency, clean combustion, and effective space heating. Additionally, they have indirect benefits, such as conserving forests, reducing women's workload, reducing indoor air pollution and hence smoke related health disorders, preventing fire hazards, and reducing cooking time (GIZ/NEEP, 2011a).

Simple metallic stoves that have two to three potholes are reasonable for most households in the region. However, models that have baking compartments and water heaters are also available. An interesting design that uses an adjustable air vent to regulate the airflow and a damper in its flue pipe to allow the efficient transfer of heat is worth considering as an option (Thapa & Shrestha, 2013). A SWOT analysis of the various technologies developed for the mountain region is attached to this report (Annex III). The details of some standard ICS models are presented below:

a. Two-pothole metallic ICS

	Features
Weight	30 kg
Length	600 mm
Breadth	300 mm
Height	220 mm
Fuel Type	Firewood
Fuel saving	30-40%
Efficiency	18-25%

Family Size	6-9
User Satisfaction	Satisfied
Life Span	5 years (minimum)
Cost	NRs. 5,639 (Subsidized cost: NRs. 2,700)

b. Three-pothole metallic ICS

Features	
Weight	40 kg
Length	610 mm
Breadth	430 mm
Height	220 mm
Fuel Type	Firewood
Fuel saving	30-40%
Efficiency	18-25%
Family Size	6-9
User Satisfaction	Satisfied
Life Span	5 years (minimum)
Cost	NRs. 7,239 (Subsidy: NRs 4,000)

The technologies for improved cooking and space heating currently being distributed in the mountain regions have delivered mixed results (GIZ/NEEP, 2011a). While metallic ICS have been widely accepted by the locals, they also improve health conditions of women and children, and help to preserve natural resources (Thapa & Shrestha, 2013). However, these stoves have some notable drawbacks. Since most manufacturers are based in urban areas, particularly in the Terai, people living in the high hills and

mountains find it difficult to access the technology. The cost of transportation of goods to remote areas is high. As a result, poor families cannot afford to pay for these stoves without subsidies and, therefore, choose to continue using traditional stoves consuming more fuelwood in smoky environment (GIZ/NEEP, 2011a). Issues like limited options for fuel (many of these stoves are only compatible with wood) and the lack of knowledge on maintenance are relevant.

ii. The hills

The hills occupy about 42% of the total land and 43.1% of Nepal's people live in this region (CBS 2011). In this region, various support programs distributed different types of improved stoves. Mud brick ICS are appropriate for the hills. The locals in this region prefer these stoves because most deigns are cheap and they can build them using locally available materials (Thapa and Shrestha 2013). The details of some notable ICS models are shown below.

a. Two-potholes ICS

Features		
ICS Type	Two-pothole (Plain surface)	Two-pothole (Second pothole raised)
Pothole Diameter (1st)	8-10 inch	8-10 inch
Pothole Diameter (2nd)	6-8 inch	6-8 inch
Length	30-34 inch	30-34 inch
Breadth	14-18 inch	14-18 inch
Height	10-12 inch	10-12 inch
Height of Chimney	20-24 inch	20-24 inch
Fuel Opening	8-10 inch	8-10 inch
Fuel Type	Primarily firewood	Primarily firewood
Fuel Saving	20-30%	20-30%

Efficiency	25-30%	25-30%
Family Size	Average (5-7)	Average (5-7)
User Satisfaction	Satisfied	Satisfied
Interval for Cleaning the Chimney	15 days	15 days
Life Span	3 to 4 years	3 to 4 years
Cost	NRs. 350-450	NRs. 350-450

Source: AEPC and CRT/N

b. Rocket stove

Rocket stoves are efficient cooking devices that utilize high-temperature combustion chambers containing insulated vertical chimneys to ensure the complete combustion of small chunks of wood. Fixed and portable versions of these stoves can be manufactured. They are suitable in all parts of the country (Practical Action, 2009). Rocket stoves have an average efficiency of 25 to 30% (Thapa & Shrestha, 2013). An analysis of the strengths and weakness of various stoves of mid hill and Terai is presented in Annex IV. The details of some appropriate versions of rocket stoves are presented below:

1. Two-pothole rocket stove

Features		
ICS Type	Two-pothole (Plain surface)	Two-pothole (Second pothole raised)
Pothole Diameter (1st)	8-10 inch	8-10 inch
Pothole Diameter (2nd)	6-8 inch	6-8 inch
Length	12 inch	12 inch
Breadth	8 inch	8 inch
Height	16-20 inch	16-20 inch
Height of Chimney	48-60 inch	48-60 inch

Chimney Diameter	4 inch	4 inch
Fire Gate	6x7 inch	6x7 inch
Fuel Type	Primarily firewood	Primarily firewood
Fuel saving	-	-
Efficiency	-	-
Family Size	-	-
Interval for Cleaning the Chimney	-	-
Life Span	-	-
Cost	-	-

Source: AEPC, CRT/N

2. Fixed one-pot rocket stove with metallic top plate

Features		
Combustion Chamber Type	Metallic	Ceramic
Length	40 cm	40 cm
Width	40 cm	40 cm
Height	27 cm	30 cm
Inner Diameter (Combustion Chamber)	10 cm	10 cm
Fuel Chamber	13x11 cm	19x11 cm
Chamka Height	2.5 cm	2.5 cm
No. of Potholes	1	1
Fuel Type	Primarily firewood	Primarily firewood
Fuel Saving	NA	NA

Efficiency	27%	26%
Burning Time	10 hrs	12 hrs
Family Size	5-7	5-7
User Satisfaction	Satisfied	Satisfied
Life Span	3 years (minimum)	3 years (minimum)
Cost	NRs. 1200-1500	NRs. 1200-1500

Source: AEPC, CRT/N

3. The Terai

The Terai occupies only 23% of Nepal's land but supports 50.15% of the total population (CBS, 2011). Three types of biomass are used most frequently for cooking purposes: firewood, cow dung, and agricultural residues. However, not all ICS are compatible with cow dung and agricultural residues (GIZ/NEEP, 2011b). Therefore, various governmental and non-governmental initiatives have distributed mud ICS and rocket stoves as suitable technologies for this region.

The two-pothole mud stove with a grate in the combustion chamber is fairly popular among the locals, because it can burn agricultural residues. The portable one-pot rocket stove is also preferred because it is convenient to move around; the locals tend to cook inside or outside the house depending on whether it is summer or winter. Additionally, the design is suitable for making rotis. People in the Terai prefer to have their stove outside their house because snakes may enter houses for the warmth from stoves. Thus, two potholes stoves and portable rocket stove is suitable for this region. The detail about different appropriate mud stove model for this region is discussed in previous section and the details of this stove are given below:

a. Rocket stove

Portable one-pot rocket stove with metallic top plate

Features

Combustion Chamber	Metallic
Height (Combustion Chamber)	35 cm
Diameter of the Top Plate	52 cm
Fuel Chamber	15x15 cm
Fuel Type	Primarily firewood
Fuel Saving	Information not available
Efficiency	34%
Burning Time	15 hrs
Family Size	5-7
User Satisfaction	Satisfied
Life Span	3 years (minimum)
Cost	NRs. 1,200-1,500

Source: AEPC, CRT/N

CONCLUSION

Regions	Suitable ICS type	Cost	Fuel efficiency	Durability	Family size	Advantages	Disadvantages	Remarks
Terai	a) Two-pothole ICS	NRs. 350-450	25-30%	3 to 4 years	5-7	Cheap; flexible design; low cost; efficient removal of smoke; reduction in cooking time (compared to the one-pothole model).	Requires training for its construction; generally unavailable in the market; unsuitable for space heating unless a metal chimney or a tin box is used (which can be expensive); prone to back drafts from the chimney; not portable.	Not useable for cow dung.
	b) Portable one-pot rocket stove with metallic top plate	NRs.1200-1500	34%	3 years (minimum)	5-7	Portable; low smoke emission; reduces cooking time; requires relatively less maintenance.	Requires firewood (or other fuel) to be supplied in small chunks; unsuitable for small pots; can cook only one item at a time. According to users, it burns fuel efficiently only after getting sufficiently hot.	

Mid-hills	a) Two-pothole ICS	NRs. 350-450	25-30%	3/4 years	5-7	Cheap; flexible design; efficient removal of smoke; reduction in cooking time (compared to the one-pothole model).	Requires training for its construction; generally unavailable in the market; unsuitable for space heating unless a metal chimney or a tin box is used (which can be expensive); prone to back drafts from the chimney; not portable.	Not suitable for cow dung.
	b) Fixed one-pot rocket stove with metallic top plate	NRs. 1200-1500	26-27%	3 years (minimum)	5-7	Low smoke emission; reduces cooking time; requires relatively less maintenance. Affordable.	Requires firewood (or other fuel) to be supplied in small chunks; burns fuel efficiently only after getting sufficiently hot; unsuitable for small pots; consumes more fuel until it is hot and burns efficiently only after getting hot.	

High hills and Mountains	a) Metallic ICS	Two pot: NRs. 5,639 (Subsidy 2,700) Three pot: NRs. 7,239 (Subsidy 4,000)	18-25%	5 years (minimum)	6-9	Durable; doubles as a space heater; allows simultaneous cooking.	Leakage from the joints; heavy; rigid pot-holes; expensive; difficult to manufacture

RECOMMENDATIONS

The main recommendations from this study include the following:

i. New Improved Cook Stoves should be developed, and existing ones modified, to suit the localized needs of their target populations. To date, the design and distribution of most stoves have followed a top-down approach: programs or manufactures create new models in the laboratory and send them directly into the field without getting feedback from potential users. A recommendation of this study to conduct field surveys before designing new types of ICS in the future.

ii. Door-to-door visits to offer post-installation services can play a critical role in ensuring that new users do not abandon their ICS after a few years (due to the lack of proper maintenance). Currently, the programs that disseminate ICS generally lack monitoring mechanisms. As a result, there is very limited information available on user satisfaction. Even distributors have a hard time providing accurate information on the use of ICS in their own areas. Thus, additional monitoring programs and surveys are required in order to increase and evaluate customer satisfaction.

iii. Further research is required to develop a more nuanced understanding of the most suitable designs of ICS for specific regions and communities in Nepal although this study has already compiled a reasonable volume of information on this topic.

iv. The AEPC is currently conducting a competition for new designs of ICS. Information regarding the new models participating in this contest has not yet been released. WWF Nepal might want to wait for the results from the competition, which the AEPC is planning to announce soon, before taking any concrete steps.

ANNEX

Annex III: The strengths, weaknesses, opportunities, and threats of various technologies (high hills)

S.N.	Type of technology	Strengths	Weaknesses	Opportunities	Threats
1.	AEPC/ESAP metal stove	Durable; cooks up to three items simultaneously; doubles as a space heater	Leakage from the joints; heavy; rigid potholes; expensive; difficult to manufacture	Very popular among users; reduces pollution and greenhouse gas emission substantially.	Expensive to manufacture and transport; difficult to sell without subsidy
2.	Smoke hood	Reduces indoor air pollution	Leakage from the joints; difficult to manufacture	Reduces the impact of indoor air pollution on health	Expensive to build and transport
3.	Stove promoted by local manufacturers	Custom-made	Expensive; does not meet the appropriate standards	Potentially useful in scaling up the distribution of metallic stoves	Expensive to manufacture and transport
4.	Chinese stove	Durable; allows simultaneous cooking; doubles as a space heater	Expensive; difficult to get	Popular; potential for reduction in cost by importing in bulk	Limited availability

Source: GIZ, 2011

Annex IV: Strengths and weakness of various stoves (mid-hills and the Terai)

Sn.	Type of stove	Strengths	Weaknesses	Remarks
1.	Traditional mud stove	Made from locally available materials Affordable Suits local customs and needs	High emission due to inefficient combustion Time consuming Less than 10% efficient Fire hazards	Bad for health, utensils and other household items, as well as the environment.
2.	Mud ICS (ESAP model)	Affordable Twenty-four percent efficiency Lasts six months to one year Reduces smoke significantly The design can be altered to accommodate one or two pot-holes	Inefficient burning because of the small combustion chamber that does not allow primary air to flow effectively Large deposits of ash accumulate inside the combustion chamber	Incompatible with dung as fuel
3.	Mud ICS with ceramic combustion chamber	Durable (lasts 3 to 4 years if maintained properly)	Inefficient burning because of the small combustion chamber that does not allow primary air to flow effectively	The grate needs to be modified according to the nature of the dung

	(CRT model)	Easy to install Twenty-five to thirty percent efficiency Reduces smoke significantly Multiple pot-holes for simultaneous cooking Comes with a water heating attachment The size of the stove can be modified to suit household needs Affordable	Large deposits of ash accumulate inside the combustion chamber The baffle has to be repaired frequently to maintain its shape and size	that is used as fuel
4.	Dung stove (CWS design) (Still in testing phase)	Durable Low maintenance Highly compatible with wood and dung briquettes Portable	Costly (NRs. 4,000) Difficult to manufacture locally	Potential for large-scale distribution
5.	Rocket stove (locally made with technical	Low emission Shorter cooking times (compared to	Users remark that it consumes a lot of fuel (perhaps because it requires an optimal temperature for maximum	Needs some design modification

	support from NGOs)	traditional stoves) Low maintenance Affordable	efficiency)	
6.	Briquette stove	Utilizes agricultural residues	Very little demand Ill-suited to local eating habits High emission (mainly carbon monoxide)	Cannot replace the use of dung fuel
7.	Rice husk stove	Affordable Durable Low maintenance Utilizes wastes	Creates significant air pollution	Cannot replace the use of dung fuel