INVENTORY OF INNOVATIVE INDOOR SMOKE ALLEVIATING TECHNOLOGIES IN NEPAL

PRACTICAL ACTION NEPAL

Mr. Uttam Dhakal
Consultant
March 2007

ACKNOWLEDGEMENT

This "**Inventory of Innovative Indoor Smoke Alleviating Technologies in Nepal**" is outcome of the study conducted for **Practical Action Nepal**. I would like to express my sincere thanks to Practical Action Nepal for providing me with this opportunity. My special thanks go to Mr. Min Bikram Malla Thakuri, Project Officer, Access to Infrastructure Services, Practical Action Nepal for providing invaluable support during the study and also for the significant inputs to bring the report into this shape. My wholehearted appreciation to Mr. Rajan Thapa, Deputy Director and ICS Program Manager, Centre for Rural Technology Nepal (CRT/N) for sharing his experiences and providing information extensively especially in improved mud-brick and metal cooking stoves. I would also like to thank all individuals and institutions who provided all necessary information needed for the successful completion of this study.

TABLE OF CONTENTS

ACRONYMS

AEPC	Alternative Energy Promotion Center
ALRI	Acute lower respiratory infection
amsl	Average mean sea level
ARECOP	Asia Regional Cookstove Program
ARI	Acute respiratory infection
BSP	Biogas Support Program
CBO	Community Based Organizations
CEE	Center for Energy and Environment
CES	Center for Energy Studies
CFDP	Community Forest Development Program
CO	Carbon monoxide
COPD	Chronic obstructive pulmonary diseases
CRT/N	Center for Rural Technology
DANIDA	Danish International Development Agency
CWSN	Child Welfare Scheme Nepal
ESAP	Energy Sector Assistance Program
FAO	Food and Agricultural Organization
FoST	Foundation of Sustainable Technology
GHG	Greenhouse gas
GJ	Giga joule
GO	Government organization
GoN	Government of Nepal
IAP	Indoor air pollution
ICIMOD	International Center for Integrated Mountain Deveolopment
ICS	Improved cook/cooking stoves
IDS – N	Integrated Development Society - Nepal
INGO	International Non Governmental Organization
IOE	Institute of Engineering
LPG	Liquidified petroleum gas
LPO	Local Partner Organization
KWH	Kilowatt
MGJ	Million giga joule
MOPE	Ministry of Population and Environment
NA	Not applicable

N_2O	Nitrous oxide
NAST	Nepal Academy of Science and Technology
NGO	Non Governmental Organization
NICSP	National Improved cook stoves program
NORAD	Norwegian Agency for Development Cooperation
NRCS	Nepal Red Cross Society
NRs.	Nepalese rupees (1 US$ equivalent to NRs. 71, Date: 5 February 2007)
PM	Particulate matter
ppb	Parts per billion
ppm	Parts per million
RECAST	Research Center for Agricultural Science and Technology
RSP	Respirable suspended particulates
TEG	Thermoelectric generator
TRUST	Technology and Rural Upliftment Service Team
TSP	Total suspended particles
TU	Tribhuvan University
UNDP	United Nations Development Program
UNICEF	United Nations Children Fund
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization
WTC	Women Training Center

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

1. BACKGROUND

1.1 Energy consumption in Nepal

Energy is critically importance to development; economic growth; balance of payments and peace; national and regional environmental protection; and the global climate. The efficient production and use of energy in an environmentally sound way is essential to tackle these concerns and lead to sustainable development based on equity, empowerment, environmental harmony and economic efficiency.

Nepal, sandwiched between India on three sides - East, West, and South; and China to the North is a landlocked and predominantly mountainous country with a total area of 147,181 sq. km with tropical plains in the South (Terai) and the Himalayas in the North within a mean width of 193 km. The mountainous region, which is sparsely populated covers about one third (35%) of the total land area of which only 2% is suitable for cultivation. The hills region makes up 42% of total land of which one-tenth is suitable for cultivation. Terai, the densely populated region accommodates 47% of total population comprise of 23% of total land area, which includes fertile land and dense forest (CBS, 2001).

Nepal, the state of economic development, is the highest traditional fuel consuming countries in Asia because of its high dependency on traditional biomass fuels, mostly firewood and limited extent of charcoal and residues of crops and animals (Bhattarai, 2003). These biomasses are used in preparing food; animal feed; processing of livestock products; agricultural and forest product processing; pottery; building materials; smiths and foundries; and various other rural industries and services along with space heating (Thapa, 2006). Global estimation of biomass users is about two and half million who use wood, charcoal, crop residues and dung as their primary source of energy. However the global use of biomass is declining, its use is increasing amongst the poorest segments of the world's population (Reddy et al., 1997 and Bruce et al., 2000 cited by Saldiva and Miraglia, 2004). About one billion people in Asia depend on biomass as the main source of energy (Thapa, 2006).

In 2005, Nepal was one of the lowest per capita energy consumption countries of about 15 GJ. The total primary energy consumption of Nepal in 2005 was 369 MGJ, where traditional, commercial and alternative energy sources contributed about 322 (87%), 44 (12%) and 2 (1%) MGJ respectively. Among the traditional energy sources; firewood, animal dung and agricultural residues contributed about 78, 6 and 4% respectively. Commercial energy source is shared by petroleum fuels (LPG, kerosene etc.), electricity and coal of about 8.9, 1.6 and 1.6% respectively. Energy consumption in Nepal is categorized in residential, industrial, commercial, transport and agricultural sector, in which residential sector consumed 334 MGJ, about 90% of total national share which is fulfilled by dried biofuels and commercial energy source of about

318 (86%) and 14 MGJ (4%) respectively. Industrial sector consumed 13 MGJ (3.6%) of total national energy share and contributed through 11 MGJ commercial and 2 MGJ traditional energy source. The transportation sector consumed 14 MGJ (4%) of total energy source which is contributed almost solely through imported petroleum fuels. Commercial sector also consumed about 4 MGJ (1%) of total energy source and contributed through both traditional and commercial energy source of each 2 MGJ. Despite being agricultural based country, the energy consumption in agricultural sector is insignificant, i.e. 3 MGJ (less than 1%) and relied mostly on petroleum fuels and some electrical energy source (WECS and CES/IOE/TU, 2005, cited by Bhattarai, 2006).

The national population growth is 2.25 %; however, the population growth rate in urban and rural areas of Nepal is 2.30 and 1.70% respectively. The main source of energy of 94.1% rural household is firewood, whereas in urban areas, the main source of energy are firewood, kerosene and other sources of commercial energy which accounts about 39, 35 and 25% respectively (CBS, 2003). Energy demand has been consistently increasing due to population growth and highly required economic growth (ICIMOD, 2006).

Agriculture is the mainstay of about 85% Nepal’s rural populations. Hills households in rural areas consume about 6 and 7.6 tons of firewood during summer and winter respectively, whereas, Terai household consume about 3.7 and 5.4 tons of firewood in summer and winter respectively (WINROCK, 2004). It is estimated that residential cooking, which account about 65% of total energy consumption in rural areas, is the single largest energy end-use activity. Similarly, space heating, agricultural processing, water boiling, lighting and other activities account 8, 3, 2, 1 and 21% respectively. The end-use energy activity of urban household for cooking, lighting, heating/cooling, agro processing, animal food processing and other activities account 51, 10, 10, 3, 8 and 14% respectively (WECS, 2005). In mountainous area, 32 and 56% of household energy is used for cooking and space heating respectively whereas in hill areas, 40 and 36% energy is used in cooking and space heating respectively. The remaining 12 and 24% energy consumption in mountain and hill areas respectively is used for lighting, electrical appliances, water boiling and agro processing activities (Final report on high altitude smokeless metal stove, 2005, unpublished).

1.2 Indoor air pollution and its effect

Combustion, which is never perfect in reality, is a complex sequence of chemical reactions of fuel and an oxidant accompanied by the production of heat or both heat and light in the form of either glow or flames. Smoke, the result of incomplete combustion depends on the type of wood and vegetation being burnt; the temperature of the fire; wind conditions; and more importantly to the moisture content in fuel (Ballard-Tremeer, 1997, cited by Bates et al., 2005). When biomass is burnt, it emits harmful chemicals such as particulates, carbon monoxide, formaldehyde, and nitrogen dioxide along with carbon dioxide and water vapor (Ban et al.,

2004) and the indoor concentration of a given pollutant is established by the rates of its production and removal from the environment (Saldiva and Miraglia, 2004). One of the four greatest risks of deaths and diseases in the world's poorest countries is smoke from solid fuel because smoke in the home is the part of the daily life of more than two billion poor people who use solid fuels, such as, twigs, agricultural residues, dung, coal etc (Warwick and Doig, 2004).

The very fine particles in smoke can go deep into the lungs and fine particles, by themselves or in combination with other air pollutants, can make pre-existing diseases of the heart and lungs worse. The technology to burn the solid fuels in three-stone fires or rudimentary stoves results in poor combustion efficiency and high levels of indoor air pollution (IAP). Poverty and availability of biomass at no monetary cost and even without consideration of time cost; lack of recognition of the scale of the problem by policy-makers; lack of funds at government level to address the scale of the problem; and low status of women and children in many poor communities are the major reasons for not receiving more attention to IAP (Ballard-Tremeer, 1997, cited by Bates et al., 2005).

IAP in home is the major contributing factor of various major health hazard, such as, acute lower respiratory infection (ALRI), chronic obstructive pulmonary disease (COPD), lung cancer (mainly due to coals), pulmonary tuberculosis, low birth weight and infant mortality, cataracts, asthma, cardiovascular diseases (Warwick and Doig, 2004). The leading cause of death and disability of human life around the world are chronic bronchitis and chronic obstructive pulmonary disease (COPD). It is also reported that reproductive function in females could be the target of air contaminants and the exposure of women to emissions generated by biomass stoves has been also shown to significantly increase the rate of lung and laryngeal cancers (Smith and Liu, 1993; Cliford, 1972 cited by Saldiva and Miraglia, 2004). Homes of underdeveloped world have pollution level 100 times higher than the cities of developed world having serious ambient pollution issues. This pollution cause catastrophic health problems especially to women and children (two groups that spend the most time indoors cooking and standing near fires) that attribute about 1.8 million deaths in a year, roughly three deaths in a minute (Ban et al., 2004); and of the total death, 56% are children below five years (Bates et al., 2005). Illness caused by smoke kills more children annually than malaria or HIV/AIDS and claims nearly one million children's lives each year. Table 1 shows the IAP as main contributing factors of different health hazard.

Increasingly, human activities are also producing effects on global and regional scales. Popularly called global warming but properly called climate change is the impact of increased concentration due to cooking and heating using residential fuels i.e. greenhouse gas (GHG) emission. The resulting behavior of the earth system may include not only increased in temperatures, but also changes in rainfall patterns or extreme weather events. As large populations rely on biofuels for cooking in Asia and Sub-Saharan Africa, large GHG concentration appear in these areas. Likewise, the resulting GHG is due to heating with wood in north-eastern United States (Bond et al., 2004). About 8 billion tons of GHG is emitted annually and 220 billion tons of carbon equivalents are already accumulated in the atmosphere. Burning of fossil fuels and indefensible use of biomass are the major sources of GHG emission in Nepal. As a result, despite negligible amount of GHG emission, there were some negative impacts of climate change in Nepal as an average temperature is increasing at the rate of approximately 0.06 °C per year (Praikh, J., 2004 and Pokharel, A. P., 2002 cited by Shakya and Shrestha, 2006). Cleaning up existing combustion, or changing to different energy sources are two possible ways to reduce GHG emission (Bond et al., 2004).

Table 1: Health impacts of indoor air pollution

Health outcome	Evidence	
ALRI (children under 5 years) COPD (adults) Lung cancer (coal)	Between 10 to 20 studies Few measured exposure Confounding problematic	Strong
Tuberculosis, Cataract Upper airway cancer, Asthma	Several consistent studies but more conflicting for asthma	Moderate
Low birth weight Prenatal mortality	Very few studies, support from environmental tobacco smoke and ambient air pollution studies	Weak
Cardovascular disease	No studies but suggestive	

Source: WHO, 2006

The major tasks of the rural women in Nepal are collection of firewood, cooking and taking care of their children. Because of depleted forest, rural Nepalese women need several hours of walk and are vulnerable to back problem. Additionally, spending hours for cooking in hazardous conditions in inefficient stoves result rise to eye infections and other respiratory problems (WINROCK, 2004).

There is very limited information on indoor air quality in Nepal. A study in 18 villages by Davidson et al. (1986) revealed that the total suspended particle (TSP) was 8,800 µg/m^3, 21 ppm carbon monoxide (CO) and 368 ppb nitrous oxide (N_2O) where firewood was used as fuel (WHO & Nepal Health Research Council, 2002). The level of emission in Nepal is much higher than national and international standards. The national ambient air quality standards for Nepal for TSP and PM10 for 24 hour average time are 230 and 120 µg/m^3 respectively and 8 hour average CO standard is 10,000 µg/m^3 (MOPE, 2001). The WHO guideline for PM concentration is 50 µg/m^3. Similarly the guidelines for CO concentration are average 9 ppm for 8 hours, 26 ppm for 1 hour and 87 ppm for 15 minutes (Thakuri and Hada, 2006). Hessen et. al also monitored 24 and 8 hours concentration TSP and CO in 34 households in Jumla through principle caregivers using traditional stove and found that the TSP and CO concentration of 8420 and 5000µg/m^3 and 13.5 and 23.42 ppm for 24 and 8 hours respectively.

Acute Respiratory Infection (ARI) is the third leading cause of death in the nation. Some experts estimate that young, rural Nepalese children living in poorly ventilated conditions are 100 to 400% more likely to suffer from ARI than the children in the developed world. Women who cook on biomass in Nepal are nearly four times as likely to suffer from chronic bronchitis as their counterparts in developed nations (Ban et al., 2004). About 3.13% people are affected by ARI and the percentage of children with ARI symptom is 22.8. IAP is one of the major causes of such high occurrence of ARI (http://www.moh.gov.np). Chronic bronchitis falls at the eighth position. Pandey et al. examined 240 rural children less than 2 years of age for 6 months and found a significant relationship between number of hours spent near the fire (as reported by the mother) and the incidence of moderate to severe ARI cases. A survey conducted in Jumla in 1981 revealed that the mortality rate in 0 to 1 year age group is one of the highest ever reported from anywhere in the world. The total mortality rate was 488.9 per 1000, and 333.3 were due to ARI. It has been reported that such a high mortality rate could be due to various respiratory, bacterial, and viral infections (Pandey, 2003).

An epidemiological study conducted in 1979 in a rural community in the hilly region of Nepal revealed a significant positive correlation between the prevalence of chronic bronchitis and average amount of time of exposure to indoor air pollution both amongst smokers and non-smokers. A house-to-house survey in Sundarijal (north of Kathmandu) with a sample of 3,258 showed that 12% of the adults (>20 years) were found to have chronic bronchitis and 3.1% were associated emphysema. Around 51% of the chronic bronchitis and 38% of emphysema were found among women. The study revealed that chronic bronchitis was 3 times more common in smokers than nonsmokers. A study in four different sites of Nepal: from urban Kathmandu district; Sundarijal and Bhadrabas, the rural hill region of Kathmandu district; Parasauni, the plain region from Bara district; and Chandannath, the mountainous region of Jumla district revealed the crude prevalence rate of chronic bronchitis was 11.3, 18.3, 13.1, and 30.9% in urban Kathmandu; Sundarijal and Bhadrabas; Parasauni; and Chandannath respectively (Pandey, 2003).

The negative effects on human health due to utilization of solid fuels for indoor cooking and heating in very large population segments worldwide are extremely important and deserve substantial mitigation efforts by national/local governments. The identification and quantification of health damage is essential to put in perspective possible actions in the way of technology development and implementation to address the problem. The reduced level of lethal smoke would lead a healthier life of billions of people; however public awareness of the health risks of smoke is a crucial first step. Poverty is the major constraint of poor people to switch to a cleaner fuel, such as LPG, kerosene or biogas or modern fuels. The international community; UNDP; and a number of organizations including Practical Action are working directly with poor communities to find best solutions and scale up their efforts which needs sufficient funding and high level international political backing for such initiatives (Ban et al., 2004).

The average life expectancy of Nepal was 58.95 years at the end of December 2002 (Ninth Five Year Development Plan, 2002). But the Tenth Five Year Development Plan has set the target to increase the life expectancy of 65 years (WINROCK, 2004), and reduction of indoor smoke is one of the effort to reach that goal. To achieve substantial reduction in IAP and increased fuel efficiency, various types of technologies were introduced in Nepal by different organizations; however, local level innovation is also important in this regard. The invention of Improved Cooking Stoves (ICS); briquette burning technology; and introduction of chimney and smoke hood along with some renewable technology, such as solar cooking and bio-gas technology would help to reduce indoor smoke, however, the experience shows that the success of technologies depend on various things including availability and price of fuel; socio-cultural and ethnic values; geography; cooking behaviors; cooking items; stove operation; size of kitchen; surrounding weather etc.

This study was focused mainly on the preparation of inventory of innovative indoor smoke alleviating technologies which could be useful for relevant organizations or interested individual to get acquainted with these technologies and make right choice of technology applicable for them. Additionally, the outcome of this study would be an important reference to get an idea on various innovative smoke alleviating technologies in Nepal. This task is also expected to support organizations working in this area to know what has already been done. This will help to reduce duplication and assist to plan new innovations for future.

1.3 Objectives

The main objective of this study was to compile the information of various innovative indoor smoke alleviating technologies in Nepal.

The specific objectives of this study were to:

- Analyze the pros and cons of each innovative smoke alleviating technologies.
- Analyze the efficiency of each technology with respect to acceptability, pollution reduction, fuel saving and time saving.
- Identify appropriate smoke alleviating technologies for different socio-cultural settings, weather, geography, fuel types and cooking behavior.

1.4 Methodology

The study was carried out using primary as well as secondary information. For primary information, various organizations were contacted personally using developed questionnaire. Secondary information was collected through various reports, technical manuals/publications, bulletin, brochure etc.

The following methods were conducted to derive the information.

- The relevant literature (traditional and as well as innovative introduce IAP reduction technologies), mainly technical manuals/publications were collected and reviewed. Some relevant materials were also collected from internet websites
- Various stakeholders (I/NGOs; private sector; promoters of technologies; projects and programs; Government; academic/research institutions, manufacturers etc.) involved in promotion of smoke alleviating products were identified and interviewed
- Identification of organizations (Government, private, I/NGOs, research institutes, projects etc) involved in reducing/alleviating indoor air pollution mitigation effort and interviewed with the relevant staff
- Direct observation of the investigators
- Description of the technology with detailed sketches, figures and photographs
- Analyze the pros and cons; and efficiency (with respect to acceptability; pollution reduction; and fuel and time saving) of each innovative smoke alleviating technologies.
- Identification appropriate smoke alleviating technologies for different socio-cultural settings, weather, geography, fuel types and cooking behavior.

1.5 Limitation of the study

This study was limited only to those households who use firewood and agricultural residues as a source of energy for cooking and space heating. Due to limited time span, questionnaires were sent to organization located outside Kathmandu valley. Total number of technology promoted in actual field condition and some field problems could not be collected from some organizations as these organizations were only supporting local NGOs. However, information collected through interview, developed questionnaire and informal discussions were used to derive maximum information on innovative indoor smoke alleviating technologies in Nepal.

2. FINDINGS

To achieve substantial reduction in IAP, increased fuel efficiency and decreased cooking time, different organizations have developed and implemented various technologies in Nepal. The intervention of mud-brick Improved Cooking Stoves (ICS) including metal stoves; briquetting technology; and introduction of chimney and smokehood were some technologies that have been identified in reducing IAP for those household who use firewood and agricultural residues as a source of energy for cooking and heating; and space heating. As alternation of biomass fuel is not feasible for the vast majority of household in rural areas in foreseeable future, the appropriate technological intervention to utilize these biomass based energy has become very important for sustainable development and environmental protection. However, this study also depicts the importance of renewable technology, such as, biogas and solar cooking technologies for the alternation of biomass based energy as forest resource has been limiting for the growing population.

2.1 Cooking stoves

In Nepal, large segment of people still depend on simple and primitive; low combustion efficient; and locally fabricated biomass fuel combustion devices in the household, rural industries and in commercial sector. These devices are vulnerable to emit IAP which subsequently pollutes the atmosphere and cause many diseases. For example, the measurement of PM10 concentration monitored by Nepal Environmental & Scientific Services (NESS) in 2001 in city core, sub-core, remote and industrial areas of Kathmandu for firewood, LPG and kerosene fuel found that wood burning houses has 6 and 2.4 times greater PM10 concentration than LPG and kerosene burning houses respectively (MOPE, 2001). Some traditional household and institutional cooking stoves are shown in Photograph 1.

Nepal became open to outside world after abolishment of Rana regime in 1951. Planned development was started in 1956 in Nepal. ICS was one of the first development initiatives after establishment of democracy in Nepal. Those first ICS, which were multi-pot stoves, were developed in India. Those stoves were of high mass and shielded fire type and had a chimney to remove smoke from the kitchen. They also had adjustable metal dampers to regulate the fire. ICS was first introduced as Hydarabad smokeless *chulo* (stove) at Bikas Pradarshani (exhibition) in 1956 in Bharatpur, Chitwan. Wider dissemination of ICS started in early 70s, when main emphasis was on improving fuel efficiency in order to arrest deforestation. At that time, Lorena stove, which was large mud stove with a number of rings, was promoted by the Women's Training Centre (WTC). It provided training to women on construction of Lorena stoves. In late 70s, RECAST was involved to improve these stoves and renamed them as Nepali *chulo.*

Traditional household stoves

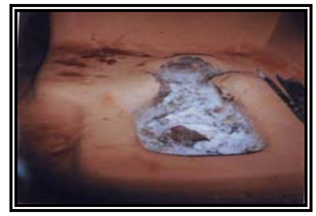

Three-stone cook stove


Chuli


Agenu


Makkal


Bhuse stove


One pothole stove


One pothole stove


Two potholes mud-stone stove


Three pothole stove in Dang

Traditional institutional stoves

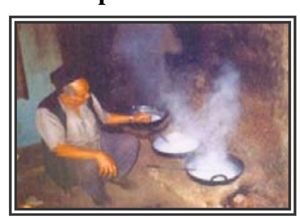

One pothole stove in Terai


One pothole stove in Rukum


Two potholes stove


Two potholes stove


Two potholes stove


Khuwa making stove


Lapsi stove


Bread making stove


Two potholes and tandori stove

Source: CRT/N

Photograph 1: Traditional cookstoves of Nepal

Detailed scientific assessment of cook stove performance in terms of efficiency and design methodology in laboratory began in early 80s, when National Planning Commission included ICS in its sixth five-year plan. Ceramic insert and double wall stoves replaced the Lorena and other mud stoves. These initiatives of RECAST were funded by government and donor agencies like UNDP and FAO. Community Forestry Development Project (CFDP) was involved in large-scale distribution of ICS in rural areas of Nepal. Agricultural Development Bank also introduced ceramic cook stoves and the new Nepali *chulo* with support from UNICEF. Likewise, Earthquake Rehabilitation Project also constructed large-scale household mass stove (mud/stone stoves) in the eastern part of Nepal during late 80s.

A glance over history of ICS development in Nepal reveals that various international donors had a very strong influence on ICS promotion because they supported almost all activities. As with other development interventions, impact of ICS programs also could not sustained. That was because the program could not address the real needs of various users, did not have a long-term development objective, could not establish an institutional arrangement and did not develop human resources as per need. As a result, any program on ICS couldn’t sustain as soon as external funding stopped.

New initiatives for ICS dissemination have been taken since 90s. It comprises of new and locally adaptive stoves design that can be built completely from cheap and easily available local materials. The study of SECCON (2000) also revealed that the insert stove, double wall stove, new Nepali *chulo* (UNICEF Model), improved Tamang stove, mud/brick stove RECAST raised two potholes mud/brick stove, RECAST mud stove, smoke recyclable stove are some types of pottery liner stove that have been disseminated so far until 1990s. At present, the sun dried mud-brick stoves are cast on site by trained stove promoters; however at the time of inception, it was initially made with mud and stone with burnt clay pipe chimney. Among the various models, Tamang stove (two potholes) is widely accepted in the hilly areas, especially mid hill regions of the country. The approach has also been changed from top down, target oriented, subsidy based to bottom up, demand driven and self-construction approach. Ninth five-year plan (1997-2002) has provided policy guidelines to encourage development and application of energy saving devices as well as promotion and dissemination of alternate energy technologies in order to reduce fuel wood pressure on forests. In tenth plan (2002-2007), particularly ICS has been given emphasis for further development. Within the current planning period, government plans for 250,000 ICS to be built. Consequently, a National ICS Program (NICSP) has been initiated with support from Energy Sector Assistance Program (ESAP) of DANIDA. The program is implemented through government’s Alternate Energy Promotion Centre (AEPC). Networking of ICS promotion organizations at regional level have also been undertaken with the support from Asia Regional Cook stove Program (ARECOP). Over 150,000 ICSs have already been built by end of 2003 and growing demand for ICS have been observed (Shrestha et al., 2003). It is estimated that until now AEPC has promoted more than 200,000 mud-brick ICS. Various INGOs, NGOs, CBOs have been also promoting and disseminating this model.

In Nepal, the simple and primitive metal stove (just inverted U type) was used in the past. The history of *bhuse chuli* is 1980s. Some CRT model metal stoves were disseminated in late 1990s. The initiation of the intervention of metal rocket stoves was started in 1996 but promoted since 2003. Foundation for Sustainable Development (FoST) was actively involved in promotion/dissemination of rocket stoves. Since late 1990s Jumla design smokeless metal stoves have been promoted in Jumla, Humla and Mugu and now some mid hills of Pokhara. At present various types of *bayupankhi* (air induced) metal stoves have been promoted/disseminated in semi-urban and urban areas of Nepal.

The objectives of the innovation of mud-brick ICS and metal stoves were to improve health of rural people by reducing IAP; reduce fuelwood consumption and thereby reduce the dependency on forest resources for domestic energy consumption; reduce drudgery of rural women; improved kitchen sanitary conditions (clean kitchen such as cooking pots/pans are less darkened with soot deposits; good lighting, less soot on walls, floors and ceiling); reduce cooking and fuelwood collection time and hence involvement of rural people in some other income generating activities.

A recent survey report in 34 mid hill districts revealed that the implementation of ICS programs declined the tripod, three stone and traditional mud stove users by 29.8, 30.5 and 9% respectively. Among the users, 86.3, 87.8, 21.1, 19.9 and 13.7% reported less time consuming (23 minutes a day), smokeless (which ultimately reduces the expenditure on health by NRs. 463 per household), firewood saving (23.5%), easy cooking and clean kitchen (non-hazy environment, good lighting, and less soot on walls, floor and ceiling). 99.7% ICS were in operation with 91.1% in daily use and 73.6% ICS users were found satisfied during monitoring field visits. Due to National Improved Cook Stove Program (NICSP), the time saved during cooking and collection of firewood is used in other income generating activities. This program also employed three persons of each Village Development Committee (VDC) as a promoter with an average annual salary of NRs. 6000 to 24000 (CADEC, 2006).

Pandey et al. (1987) measured the personal exposure levels of Respirable Suspended Particulates (RSP), CO and formaldehyde (1 hour for RSP concentration and 1 hour concentration of CO and HCHO) during cooking periods in 20 households with traditional stoves (without chimneys) and ICS in rural areas of Nepal's hilly region in between November 1986 and March 1987. The result showed the level of concentration of RSP, CO, HCHO was 8,200 $\mu g/m^3$, 82.5 ppm and 1.4 ppm for traditional stoves respectively, whereas, the concentration level of RSP, CO, HCHO for ICS was 3000 $\mu g/m^3$, 10.8 ppm and 0.6 ppm for ICS respectively. The outcome of the study of Ried et. al, (1986) to compare the concentration level of CO and TSP of traditional stoves without chimneys and ICS with chimneys in middle hills districts of Nepal is shown in Table 2.

In order to control IAP, construction of better-ventilated rooms is equally important along with improved stoves and fuels. According to a comparative study conducted by Holly F. Reid, Kirk Smith and Bageshowri Sherchan, the mean personal exposure to TSP in *agenu* (traditional cooking stoves) and ICS was 3920 and 1130 μg/m^3 respectively. Similarly, mean personal exposure to carbon monoxide (CO) in traditional and ICS was 380 and 67 ppm respectively, which implies that ICS reduce indoor TSP and CO concentration by 71 and 82% respectively (Raut, 2006).

Table 2: Comparison of CO and TSP in traditional and improved stoves

Study location	Pollutants	Exposure on traditional stove	Exposure on improved stove	% reduction	References
Gorkha	CO	280 ppm	70 ppm	75	Reid, 1986
	TSP	3170 μg/m^3	870 μg/m^3	73	
Beni	CO	310 ppm	64 ppm	79	Reid, 1986
	TSP	3110 μg/m^3	1370 μg/m^3	56	
Mustang	CO	64 ppm	41 ppm	36	Reid, 1996
	TSP	1750 μg/m^3	920 μg/m^3	47	
Bardibas	CO	82.5 ppm	11.6 ppm	86	Panday, 1990
	TSP	8200 μg/m^3	3000 μg/m^3	63	

Source: SECCON, 2000 (cited from Sharma, 1995)

The impact study report on ICS program effectiveness in Doti, Dang, Kavre, Udaypur, Ilam, Kathmandu, Syangja, Baglung, Surket, Sindhuli, Dadeldhura revealed that the average users of two pothole mud-brick ICS were 90%. In Dadeldhura, 48% were found with one pothole stove. Three pothole mud-brick ICS were found sparsely in Sindhuli Baglung and Surkhet. The reasons for using ICS in these areas were smokeless kitchen (73%) followed by fuelwood saving, easy cooking and time saving. 65% stoves were found near window, whereas, 23% were found near door. In Ilam, stoves were found separately in a shed. The report also revealed the promoter's vital role (70%) in the adoption of ICS followed by neighbor's inspiration (18%). All users were provided with the information on repair and maintenance, whereas, 59% were provided with user manual. As per the expectation of ICS, 90% reported time saving (fuelwood collection and cooking time) and majority of household relieved from problems caused by smoke such as respiratory and ophthalmic as well as nose running, chest pain, tuberculosis etc. The overall positive impact on health and expenses were reduced by 75%. ICS are extensively used from cooking up to *kundo* (animal feed) making, almost 99% for meal preparation. The average operating hours of ICS in these districts were 3.7 hours (TRUST, 2004). The cost of useful heat per MJ (considering 1 kg of fuelwood = 16.5 MJ) in ICS ranges from NRs. 0.37 to 0.44 compared to NRs. 0.95 in tradition iron tripod stove. Likewise, for ICS users including opportunity cost, the cost of useful heat per MJ ranges from NRs. 0.37 to 0.44 compared to NRs. 0.68 to 0.78 using kerosene (SECCON, 2000). The field test in Dalchoki VDC of Lalitpur district showed 20 to 25% fuelwood saving in ICS compared to traditional stove (WP/ IDC/Sulpya, 1997 cited by SECCON, 2000).

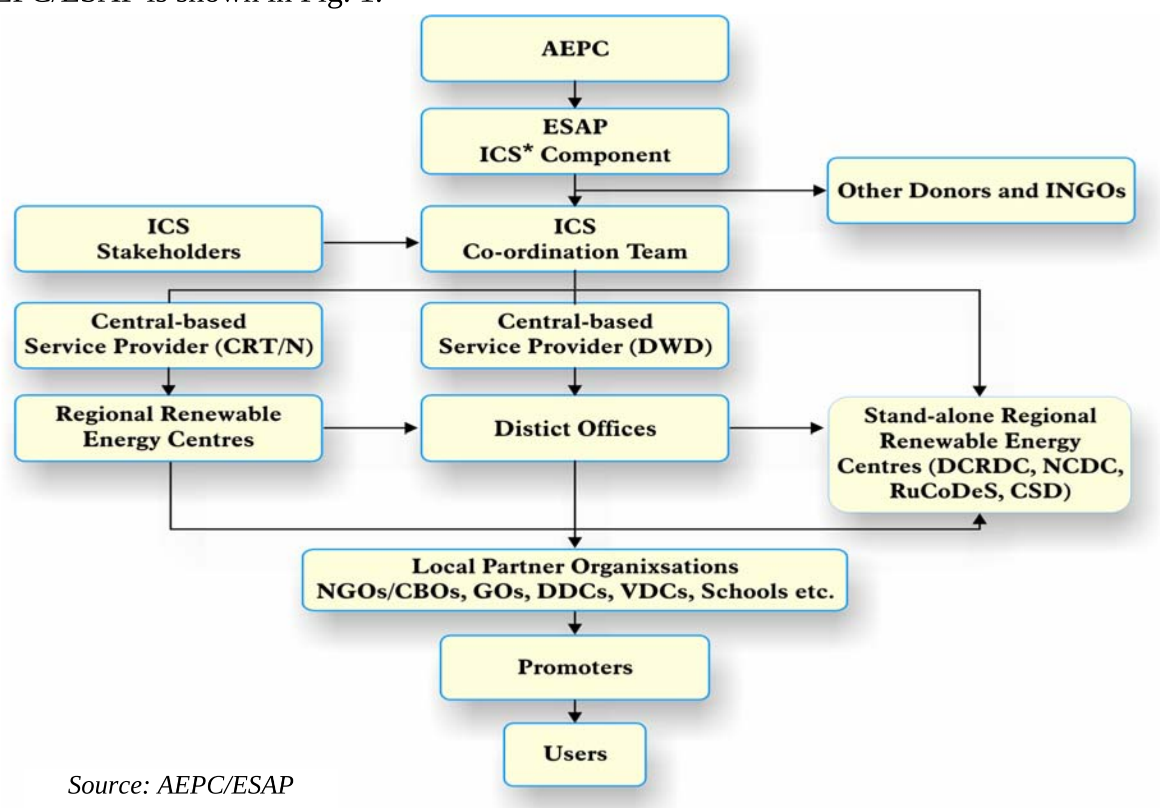
The findings of various types of mud-brick ICS and metal stoves that have been disseminated in Nepal are described below.

2.1.1 Mud-brick improved cooking stoves

AEPC/ESAP is the major organization in disseminating ICS and the major activities of ICS program includes:

- To develop and distribute appropriate Information and Education and Communication materials to the relevant organizations, program and national institutions etc.
- To identify the partner organizations or technical service providers at central and local level; and training of trainers (TOT) on ICS technical training for district level development organizations
- To identify ICS R & D organizations and institutions for adaptive and participatory research; and establishment of national level biomass forum.

Centre for Rural Technology, Nepal (CRT/N), Rural Community Development Society (RUCODES), Namsaling Community Development Centre (NCDC), Dhaulagiri Community Resource Development Centre (DCRDC), Centre for Self-help Development (CSD) and Department of Women Development (DWD) have been identified as service providing organizations for the facilitation of ICS program. The implementation of ICS is done through district based local partner organization (LPO) identified by service providing organizations. The Regional Renewable Energy Service Centers (RRESC) of AEPC/ESAP will facilitate in training and information dissemination for partner organizations; and the programs are implementing through local partners. The institutional linkage of national ICS program of AEPC/ESAP is shown in Fig. 1.



Source: AEPC/ESAP

Fig 1: National ICS Program Implementation Modality and Organization Linkage Chart

Public awareness on health impact due to IAP is one the major activities in disseminating ICS. Users received only training, promotional campaign and information material as an indirect subsidy. The mud-brick type ICS is installed by the trained villager on the request of the user as per his/her preferences, such as, one, two or three pothole with different sizes of pothole. The trained promoters are paid by end-users. As per the personal conversation with Dr. Rhiddi Bir Singh (Associate Professor and Coordinator, Bio-fuel studies, Institute of Engineering Tribhuvan University), the efficiency of traditional and mud-brick ICS normally varies from 6 to 10% and 12 to 20% respectively and the reasons for variation in efficiency are proper construction of ICS; and type and moisture content of fuel.

The materials required to built these mud-brick stoves are soil (*chimtyayelo*, i.e. sticky soil), rice husk, dung and water. Soil, dung and rice husk are mixed in 5:1:2 proportion and water is added to make a paste. Dry sand or ash is spread on the brick shaped wooden mould which is soaked in water for 30 minutes. The prepared paste is then placed in the mould and pressed and levelled. After levelling the paste, the mould with paste is overturned and the mould is removed slowly. The prepared block is sun dried for 3 to 4 days. The construction of the stove is started with the prepared bricks with soil paste. Soil paste is used to join the bricks and to fill up the small opening to make air tight. A layer of stones is fixed if stove is made other than the ground floor. 2 inch gap is maintained between the kitchen and stove wall, which is filled either with husk or ash for insulation. Metal plate or metal rods/rings is place around the pothole for additional strength to prevent the stove from cracking during cooking. The outlet of the chimney, which is usually made of metal are of various types such as hood, L or T types, will be extended outside through the hole of the kitchen wall and the chimney height is maintained about 5 feet. Longer chimney sucks the flame and hot air and reduce the eifficiency of the stove and the shorter chimney has less draught. During construction, there is a provision of small hole in the stove to remove the deposited carbon (soot) in the chimney. Chimney should not bend more and cleand at least in two weeks. As these stoves are not portable, wind direction should be considered before designing the kitchen and especially the location of stove. Ambient air, which contains oxygen for proper combustion is denser than the smoke. So the window of kitchen should face the wind direction for proper combustion as well as removal of smoke from the kitchen as shown in Fig. 2.

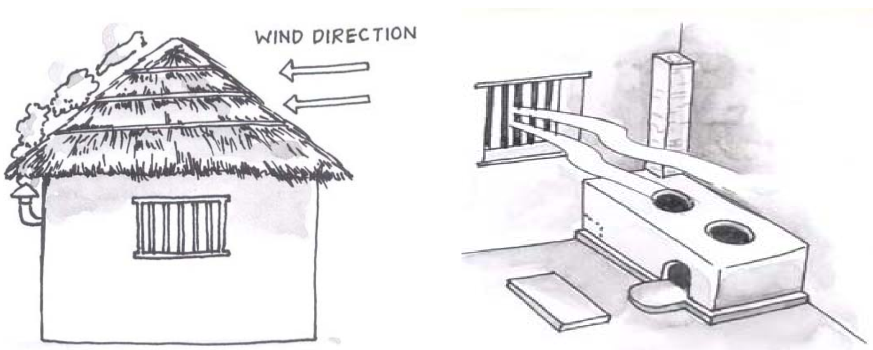
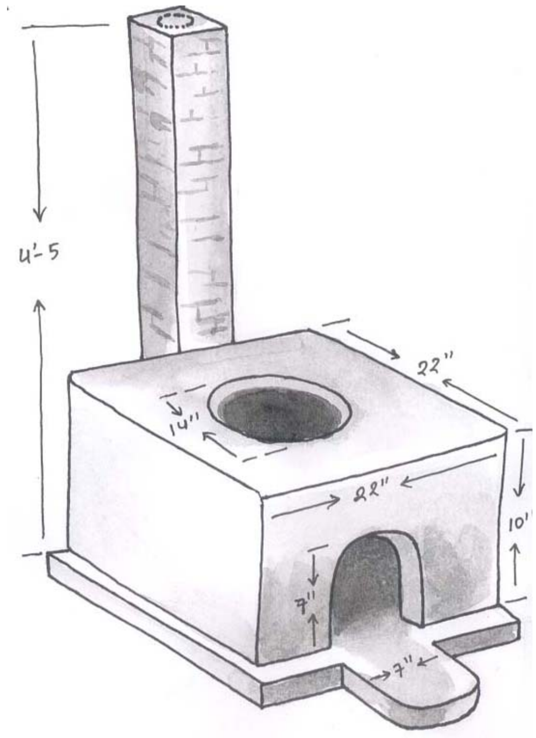


Fig. 2: Kitchen design Consideration

The various types of mud-brick ICS are shown below.

A. One pothole ICS



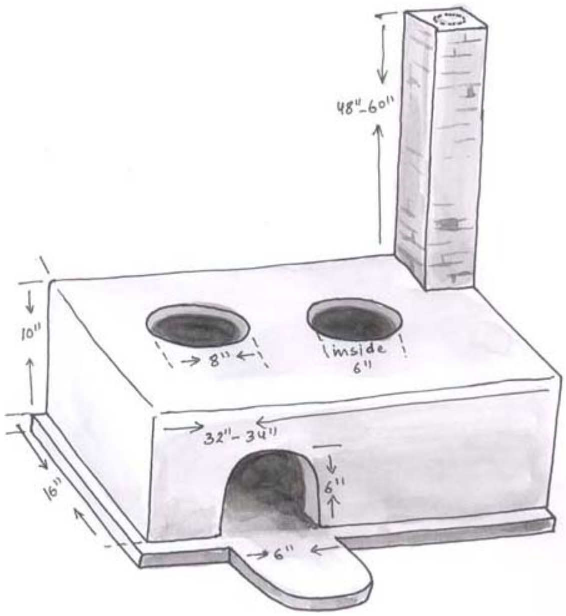
Source: AEPC

Fig. 3: One pothole ICS

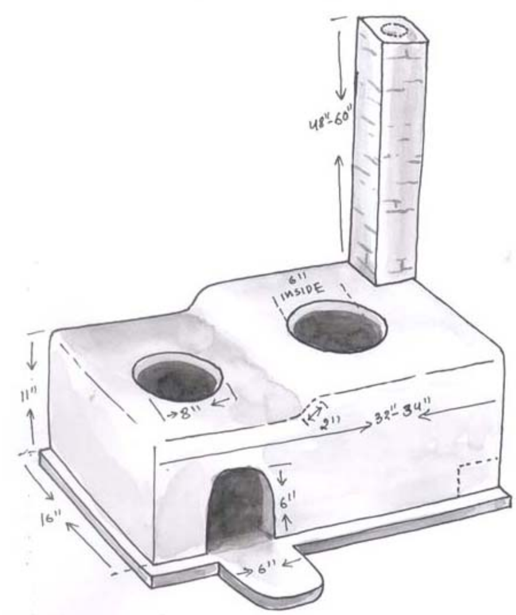
Year of dissemination	Early 90s
Cost	NRs. 150 to 200 (but varies with size and base construction)
Quantity disseminated	Around 20,000
Technological description	Simple design
Area/Region with reasons	Mid hills as well as in Terai. Though accepted in Terai, model adaptation is needed because majority households are made of thin wall and thatched roof. But it is also common to cook outside in some districts of Terai.
Advantages	Flexibility in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Can be used extensively from cooking to making *kundo* (animal feed). Bigger stove can be used in institution for pot having larger diameter.
Disadvantages	Constructed only by trained promoters and not available in the market. Time consuming because of one pothole. Unsuitable for space heating.

Major organizations involved in promotion/dissemination: GOs, I/NGOs and CBOs.

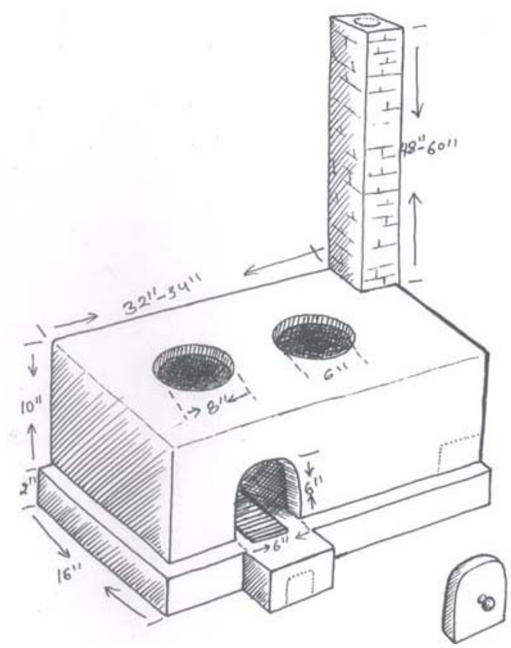
B. Two potholes ICS



A. Two potholes (Tamang) ICS



B. 2nd pothole raised two potholes ICS



C. Two potholes ICS with grate

Source: AEPC

Fig. 4: Two potholes ICS

Year of dissemination	Early 90s
Cost	NRs. 150 to 250 (but varies with size and base construction)
Quantity disseminated	More than 200,000 from 2000 onwards after improvement in chimney and combustion chamber (by NICSP supported by ESAP and coordinated by AEPC). 2nd pothole raised is more

accepted because of better combustion and suitability of two bigger pots. These types of stoves cover more than 85% of total disseminated mud-brick ICS.

Technological description

There is only one fuel inlet below first pothole. Baffle is used at 60º and at just below the second pothole so that the flame and hot air directly goes to the bottom of the second pot. The construction of baffle is shown in Fig. 5.

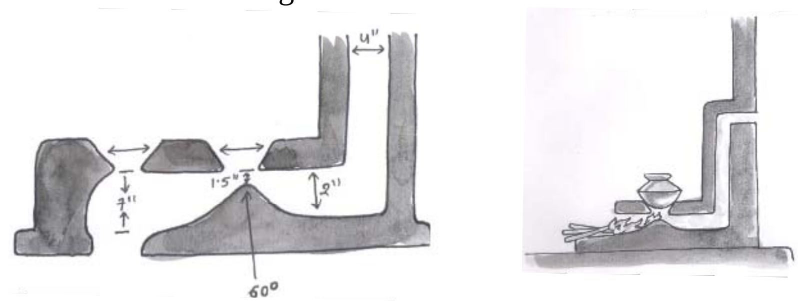


Fig. 5: Construction of baffle in two potholes mud-brick stove

Two potholes stove with grate facilitate the proper air circulation and aid in proper combustion. It is also more suitable to burn agricultural residues and ash collection. It is advisable to rotate the pot in pothole which is of daily use. This helps the pot best fit in the pothole and prevent leakage of smoke from pothole.

Metal chimney can be used in mud-brick stove. In temperate climate, metal tin is placed in the second pothole for space heating. Figure 6 shows the ICS with metal chimney and use of metal tin for space heating.

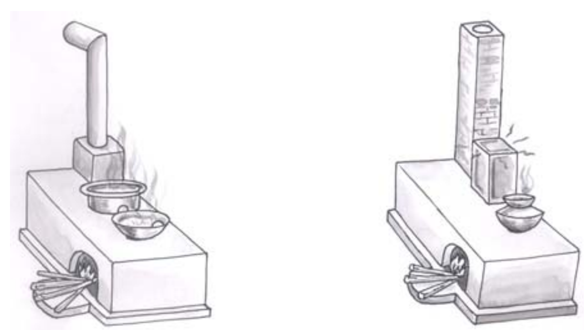


Fig. 6: Metal chimney and use of tin for space heating

If both potholes are not used for cooking/heating, it is advisable to use next pothole for water heating or cover as shown in Fig. 7.

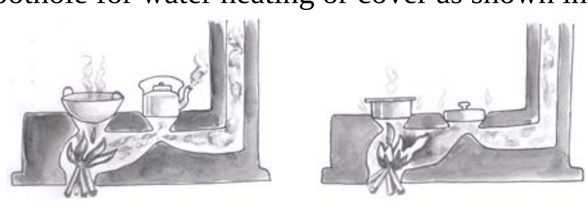
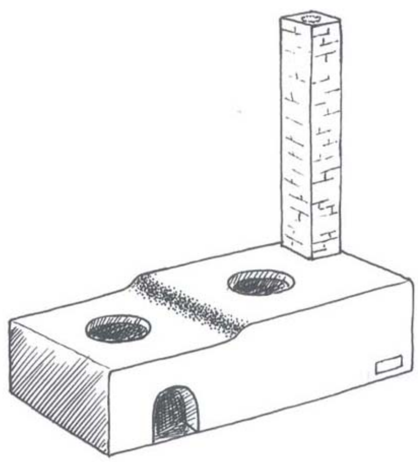


Fig. 7: Use of two potholes stove

Area/Region with reasons	Very well accepted in mid hills Though accepted in Terai, model adaptation is needed because majority households are thin wall and thatched roof. In Terai, the stove with grate is more accepted because of its appropriateness to burn agricultural residues.
Advantages	Flexibility in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Time save because of two potholes.
Disadvantages	Constructed only by trained promoters and not available in the market. Not suitable for space heating. Sometimes backfire from the chimney problem with two big size pots.

Major organizations involved in promotion/dissemination: GOs, I/NGOs and CBOs.

C. 2nd pothole raised two pothole ICS at waist height



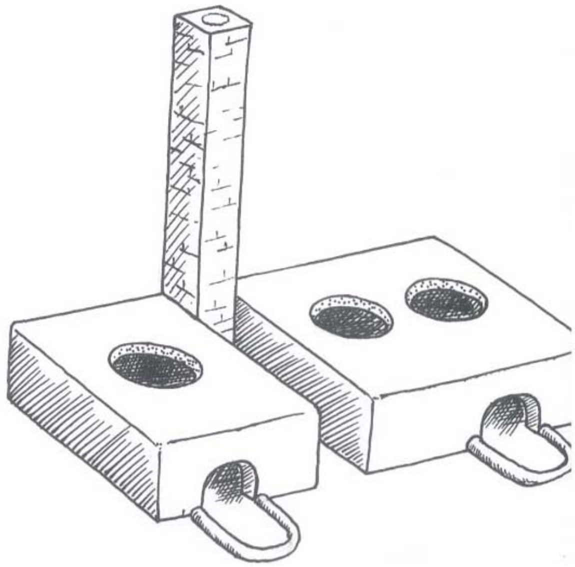
Source: AEPC

Fig. 8: 2nd pothole raised two potholes ICS at waist height

Year of dissemination	Early 90s
Cost	NRs. 150 to 250 (but varies with size and base construction)
Quantity disseminated	Few
Technological description	Similar to 2nd pothole raised two potholes stove
Area/Region with reasons	Mid hills as well as in Terai
Advantages	Flexibility in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Time save because of two potholes. Easy to operate and relieved from back pain.
Disadvantages	Constructed only by trained promoters and not available in the market. Unsuitable for space heating.

Major organizations involved in promotion/dissemination: GOs, I/NGOs and CBOs.

D. Three pothole multifunction ICS



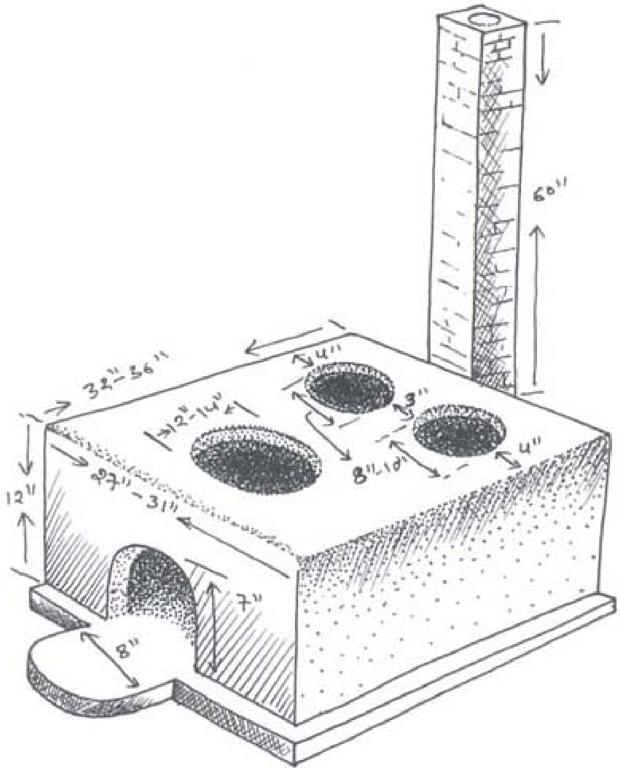
Source: AEPC

Fig. 9: Three potholes multifunction ICS

Year of dissemination	Early 90s
Cost	NRs. 150 to 250 (but varies with size and base construction)
Quantity disseminated	Few
Technological description	
Area/Region with reasons	Mid hills as well as in Terai, especially in mid hills.
Advantages	Flexibility in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. High efficiency and 40% fuelwood saving. Time saving.
Disadvantages	Constructed only by trained promoters and not available in the market. Unsuitable for space heating.

Major organizations involved in promotion/dissemination: GOs, I/NGOs and CBOs.

E. Three potholes institutional ICS (IICS)



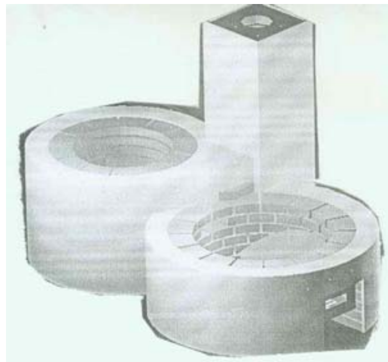
Source: AEPC

Fig. 10: Three potholes institutional ICS

Year of dissemination	Early 1990s
Cost	NRs. 250 to 700 (varies with size and base construction)
Quantity disseminated	About 1000
Technological description	There is grate in the first chamber and 2 horizontal bars which serves as top grate and support for smaller diameter pots. In order to fit in larger size pots than the pot hole diameter, pot rests are recommended. Efficiency varies from 15 to 25%.
Area/Region with reasons	Mid hills and Terai, especially in mid hills.
Advantages	Cooks three items at a time, suitable in restaurant and institution (barrack, hostels etc). Saves 20 to 30% fuelwood.
Disadvantages	Requirement of trained promoter to construct. Unsuitability of space heating.

Major organizations involved in promotion/dissemination: CRT/N, REDP and some other organizations. The total cost of IICS with kitchen design promoted by REDP is NRs. 40000 (Subsidy for IICS promoted by REDP: 54% by WFP; 8% by REDP; but 38% has to bear by the community).

F. ESAP model institutional ICS



Source: AEPC

Photograph 2: Two potholes IICS

Year of dissemination	2004
Cost	NRs.7000
Quantity disseminated	175
Technological description	This stove is made of special mud-brick Iron pot rings on both potholes are used to fit the cauldron tightly. The diameter of first and second pothole is 56 and 33 cm respectively. About 80% heat is produced in the first hole while remaining 20% produced in second one. The height of the chimney is 2.4 to 2.7 m. It has a grate on the fuel bed and an iron gate. The gate/door is used to regulate the draught.
Area/Region with reasons	In schools of 4 pilot districts (Jajarkot, Surkhet, Salyan and Makwanpur) which have day-meal feeding program
Advantages	High efficiency and fuel saving. Fire can be extinguished whenever needed.
Disadvantages	High cost and unavailability in the market. Cooking only in one pot hence expensive.

Major organizations involved in promotion/dissemination: CRT/N, Sunder/Nepal and other local NGOs in Surkhet, Jajarkot, Salyan and Makawanpur.

G. Lapsi stove

Source: AEPC

Photograph 3: Lapsi stove

Year of dissemination	2001 (Initial improvement was done in 1997/98)
Cost	NRs.1000 to 1500
Quantity disseminated	10
Technological description	The overall size of the stove is 41×39.2×18 inches. The construction materials of stove are bricks, cement, sand, iron tripod, grate and iron pipe. Metal grate at the fuel bed facilitate frequent removal of ambers and ashes. Mud plaster is paste inside the combustion chamber to repair cracks. The half sunk pot usually made of half cut kerosene drum is used. Fuel (Lapsi seed) is fed through a hollow metal tube.
Area/Region with reasons	Sanga, Kavre because of abundance production of *Lapsi*
Advantages	High efficiency and fuel saving.
Disadvantages	Unavailable in the market.

Major organizations involved in promotion/dissemination: RECAST, ITDG and CRT/N

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H. Mud rocket stove (in demonstration phase)

Source: C.Kellner

Photograph 4: Mud rocket stove

Year of dissemination	Still in demonstration phase
Cost	About NRs. 300
Quantity disseminated	NA (Only few demonstrable models in Makwanpur, Dhading, Nuwakot)
Technological description	This demonstration model was built by CRT/N with the technical assistance from Mr. C. Kellner. It is made with mud-bricks with the insulation of refractory brick liner in the combustion chamber. The dimension of combustion chamber and fuel entrance chamber is 12 ×12×30 cm and 10×12 cm respectively. The efficiency is about 25% (CRT/N, 2006).
Area/Region with reasons	Mid hills and Terai.
Advantages	Chimney less and less smoke
Disadvantages	Requirement of smaller pieces of fuel and cooking one item at a time. Not suitable for smaller sized pots

Major organizations involved in promotion/dissemination: Still under demonstration.

Information of various organizations involved in promotion/dissemination of mud-brick ICS is shown in Annex 1.

Models of stoves vary with geographical areas and climatic conditions. Therefore while developing ICS; proper attention should be taken that these stoves should match the specific needs of geographically diverse group of people. From the findings of mud-brick ICS, it can be concluded that 2nd pothole raised two potholes stove and two potholes with grate stove are more suitable in mid hill regions of Nepal as mid hill areas are neither too hot nor too cold. Two potholes stoves with grate in the combustion chamber are accepted in Terai as people burn substantial amount of agricultural residues. Single pothole and rocket type mud-brick stove is also suitable in Terai. However, model adaptation is needed for Terai because majority of house are made of thin walls and thatched roof. Model adaptation is also need in high hills.

It is very difficult to trace out the total number of each ICS, but two potholes ICS with grate and 2nd pothole raised with short chimney (4 to 6 feet high) with chimney outlet T type (improved Tamang) have been disseminated at very large scale.

In general, the dissemination of mud-brick ICS has been found very successful due to following reasons.

1. Government and donor support for raising awareness, training, demonstration etc. (implementation program); and training to the promoter and demonstration to the users on advantage of chimney and the outlet in ICS
2. Acceptability of typical kitchen of a rural household. Flexibility to cast in various forms (one, two or three pothole) and sizes according to the user preferences. Can be built by local artisan or trained personnel through locally available material.
3. Active participation of local NGOs, CBOs, VDCs, LPO etc. in dissemination
4. Low construction cost (NRs. 150 to 250 for CRT/N disseminating stoves and up to NRs. 500 of some organizations) and ease in construction, operation and maintenance
5. Highly efficient (12 to 20%) compared to traditional stoves (6 to 12%)
6. Reduction of IAP, which ultimately reduce eye irritation, ARI, COPD, infant mortality and other diseases.
7. Reduction of deforestation through efficient use of fuelwood (25 to 40% fuel saving)
8. Reduction in cooking time (0.5 to 1 hour per day). Because of cooking two items at a time as two potholes stoves are widely accepted.
9. Increase livelihood of poor people

However, there are some still some difficulties in the effective implementation of this intervention.

1. Health risk associated with IAP; and fuel and time saving is not high priority agenda of users (awareness lacking). Beliefs in reducing the pest termite effects and inconvenience of large pots (unsuitable for agro-processing and alcohol preparation)
2. Requirement of different design for different climatic and geographical regions. Unsuitability of mud stove on space heating in colder regions.
3. Tunnel, baffle, flue exit hole, chimney height and pot rings are not well maintained
4. Lack of proper maintenance, which result less efficiency in IAP reduction; and fuel and time saving. Chimney outlet worn out faster and if not maintained and replaced there is a smoke back draught in the kitchen and hence increased pollution

5. Less efficient, if one meal is cooked at a time
6. In some rural house, kitchen in the attic or in the first floor result difficulties to installed chimney. In some Rai’s community, stove should be constructed in the middle of kitchen (or *aangan*), which makes difficult to construct chimney
7. Dissimilar to the existing one in some cases
8. More programs are project based approach rather than market based approach
9. Lack of coordination among promoting organizations.
10. Requirement of trained promoter to build these stoves. Migration of trained promoters to other profession. In case of women promoter, it is difficult for them to go far away for stove construction.

2.1.2 Metal stoves

The major advantages of the household metal stoves are smoke alleviation/reduction; fuel saving which ultimately reduce biomass through proper combustion; portable (except few models) and easier to use. Contrary, it requires time consuming job to make small and most preferably consistently sized fuelwood. But the small pieces of fuel are comparatively dry and led to better combustion. The efficiency of metal stoves is higher compare to traditional and improved mud-stove. As per the personal conversation with Dr. Rhiddi Bir Singh (Associate Professor and Coordinator, Bio-fuel studies, Institute of Engineering Tribhuvan University), the efficiency metal stove normally varies from 18 to 32%. Similar to mud-brick ICS, the reasons for variation in efficiency are proper construction of stove; and type and moisture content of fuel. The various types of metal stoves disseminated in Nepal are discussed below.

A. Jumla design smokeless metal stove

Source: Mr. Zahnd

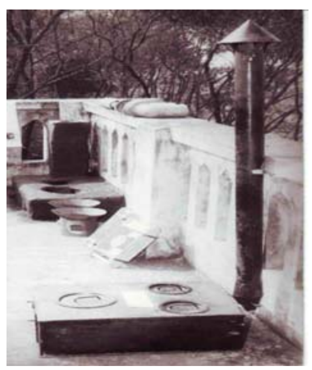
Photograph 5: Jumla design smokeless metal stove

Year of dissemination	1998
Cost	About 7500 (manufacturing and transportation cost attributes NRs. 4500 and 3000 respectively) but subsidized to farmers to NRs. 2500
Quantity disseminated	3000 in Jumla, Humla and Mugu (Karnali Community Skill Training Project and now through a local NGO, RIDS-Nepal) 1500 in mid hills of Pokhara
Technological description	Every stove is numbered and tested; and manufactured with the best possible quality. These stoves are manufactured through only one trained manufacturer located in Nepalgunj. 1.5 mm steel walls and 4 mm cooking surface stove weighs about 40 kg. Three potholes along with a slot for baking *roti* (traditional bread) and a 9 liter stainless steel tank attached for water heating. Bottom of the stove is double mud filled to prevent heat loss. Adjustable air vent in the main door which allows the regulation of draught air for combustion and damper in the flue pipe are used to transfer heat efficiently towards the cooking pots. The average cooking efficiency is 14 to 22%. The life expectancy is about 15 years and is suitable above 2000 m altitude. This model has been further improved in Mechanical Department

	in Kathmandu University as KU 1 and KU 2 stove.
Area/Region with reasons	Jumla, Humla, Dolpa and mid hills of Pokhara, because of colder regions. The design was based on the local, high altitude communities and families' eating habits and food availability.
Advantages	Cooks three items at a time as well as baking bread. Good for water heating and space heating. Suitable for family size up to 7 persons. 40% less fuelwood consumption to other locally available traditional stoves. Appreciation and request from the villagers; and donor focused are some of the major reasons for wide spreading of this technology.
Disadvantages	Heavy. Expensive and requires fabrication in workshop in town.

Major organizations involved in promotion/dissemination: Mechanical Department, KU.

B. CRT promoted metal stove



Source: CRT/N

Photograph 6: CRT promoted metal stove

Year of dissemination	1994/95
Cost	About NRs. 4500 in 2000/01
Quantity disseminated	10,000 in Karnali zone
Technological description	The size of the larger pothole in the front is 28 cm and the smaller potholes in the rear are 15 cm. The thickness of wall and top, which is made with mild steel sheet, is 2 and 4 mm respectively. Efficiency ranges from 14 to 22%.
Area/Region with reasons	Jumla, Humla, Dolpa and Kalikot.
Advantages	Cooks three items at a time. Good for space heating
Disadvantages	Expensive and requires fabrication in workshop in town

Major organizations involved in promotion/dissemination: ACAP, CRT/N, CECI CSD and other I/NGOs.

C. *Bayupankhi* (Air induced) stoves

Source: CRT/N

A. Fan at side

Front view Side view

Source: Sindu Urja Kendra

B. Fan at side

Front view Back view

Source: Sindu Urja Kendra

C. Fan at bottom

Photograph 7: *Bayupankhi* stove

Year of dissemination	2003 (Initially promoted by Sindhu Urja Kendra (P) Ltd. and has the patent right)
Cost	NRs. 600 to 5000 as per size and construction materials (The price of the smallest stove, which is adequate for cooking for 5 to 6 persons ranges from NRs. 600 to 1650)
Quantity disseminated	60,000
Technological description	These stoves are made of about 3 cm cylindrical shape double wall metallic sheets with perforations in the inner wall for air inlets and hence named *bayupankhi* stove. The perforations are based on various designs. This is normally a portable stove fitted with low voltage electric fan of 3 to 4 inches. 12 volt adaptor is

	connected with fan to supply primary and secondary air; however, fan can be operated by using battery. Fan is connected with 220V in big metal stoves which are especially used in institution or for other purposes. The cylindrical and overall height of the stoves manufactured by Sindhu Urja Kendra is about 15 and 23 cm respectively. The internal diameter of the cylinder, which differentiates the small, medium and large stove, is about 10, 15 and 18 cm respectively. The fan is located either on the bottom of the stove or on an extended welded pipe which is about 18 cm away from the stove body. In case of fan located at the bottom of the stove, glass wool is place in the lower portion of base as an insulation to prevent fan from overheating and burning. Because of supply of fresh air and proper combustion, it consumes less than one kg fuel for one day to cook a meal for 5 to 6 persons. The efficiency of this type of stove ranges from 25 to 30%. Big sized, named as Jumbo *bayupankhi* stove is suitable in institutions. In these types of stoves, fuel is added from the top of the stove.
Area/Region with reasons	Urban and semi-urban areas.
Advantages	High efficiency, portable and fast cooking. Smoke reduced by 90%
Disadvantages	Requirement of smaller size of fuel and electricity to operate fan

Major organizations involved in promotion/dissemination: Private companies and local workshops

D. *Bayupankhi* barbecue stove

Front view

Ash removal tray

Fan place

Source: Sindhu Urja Kendra

Photograph 8: *Bayupankhi* barbecue stove

Year of dissemination	2003 (Initially promoted by Sindhu Urja Kendra (P) Ltd. and has the patent right)
Cost	NRs. 1250 to 5000
Quantity disseminated	Around 7000
Technological description	Metal bars to hold fuels. Fan and ash removal tray slot in two opposite sides
Area/Region with reasons	Urban and semi-urban areas. .
Advantages	Uniform heating. Can be used for fuelwood, briquette and agricultural residues
Disadvantages	Requirement of smaller size of fuel and electricity to operate fan

Major organizations involved in promotion/dissemination: Private companies and local workshops

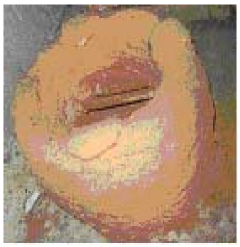
E. Beehive briquette stoves

Stove dimension:
Length : 28 cm
Breadth : 28 cm
Height : 24 cm

Mud clay stove 1

Stove dimension:
Length : 31 cm
Breadth : 31 cm
Height : 19 cm

Mud clay stove 2



Stove dimension:
Diameter : 24 cm
Height : 19 cm

Clay stove

Stove dimension:
Diameter : 26.5cm
Height : 23 cm

Clay stove with mental ring

Stove dimension:
Diameter : 24 cm
Height : 21 cm

Double wall metal stove
Source: Shakya et al. (2005)

Stove dimension:
Diameter : 20 cm
Height : 23 cm

Metal stove with clay lining

Clay stove
Source: CRT/N

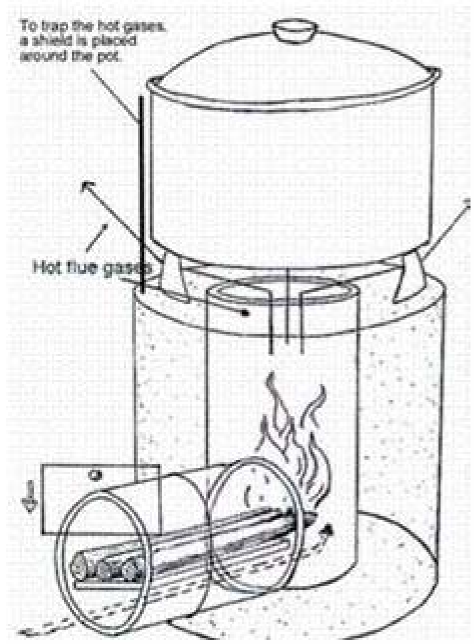
Photograph 9: Beehive briquette stoves

Year of dissemination	1998
Cost	NRs. 50 to 75 for mud stove and NRs. 300 to 400 for metal stove
Quantity disseminated	Around 5000
Technological description	The materials used in the construction of stoves are metal sheet, metal rod, clay, mud and cement, where clay, cement and rice husk are kneaded together. The construction of all these stoves except double wall metal stove is simple and suitable for the people having low economic status. These devices are especially useful for beehive briquette however other fuels such as charcoal, wood, etc. can be burnt. Ignition chamber is below the grid which separates it from fuel chamber. The fuel burning is totally depended on the natural airflow through the combustion chamber; however there are some measures for controlling airflow in some stoves. In case of clay stove with metal ring, the welded metal reinforcement give strength to the stove and also act as the

	potholder. The upper portion of the ring is at a height of 5 cm above the clay level for providing secondary air to the stove. In double walled metal stove, the space between the walls is insulated with rice husk, clay, ash etc. The bottom of this chamber has a sliding door to control the airflow. In case of mud stove with clay lining, only air inlet is made through the base of the stove. Normally, the beehive briquette is placed into the fuel chamber from the top and the grate is used to hold these briquettes. The flame torch (made with a metal rod wrapped with cotton and soaked in some kind of oil, preferably in kerosene) is introduced to the bottom of combustion chamber and held just below the grate to ignite the fuel. The heat generated can be used either for cooking or space heating. The diameter of the stove should fit the briquette otherwise there will be heat loss which results in lower efficiency. Application of insulation (e.g. clay) on the inner side of stove saves heat loss and hence enhances efficiency of the stove. During lighting, there is a little smoke. It is taken into the room when stable flame reached. Efficiency ranges from 20 to 23%.
Area/Region with reasons	Urban and semi-urban areas.
Advantages	Portable, easy to handle, suitable for space heating and easy to fabricate. Smoke is reduced by 90%. Ease in barbecue preparation,
Disadvantages	None

Major organizations involved in promotion/dissemination: CEE, CRT/N, FECOFUN, RECAST and other NGOs and CBOs.

F. Rocket stove



Source: htpp://members.efn.org/~apro/AT/attitlepage.html

Fig. 11: Rocket stove

Year of dissemination	2003
Cost	NRs. 1200 to 1500
Quantity disseminated	Very few
Technological description	This is usually an ash insulated double wall metallic stove, which can be built from tin cans or metallic bucket. Elbow is one of the key designs of this stove which can be constructed from metal pipe of ceramic materials. This stove has a 12 cm diameter and 30 cm high combustion chamber with an insulated skirt around the pot. To increase the convective heat transfer, a narrow gap is maintained between the pot and the skirt. The efficiency is 25 to 30%.
Area/Region with reasons	High hills
Advantages	Portable, less emission and good combustion.
Disadvantages	Requirement of smaller size of fuel. Expensive and requires fabrication in workshop in town

Major organizations involved in promotion/dissemination: FoST, CRT/N.

G. CRT/N DK model stove

Photograph 10: CRT/N model DK metal stove

Year of dissemination	
Cost	NRs. 2500
Quantity disseminated	Very Few (Manufactured only on demand/request)
Technological description	Two potholes with water jacket retrofitted in the metal chimney. The warmed water during cooking can be used for dish washing and for other purposes. The total weight and cost of this stove is 12 kg. Average efficiency is about 25%. The total weight of stove is 12 kg.
Area/Region with reasons	High hills and mountains
Advantages	Cooking two items at a time and warming water to wash dishes and hand. Comparatively light to some other stoves having water heating facility.
Disadvantages	Expensive and needs fabrication only in workshop

Major organizations involved in promotion/dissemination: CRT/N

H. Bijuli Dekchi

Year of dissemination	1992
Cost	
Quantity disseminated	83 in Ghandruk as of 1994 (average 2 per household, one for cooking rice and another for water heating)
Technological description	It is a low watt cooker with a combination of storing heat in the form of water. Heated water is used for other cooking (rice, lentils, boiling vegetable and milk etc) and washing purpose. High efficiency and good heat retention capable bijuli stove consists of two locally available aluminum pots which are fitted into each other with an air gap in between which acts as an insulator reducing heat losses through the side and base resulting efficient cooker. A low watt heating element is attached to the bottom of the inner pan. A thermoswitch which turn the dekchi into an automatic rice coker is installed to protect the pan from over boiling. As per the user demand, the size of the cooker varies from 3 to 40 liters where largest pan can be heated water up to 80°C. Low-high switch in the cooker regulates the night time heating up of water at half the original watt of the cooker. Abundantly available of fuelwood; non reliable electric supply; limited power and high cost of subscription are some of the major constraints in wider dissemination of this technology.
Area/Region with reasons	Ghandruk, Chomrong (1750 to 2050 m *amsl.*)
Advantages	Low cost. Local manufacture and repair. Smokeless.
Disadvantage/s	Not feasible with socio-economic factors, dietary habits. Requirement of electricity.

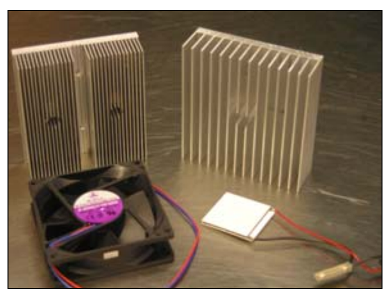
Major organizations involved in promotion/dissemination: Formerly Intermediate Technology Development Group (ITDG) and now Practical Action Nepal; Development and Consulting Services, Butwal

I. Ujjeli chulo (stove)


Source: STARIC/N

Photograph 11: Ujelli Chulo with TEG (left) and room after installation of Ujelli Chulo (right)

Year of dissemination	Still in demonstration (field test) phase
Cost	Still to be decided as modification and field is being carried out
Quantity disseminated	NA
Technological description	Proven technology of integrating a thermoelectric generator (TEG) into fuel efficient, low emissions wood stove. Simple, quiet and reliable thermoelectric cells produce electricity based on temperature differences across them and typically work best in applications having power output less than 20 watts. This module will produce 2 watts of power to drive a fan and 3 watts of power to light a low power consumption but high intensity light emitting diode (LED) which is capable to illuminate entire room.



Source: STARIC/N

Photograph 12: Module, hot and cold heat sink and fan

Two finned heat sinks on the left of Photograph xx will help to keep hot side hot and cold side cold. Two selected heat exchangers move enough heat through the module to produce maximum power. The fan of the generator takes some power from the module to aid in cooling the cold side. The laboratory test of the generator showed that the generator units produce a peak output of 18 watts resulting net system of power of 16 watts. The installation time of the "Ujelli Chulo" is about 2 to 3 hours.

	The users are required to use the stove daily and fill up the monitoring sheet up to three months from the date of installation.
Area/Region with reasons	NA but expected to be suitable in high hills and mountains. Suitability for space heating
Advantages	Dual purpose technology. Light weight and clean cooking with lighting facility. Less fuelwood requirement.
Disadvantage/s	Expected to be expensive. Not suitable in mid hills and Terai as metal promote space heating

Major organizations involved in promotion/dissemination: Sustainable Technology – Adaptive Research & Implementation Center.

J. CRT/N RT model stove (in demonstration phase)

Photograph 13: CRT/N model RT metal stove

Year of dissemination	Still in demonstration phase
Cost	NRs. 1000
Quantity disseminated	Few
Technological description	This metal wall stove has a grate and insulation liner inside based on rocket stove principle. 22 to 24% efficiency.
Area/Region with reasons	High hills and mountains
Advantages	Suitable for cooking and space heating. Suitable for fuelwood, agricultural residues and honey comb charred briquette. Fast cooking. Accommodates various sizes of pot
Disadvantages	Requirement of smaller size of fuel and fabrication only in workshop

Major organizations involved in promotion/dissemination: CRT/N

K. KU 2 design metal stove (in demonstration phase)

Source: Zahnd

Photograph 14: KU 2 design metal stove

Year of dissemination	Still in demonstration phase
Cost	NRs. 3700 to 4500
Quantity disseminated	Very Few
Technological description	There are two and one potholes in the primary and secondary chamber respectively. 8 liter water tank is attached with primary chamber. The stove weighs about 37 kg. This is the improved version (such as insulating the primary and secondary combustion chamber and the heating tank to increase the temperature and reduce heat loss) of KU-1 model, however it is still under field testing.
Area/Region with reasons	High hills and mountains
Advantages	High efficient and clean combustion
Disadvantages	Higher cost and fabrication only in workshop

Major organizations involved in promotion/dissemination: CRT/N

Information of various organizations involved in promotion/dissemination of metal stoves is shown in Annex 2.

According to findings, *bayupankhi* stove was found more efficient in fuel consumption as it reduces the fuel consumption by 40%, followed by metal stove (20%) and mud-brick ICS (20 to 40%). Similarly, *bayupankhi* stove reduced cooking time by 1 hour per day, whereas metal and mud-brick stove reduces cooking time by 0.5 and 0.5 to hour. As briquette burns slowly, it has negative impact on time saving. In high hills and mountains and especially in mountains, due to the severe cold climate, metal stoves are suitable. Jumla design smokeless metal stove was very popular in Karnali zone and some mid hills areas of north Pokhara. It is expected that the KU-2 design metal stove will be accepted by the users if it gives the same performance as in lab tests. Portable type metal stoves are also suitable in these regions. Ujjeli stove with TEG could be one of best solutions because of its dual purpose.

One of the latest interventions in ICS, i.e. the portable type high efficient *bayupankhi* (air induced) stove is most suitable in place where there is access of electricity.

In general, the dissemination of metal stoves has been found very successful for the following reasons.

1. Government and donor support for raising awareness
2. Subsidy (maximum NRs. 2500 subsidy by AEPC; and training and about 66% for farmers for Jumla designed metal stoves by the implemented project)
3. Acceptability of typical kitchen of a rural household
4. Involvement of NGOs and CBOs including private sector in dissemination
5. Highly efficient (20 to 32% and some even 40%)
6. Variability in design (3 potholes heavy with bread making and water heating facility to small portable type) including air induced (*bayupankhi*) for better combustion. Availability of briquette stoves as well as barbecue stoves.
7. Advantage of space heating in high hills and mountains.
8. Highly efficient (almost smokeless) in pollution reduction because of better combustion. Fuel saving is 25 to 40% and time saving is 0.5 to 1 hr per day.
9. Increase livelihood of poor people

However, there are some still some difficulties in the effective implementation of this intervention as follows:

1. Health risk associated with IAP and fuel and time saving in not high priority agenda of users (awareness lacking). Beliefs in reducing the pest termite effects and inconvenience of large pots (unsuitable for agro-processing and alcohol preparation)
2. Variation and quality of stove due to quality and availability of manufacturing materials
3. High cost of some metal stove. Most metal stoves need workshop/factory for fabrication.
4. Requirement of small and most preferably consistent sized fuelwood
5. Requirement of electricity (or solar or battery) for *bayupankhi stove*
6. Dissimilar to the existing one
7. Lack of proper maintenance, which result less efficiency in IAP reduction; and fuel and time saving.
8. Less efficient, if one meal is cooked at a time in 3 pothole stove.
9. More programs are project based approach rather than market based approach
10. Lack of coordination among promoting organizations.

For successfully wider dissemination of mud-brick ICS and metal stoves, following recommendations have been drawn.

1. Dissemination of information materials like posters, pictorial manual informing health hazards due to IAP
2. Compulsory session on health hazards of smoke and IAP to the promoters and users
3. Focusing the program where it is hard to collect fuel.
4. Assesses potential market of improved stoves through market survey
5. Considering local artisan feedback during designing. Ease of lighting with output power adjustments
6. Government assists in dissemination; technical advice; quality control; and monitoring and evaluation
7. Extended government or donor support for at least five years for the development of local institutions and local expertise

2.2 Briquetting Technology

Biomass briquette is a non-polluting, high density and energy concentrated dry (completely or negligible moisture content) and regular shaped briquette fuels converted through the low density and high moisture content bulk materials. It is made naturally (without any added chemicals), just chopped/grind in some cases and pressed under certain temperature and pressure. Because of definite shape and size, briquettes are very much easier to store and transport than conventional energy sources. Biomass briquette produces less smoke compare to fuelwood, which can be further reduced by designing the proper efficient cook stoves. Normally, briquette burning is not necessary to monitored continuously compare to fuelwood burning. Singh and Heejoon (2003) also mentioned that briquette fuel has better physio-mechanical properties and combustion properties; and the advantages of briquette include higher heating values, lower emission of SO_2, NO_x etc.

Nepal produces substantial amounts of agricultural and forestry processing residues (such as rice husk, rice straw, bagasse, cotton stalk, jute stick, almond shells, sawdust etc.) having low bulk density and high moisture content. Woody residue, such as sawdust and non-woody plant biomass, such as, crop harvesting and processing residues; and animal waste, mostly cattle dung are the important alternate source of energy in wood deficit areas. The various types of residues used in manufacturing briquettes are shown in Table 3.

Biomass briquette is a good substitute of wood/coal in industrial boiler and brick kiln in commercial sector and reliable source of replacement of wood/coal/kerosene/LPG in household levels. Manufacturing plants of biomass are of various forms or types i.e. from household and community level to highly commercial scale, which also aid to the local employment along with safe environment.

Table 3: Raw materials for briquette

Residue	Production (MT/Yr)	Remarks
Rice husk	1,343,366	Husk: 25% paddy
Bagasse	701,142	Bagasse: 33% of sugarcane
Almond shell	4	Shell: 33% of almond pod
Cotton stalk	3,688	3 MT of cotton stalk/ha
Jute stick	43,605	3 MT of jute stick/ha
Maize cob	433,635	Maize cobs: 30% of maize grain
Herb residue	7,016	Residue: 98% of raw herbs

Source: RONAST, 2003

Depending upon the nature, scale and materials used in production, briquettes are found in various shape and size. Briquetting technology was first introduced in Nepal with heated-die screw-press Taiwanese machine in the late 1980s, but subsequently closed due the high cost of the screw and briquette manufacturing materials (such as rice husk) including timely availability. At present, Mhyaipi Briquette Industry, located in Kawasoti, Nawalparasi, Nepal is producing biomass briquette made of rice husk at commercial scale although the factory runs only six months in a year with 25% of its full strength. Other biomass briquettes made of woody residue (sawdust), non-woody residue, i.e. crop/vegetal residue (rice husk) and *banmara* (forest killer i.e. fast growing herb which is considered as a weed and found year round) have been also introduced. The scientific name of *banmara* is Eupatorium *Adenophorum*. Research organizations, such as RONAST and a NGO, Integrated Development Society (IDS-N) have been involved in developing and disseminating the beehive briquette (made of *banmara*). NGO, such as, Foundation for Sustainable Technologies (FoST) is involved in research and demonstration of briquette production mainly through the household waste.

The various types of briquettes are shown below.

A. Rice husk briquettes

Source: Mhyaipi Briquette Industry

Photograph 15: Rice husk briquette

Year of dissemination	Late 1980s but stopped, now from 1994
Cost	NRs. 10 per kg (About 10 inches of briquette weighs 1 kg)
Quantity produced	3000 tons
Manufacturing process and technical description	These briquettes are produced in a heated-die screw-press machine in which rice husk is forced by a screw through a heated die which is maintained at approximately 300 °C by an electrical coil heater fixed around it. Before passing through the heated die, the moisture in the rice husk is removed either by mechanically or manually. The briquette produced by this method is much stronger and denser. The internal and external diameter is 5 and 10 cm respectively with a calorific value of 4000 kcal/kg. The circular hole in the middle facilitates air exchange which ultimately aid in better combustion. This briquette has ash content of 18% and less volatile compare to firewood (2%). The flame goes up to 40 minutes and charcoal that produce heat lasts for about 2.5 hours. These briquettes can be burnt in any stoves but *bayupankhi* (air induced) stove is better because of double combustion. But *bayupankhi* stove has a major constraint that it needs electricity or battery to run the fan.
Area/Region with reasons	Produced in Nawalparasi but suitable in all areas
Advantages	This briquette is suitable for both heating and cooking; and space heating; and is suitable for all geographic and climatic condition. This is also more applicable in the preparation of barbecue. This briquette save at least 10% fuel in comparison to LPG, kerosene and reduce smoke up to 80% compare to fuelwood. This is more suitable in institution compare to domestic purpose
Disadvantages	Some problems of this briquette include high ignition time and difficult of extinguish once it burns. High initial investment to produce commercially.

Major organizations involved in promotion/dissemination: Mhyaipi Briquette Industries P Ltd.

B. Beehive briquettes

Source: RONAST

Photograph 16: Dried beehive briquettes

Year of dissemination	2004
Cost	NRs. 6 to 15, however in Kathmandu valley, the price ranges from NRs. 12 to 15 outside valley.
Quantity produced	Around 13,000 kg
Manufacturing process and technical description	*Banmara* has also tremendous negative impact on forest as it can not be used as fodder and foliage for cattle. Contrary, it has low moisture and ash content; and suitable for fuel. Besides *banmara*, the raw materials for beehive biomass briquette are clay, dung and lime. Clay, having good binding and compaction property is the alumino-silicate compound and named 'benthonite clay'. Dung contains digested/undigested starch which has both binding and burning property, and mixing with other materials possibly enhances fuel quality. Dried dung, locally called *guintha,* is also one of the common sources of fuel in many households in rural areas. Lime or calcium oxide (CaO) is exothermic in nature which emits heat and diminishes the emission of NO_X, SO_X etc., acting as a disulfurizing agent. It is also a good additive to lower smoke emission from fuel (Beehive Briquetting Project, 2005). About one week sun dried *banmara* were cut into pieces of about 1 foot and charred in a drum or pit. The recovery of charcoal in pit burning is comparatively better. The pit was covered with a plain metallic sheet and the burning was left inside the pit overnight to form charcoal. The resulting charcoal was powdered by using either electric or manual driven grinder machine on the following day and mixed in different proportion with dung, clay, and lime. Water is added to the mixture to make paste and the paste is filled in a mould of different sizes. After pressing the paste in the mould manually, the paste is removed from the mould and dried under the sun for 5 days. Because of variation in compaction as compaction is done manually, it is very hard to make consistency in weight. The ash

content of this briquette is also high. The materials and procedure of producing beehive briquette is shown in Photograph 17.

Source: RONAST

Photograph 17: Materials and production of beehive briquette

The cylindrical type briquette of 5" diameter and 5" height are common. There are 19 evenly distributed holes of 1 cm diameter along height, which facilitates better combustion. This size of briquette weighs 0.5 kg and color varies from gray to black. This briquette burns 60 to 90 minutes.

Area/Region with reasons: Bishankunarayan, Lalitpur; Nawadurga, Kamdi, Banke; Marsangidhi, Turture, Tanahu; and Panchpokari, Santinagar, Jhapa.but suitable in all areas

Advantages: Ease in handling, transport and store and alternate eco-friendly fuel. Less polluting and hence suitable for non ventilated kitchens. Furthermore, it has a good commercial potential because of low investment requirement Suitable for both slow heating and cooking; and space heating, hence more applicable in the preparation of barbecue. Suitable for all geographic and climatic condition. A smoke emission was 0-3 on Bacharach True-spot Smoke Tester.

Disadvantages: The production is suspended during monsoon since raw materials need to be completely dry before charring. Adequate funding for capital investment and training are the barriers to implement this technology in wider scale.

Major organizations involved in promotion/dissemination: IDS-N, NAST and RECAST.

C. Briquette from household and agricultural waste

Year of dissemination	2002
Cost	NA
Quantity produced	NA
Manufacturing process and technical description	Briquette can be made from household waste, such as, paper, grass, leaves, saw dust, bagasse, slurry and dung. The briquette made of paper is easy to ignite and less smoky and the paper works as a binding material. An approximately 5 mm thickness cylindrical shaped mould of about 90 mm diameter and 300 mm height is used produce briquettes. There is also a metal rod of about 12 to 16 mm at the middle of the cylinder to make a hole in the briquette for better combustion. The waste is grind in some cases and water is added to make a paste. As soon as the paste is prepared, it is put in a mould and compacted up to that extent so that it can not be pressed by bare hands. The organization (FoST) has developed two pressing machines. One is heavy duty, i.e. lever press which required two persons to operate, one operating the pressing device and another mould. The other one is simple which is operated by a single person and results comparatively less compacted briquette. Normally, this briquette is more porous than firewood and results less smoke. The manually compaction device is more suitable for household level. Highly compacted briquettes are less porous which can result higher smoke in ordinary cooking stove but the compaction has no effect in *bayupankhi* (fan operated) stoves due to proper air fuel mixture. Designed pressing machine could produce a rectangular shaped briquette cake of approximately 18 × 2 × 2 inch size.
Area/Region with reasons	Suitable in all areas
Advantages	Eco friendly, which reduces deforestation and save environment. These briquettes could reduce smoke up to 90%, and save expenditure on fuel up to 40%.
Disadvantages	NA

Major organizations involved in promotion/dissemination: FoST

The information of organizations involved in briquetting technology is shown in Annex 3.

From the finding of briquetting technology, it can be depict that briquetting technology is simple, and easier to disseminate at household and community level. Despite, huge variation of cost of manufacturing plant, it is relatively very affordable at household and community level.

This technology, which also aid in local employment, is alteration to firewood and very efficient in reduction of IAP and fuel saving. Briquetting technology of *banmara* and household waste especially reduce deforestation and degradation of environment. Being agricultural country and availability of abundance quantity of agricultural residues, it is expected that if there is a timely availability and in particular the timely distribution of agricultural as well as non agricultural residues, there is a high potential of industrialization of this technology in Nepal.

Forest resources have been limited and wood collection is getting tougher and needs several hours of walk. Biomass briquette technology, which reduce deforestation and promote bio-diversity, can play the major socio-economic impacts on the livelihood of Nepalese people as these bio-briquettes have no climatic and geographical limitations with high potential in the reduction of IAP.

But, the major constraints for the proper industrialization of briquette manufacturing industries that were established in 1980s were increase in the price of raw materials (e.g. rice husk, saw dust etc.) including timely availability; lack of long-term marketing strategy; lack of spare parts and proper training for operation and maintenance of machines; high electricity consumption and short screw lifetime of machines; unsuitability of traditional stoves; lack of technical research and development support to the biomass briquette manufacturers; and lack of subsidy like other fossil fuels (e.g. kerosene, diesel, petrol, LPG etc.). Additionally, it consumes comparatively higher time being less volatile compared to firewood. Production of briquette is also affected during monsoon due to proper shading and drying.

For the promotion of these biomass briquette technology in wider (i.e. household and community to commercial) scale, following steps should be considered.

1. Efficient government policy, planning and implementing strategy with effective public awareness activities
2. Recognition of organizations working intensively in biomass briquette technology
3. Technical research and development support to the biomass briquette and appropriate biomass briquette firing stove researchers/manufacturers
4. Adequate funding for capital investment, training
5. Lack of donor agencies’ role in disseminating this technology to the community level
6. Subsidy to biomass briquette research organizations and manufacturers

2.3 Smokehood

Smokehood is a structure placed over a cookstove so that the smoke produced during incomplete combustion of fuelwood will be removed from the kitchen. Smokehood could be of various dimensions depending upon the stove size and kitchen design. RECAST, a research and development organization is working on the effect of smokehood in the reduction of IAP and Practical Action Nepal, an INGO is introducing smokehood through the project entitled “Smoke, health and household energy” to reduce the major health risks problems caused by smoke.

Previous studies, researches and experiments showed that smokehood reduce the indoor smoke. Ballard-Tremeer & Mathee (2000) compiled and compared various sources of interventions, such as, the source, living environment and user based intervention with open fire. They considered improved cooking devices with and without chimney; briquette and pellets; and charcoal and other alternatives fuel for source based intervention. For living environment based intervention, they considered hoods/fireplace and windows/ventilation holes. Similarly, for user based intervention, they considered fuel drying, use of pot lids, good maintenance and sound operation. The result revealed that the exposure level was reduced up to 33, 75 and 10% using improved cooking stoves with chimney; use of briquette and pellets; and charcoal respectively. For living based intervention, hoods/fireplace and windows/ventilation holes reduce the exposure level up to 50 and 15% respectively. Likewise the exposure level was reduced up to 50% using pot lids.

Smoke extraction through smokehoods; ventilation through windows and eaves spaces; and improved combustion through improved stoves were three interventions in Kenya that were promoted during the ITDG Smoke and Health Project. Smokehoods were the most successful intervention in terms of smoke alleviation especially where windows were installed at the same time, which provide a good draught to optimize combustion. Smokehoods work irrespective of weathers and have variations in geometry. Additionally smokehoods are effective and can be copied more readily at local level. The simple, cost effective and efficient smokehood introduced by the Practical Action for the Maasai women in the Kajoado region of Kenya was successful in reducing the smoke by 80%. Eaves spaces are less appropriate as because in winter cold air infiltrates into the room whereas in summer, it allows mosquitoes and other insects to inter the kitchen. But it helps to escape substantial amount of smoke rather than curling round the room. Shutter was needed to close these eaves at night to alleviate this problem. To avoid IAP in Kenya, locally available wood is being used to construct eaves spaces and windows through local artisan. Window itself was not successful, but was useful in collaboration especially with hoods as cold and heavy air replaced hot air and also useful in combustion when window were opened. Stoves did not significantly reduce smoke but reduce the need for fuelwood, which might suggest that there would be a reduced quantity of products of combustion (ITDG Smoke and Health project, 1998-2001; and Practical Action).

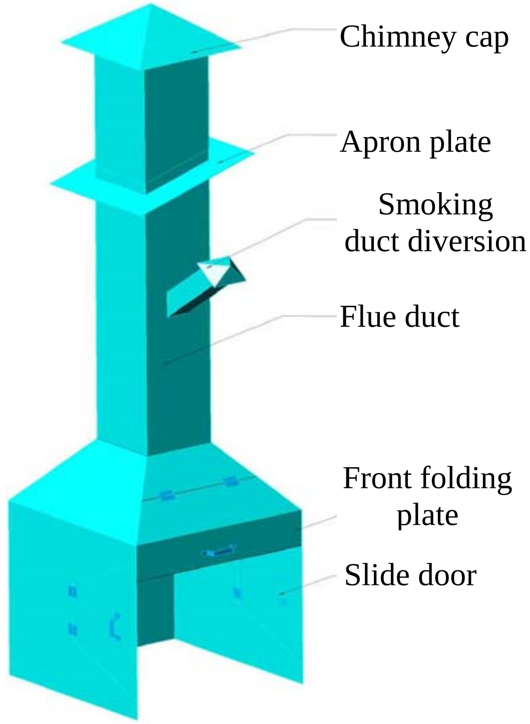
The smokehoods promoted by RECAST and Practical Action Nepal is shown below.

Smokehood

A. First design

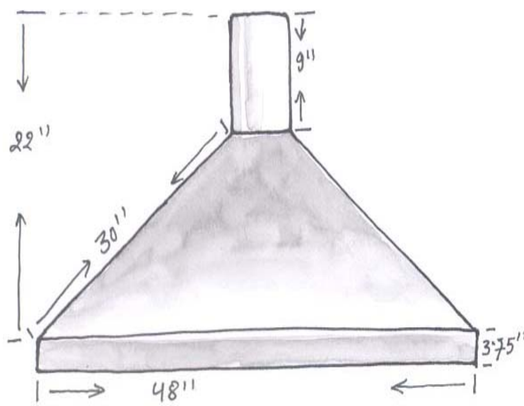
C. New design (I) D. New design (II)

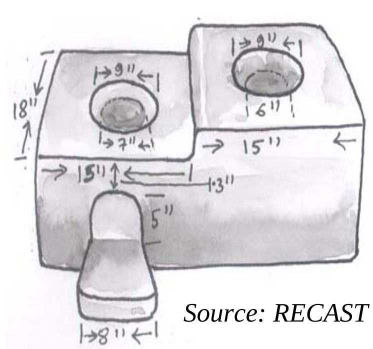
Source: Practical Action Nepal



E. Improved smokehood

Photographs 18: Smokehoods promoted (with technical modifications) in Gatlang by Practical Action Nepal

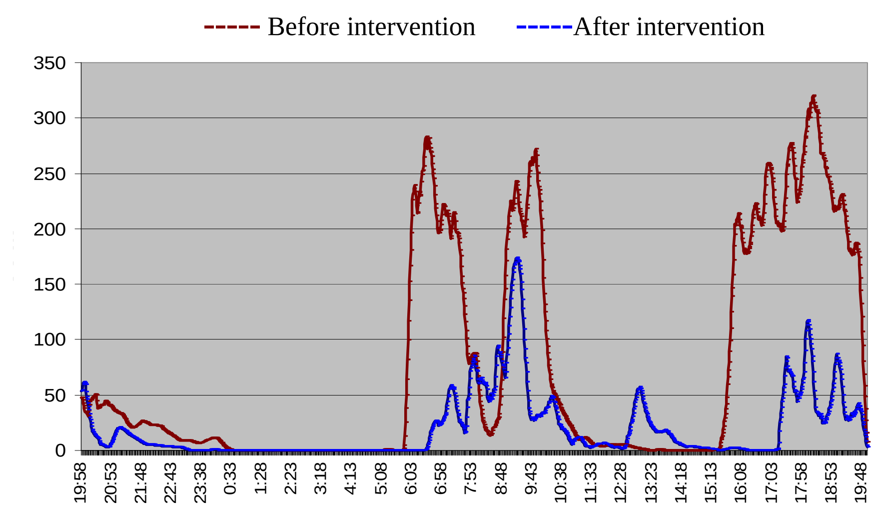




Source: RECAST

Fig. 12: Smokehood researched at RECAST

Year of dissemination	2001 by Practical Action Nepal
Cost	NRs. 5000 for Practical Action Nepal Smokehood, but 35% subsidy from the project and provision of payments in installment basis with 20% down payment. Practical Action Nepal is also facilitating to increase access to credit facility through locally managed revolving fund.
Quantity disseminated	280 by Practical Action Nepal
Technological description and other improvements in traditional stove	Besides smokehood of metal sheet constructed by trained local artisans, the project of Practical Action Nepal also carried out other necessary activities such as wall insulation of stove with the mixture of clay, straw and animal dung; improved stove by building a protecting base around the back and sides of tripod; and bar, set across the front of the stove to allow the air to improve the combustion. Other public awareness activities, such as, fuel drying; and reduction of personal exposure time during cooking and sitting nearby fire were also discussed.
Area/Region with reasons	Gatlang, Rasuwa, northern part of Nepal (NA for RECAST). No climatic and geographical limitations (suitable in all areas)
Advantage	The intervention of RECAST was found positive in IAP reduction up to 70%. The average concentration of PM of 31 household was 1264 and 761 µg/m^3 during winter and summer respectively, but the intervention of smokehood could reduce about 63% PM. Likewise, the concentration of CO during the peak period of summer and winter was 320 and 195 ppm respectively, but the smokehood could reduce CO significantly as shown in Figure 13.



Source: Thakuri and Hada (2006)

Fig. 13: Effect of smokehood in CO concentration

	With the level of reduced indoor smoke and subsequently reduction of PM and CO concentration, there was a positive impact on the health of the people of Gatlang. There was a significant reduction in eye irritating problems along with 6.5% reduction in persistent cough and chest pain. As per the personal communication with Mr. Min Bikram Malla Thakuri, the recent study shows that the smokehood could reduce IAP up to 80%, with 15% fuel and time saving because the project includes not only the introduction of smokehood but also the improvement of stoves. The technology is irrespective of weather and variation in geometry. This is also simple and easily copied. As rural populations still believe that smoke could reduce pest and termite effects as well as used in drying
Disadvantages	High cost despite subsidy and provision of payment in installment.

Major organizations involved in promotion/dissemination: Practical Action Nepal, RECAST

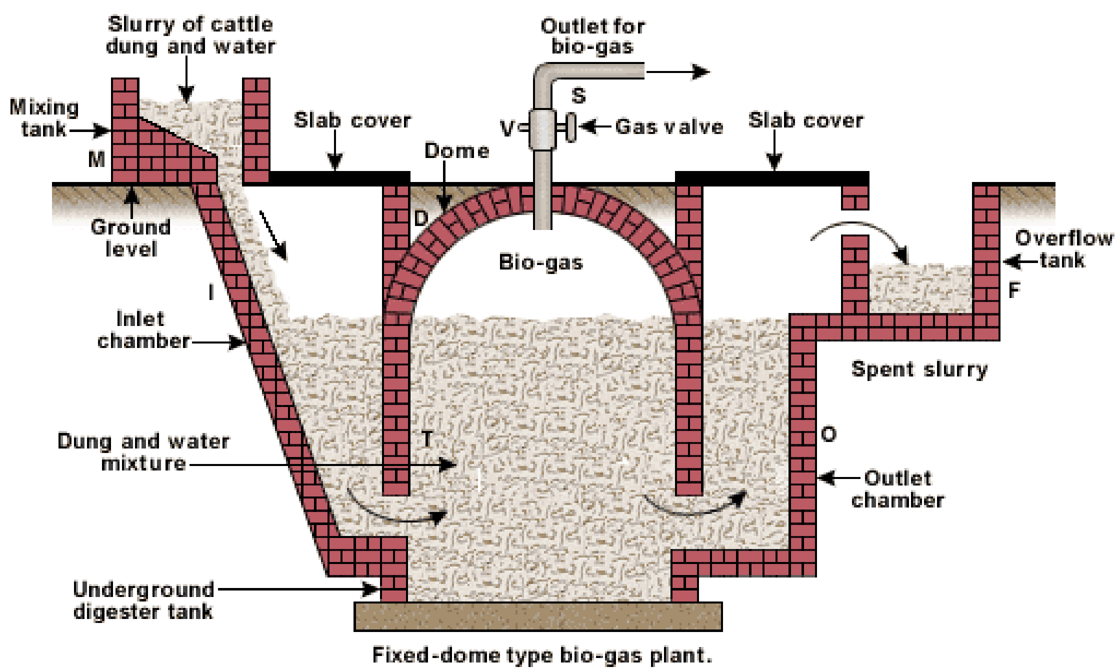
The organizational information of RECAST and Practical Action Nepal is shown in Annex 4.

Based on the success of the intervention of Practical Action, following guidelines have been drawn for the effective implementation of smokehood in the future.

1. Effective government policy and planning
2. Conduction of promotional activities, awareness campaigns including home visits, video show, training and workshops at community and districts level.
3. Training of local entrepreneurs on product manufacturing and business management
4. Joint effort of the households, community, local governments and central government; and involvement of donor agencies
5. Effort to scale up the best practices and continuation of research to improve the design and efficiency
6. Increase access of beneficiaries group to appropriate technologies/product to mitigate IAP
7. Providing support to forecast market, develop business plans for the entrepreneurs and supporting them in identifying and disseminating promotional strategies

2.4 Biogas technology

Biogas, which is combustible in nature, is produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria. This odorless gas is 20% lighter than air and burns with blue flame as LPG. This gas is principally of methane and carbon oxide and has the proportion of gas as: methane (50 to 70 %), carbon dioxide (30 to 40%), hydrogen (5 to 10%) and nitrogen (1 to 2%). Fermentation (retention time) of biodegradable materials is the method of production of this gas and the fermentation varies from 40 to 60 or 70 to 90 days depending upon temperature and type of material. Generally biogas refers the gas produced from animal excreta; however it can also be generated from human excreta, wastewater from industries, by product of food industries, municipal waste, energy crops like hyacinth and various organic products. The waste materials of plant and animal origin consist mainly of carbohydrates, lipids, proteins and small amounts of metabolites and generally insoluble in water. If organic (biodegradable) materials are decomposed or incubated in anaerobic condition, combustible gas methane is produced by the bacterial action. The typical biogas production plant of Nepal is shown in Photograph 19.



Source: AEPC bulletin

Photograph 19: Fixed dome digester biogas plant

Livestock plays an important role in the Nepalese farming system. A total household with cattle and buffalo in Nepal was estimated 2.7 million in 2001. There is a huge potential of biogas throughout the country which can generate 100s megawatt energy, particularly helping the livelihood of the rural communicates, such as health, economy, sanitation, education etc. It is estimated that a total of 1.9 million biogas plants (of which 1 million is economically potential) can be installed in Nepal with the distribution of 57, 37 and 6% in plain, hilly and mountainous region. But it is estimated that only 150,000 (140,549 in 2005) biogas plants have been installed in 67 districts under BSP. Until 2005, BSP has covered 2593 VDCs of total 4000 VDC and paid more attention in periodic plan since seventh plan (1985 to 1990). The tenth plan (2002 to 2007) has taken a long term approach of economic development and commercialization of biogas sector and target to install 200,000 biogas plants. A total of 93,521 toilets have been constructed and connected its outlet to biogas plants and 96% of the constructed plants are in operation. About 1 million people are directly benefited and about 11,000 were employed. 118 micro finance institutes are mobilized, 60 private biogas companies have been strengthened and 15 bio gas appliances manufacturing workshops are developed.

There are different practical models of biogas plant. Floating drum digester, fixed drum digester, fixed dome digester, Deenbandhu model are the common type of biogas plant. Among these, fixed dome digester (GGC Model 2047) with the capacity of 4, 6, 8 and 10 cu. m have been widely adopted in Nepal. These models are feasible up to 2100 m altitude and the cost of this model with 6 cu. m. was NRs. 24,621 in 2005/2006. But, there is a subsidy of NRs. 8,500 from government. The present policy of the government has a provision of providing capital subsidy to the biogas users based on geographical area and the size of the plant as shown in Table 4.

Table 4: Government subsidy policy for biogas user

S. N.	Geographical Distinction (Districts)	Subsidy rate (NRs.)
1	20 districts of Terai as specified by GON	6,000 per plant
2	40 hilly districts with road access as specified by GON	9,000 per plant
3	15 remote districts without road access as specified by GON	2,000 per plant
4	Specified low penetrated districts will be provided with additional subsidy of NPR 500 per plant	
5	To encourage small users, 4 to 6 cu.m. capacity plants will be provided with additional of NPR 500 per plant	

Source: BSP, 2006

The major organizations working on the bio- gas technology:

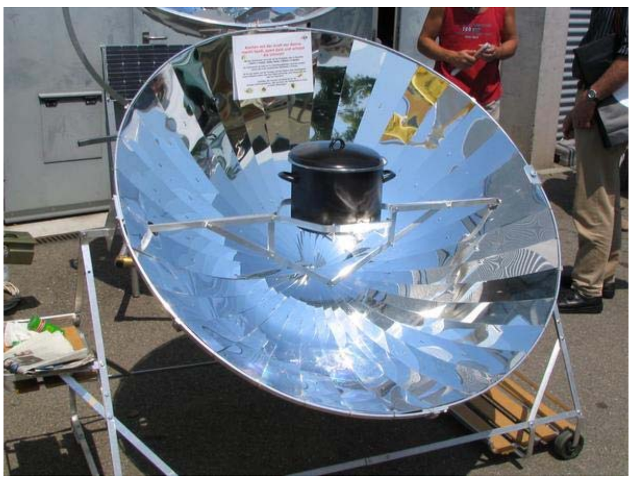
- Alternative Energy promotion centre / MOEST (AEPC)
- Biogas sector Partnership Nepal (BSP-N)
- Bio-Gas support Nepal(BSP/Nepal)

- Yashoda Sustainable Development (P)Ltd.
- Centre for renewable Energy(CRE)
- Association of District Development Committees of Nepal
- Center for appropriate technology nepal
- All Nepal Biogas company
- Biogas tatha urja bikash company
- Butal Gobar gas company
- Gobar gas tatha krishi yantra bikash(P)Ltd.

The reason for limited biogas plant in high hilly mountainous regions is low temperature as biogas is satisfactorily produced in 30 to 40 ºC and the production virtually stops below 10 ºC. But the research is being undertaken to develop special model of biogas plant so that it can be extended to all districts of Nepal. Besides animal dung, grass, kitchen waste, litter from poultry, night soil, elephant dung, municipal waste and industrial waste utilization process have been promoted by the BSP/Nepal and other concerned organizations. An initiative has been taken to establish the biogas plant for feeding once or twice in a year and produce gases throughout the year. As a result, a demo Puksin plant has been installed in CES/ IOE in Pulchowk premises.

2.5 Solar cooking technology

The heat energy of solar radiation can be utilized in various forms of thermal as well as photovoltaic use. The high heat obtained by concentrating the solar radiation using reflectors can be used for cooking. High temperatures are not needed for cooking as the temperature of food can not go above 100° C (212° F) at sea level unless it is pressurized by any cooking vessel. An oven will cook just fine as long as it gets up to about 90° C (200° F) or so. Higher temperatures cook larger quantities, cook faster, and allow for cooking on marginal days. The temperature reached by box cookers and panel cookers depends primarily on the number and size of the reflectors used. The similar temperature of the cooking pot as of oven can be identified by placing an oven thermometer exactly over the oven which is facing the sun. The common types of solar cooker in Nepal are shown in Photograph 20.



Parabolic type solar cooker

Source: www.crtnepal.org

Box type solar cooker

Source: www.solarcooking.org

Photograph 20: Common types of solar cooker

A single-reflector box cooker usually tops out at around 150° C (300° F). A single-reflector box cooker will take about twice as long as in a conventional oven. Few pots with desired foods is put in the box and come later, may be sometimes in the day. Each food in the box will be perfectly cooked and stay hot until removing from the box. But, cooking with the parabolic cooker is similar to one burner conventional stove. The concentrated sunlight directly reflected on the bottom of the pot. In this cooker, pot heats up and cooks very quickly. As there is a possibility of burned food, food should be stir at regular interval. Typical parabolic type of solar cooker of (1.4 m diameter and 28.6 kg weight) developed by CRT/N has shown the result of 1 hour to boil 10 liter of water, 30 minutes to cook 0.5 kg rice and 45 min to cook chicken.

Box cookers with one back reflector do not need to turn unless beans are cooking as beans takes up to 5 hours for cooking. Panel cookers need to be turned more often than box cookers, since they have side reflectors which can shade the pot. Parabolic cookers are the most difficult to keep in focus. It should be turned every 10 to 30 minutes depending on the focal length.

Allart Ligtenberg, an Engineering Manager started to work on solar cooker in collaboration with CRT/N from 1992, hence recognized as the pioneer of solar cooker in Nepal. Awareness creation was accomplished through demonstrations, food testing, pilot projects, media exposure, and the distribution of informational handouts. Initially, Ligtenberg and CRT/N created interest among NGOs, community leaders, environmentalists and scientists to sent their representatives to solar cooking workshops. Then they disseminated cookers to rural people. Although the momentum for the promotion and dissemination of cooker in Nepal is in slow pace, it is quite encouraging. CRT/Nepal has focused its promotion in urban/semi urban areas and tourism areas. Nepal government has been providing partial subsidy for its promotion. So far about 1000 units of SK 14 parabolic solar cooker have been disseminated in various parts of the country through collaborative efforts with the government and other various development partner organizations. CRT/N has planned to promote 2500 solar cookers within next 5 years along eco-tourism areas of Nepal. One assessment study made in Bamti Bhandar shows that use of each solar cooker for 4 to 5 hours in a day and 7 months in a year can save yearly average of 2300 kg fuel. About 3000 refugees from Bhutan (Bhutanese Refugee Camp Beldangi-I Jhapa) have been benefited from the solar cooker and others are waiting.

Realizing the usefulness of solar cooker and recent increases in price, Nepal government has provided 50% (but not exceeding NRs. 4000) subsidy to solar cooker (box type and SK 14 parabolic type) as per renewable energy subsidy delivery mechanism.

Despite high cost even after subsidy, there is a high potential of this technology in Nepal because of high solar intensity (about 4.5 $KWH/m^2/day$) with national daily average sunshine duration of 6.8 hours; increased cost of other energy sources; scarcity of fuelwood; renewable and pollution less; and difficulties for other alternate technologies. As a result, various I/NGOs; and private as well as government sector have shown interest in promoting this technology throughout the country. The major organizations working in solar cooking technology are:

- Alternative Energy Promotion Center Nepal (AEPC/ N)
- Centre for Rural Technology Nepal (CRT/N)
- Foundation for Sustainable Technology (FoST)
- Kathmandu Environmental Education Project (KEEP)
- Trekking Agencies Association Nepal (TAAN)
- Gramin Urja Tatha Prabidhi Sewa Kendra (P) LTD
- Solar Energy System (P.) Ltd

3. CONCLUSTION AND RECOMMENDATIONS

3.1 Conclusion

Nepal, challenged by the growing population, is heavily dependent on traditional biomass fuels which contributed about 87% of total energy consumption. Nepal was one of the lowest per capita energy consumption (about 15 GJ) countries in 2005 and most of the energy consumed is used for cooking (65%) followed by space heating and other activities

Smoke in the home is the major contributing factors of many diseases of large segment population of the country as well as the cause of GHG emission. The negative effects on human health; and on local and global environment deserve substantial mitigation efforts by national/local governments as well as I/NGOs and private sectors.

Mud-brick ICS; metal stoves; briquette burning technology; and chimney and smokehood are some technologies that have been disseminated for those households who use firewood and agricultural residues as a source of energy for cooking and heating; and space heating. At present and in foreseeable future, alternation of biomass fuel is not feasible for the vast majority of the people; however, other renewable technologies, such as biogas and solar cooking have been also researched, developed and disseminated in some parts of the country.

Various technologies, despite some at local level covering few areas, are found effective in IAP reduction along with fuel and time saving. Mud-brick ICS especially two potholes are suitable in mid hills; and metal stoves are suitable in high hills and mountains. Single pothole mud-brick ICS and two potholes mud-brick ICS are also accepted in Terai, however, more research is needed for model adaptation because of the structure of house such as thin wall and thatched roof. In Nepal, mid hill and high hill ranges from 1300 to 2500 and 2500 to 5000 m *amsl* respectively and metal stoves are even suitable above 2000 m altitude. Metal stoves are more efficient than mud-brick stoves because of the requirement of fairly evenly small sizes of fuel. These fuels are comparatively dry and aid in proper combustion. Beyond the limitation of accessibility of electricity, *bayupankhi* (air induced) stoves are more suitable because of proper combustion and high efficiency. There is a high level of satisfaction among the users of mud-brick ICS and metal stoves, as these stoves are efficient in fuel consumption, which ultimately of reduces the fuel collection time; and reduction of IAP.

Briquetting technology, which unfortunately could not industrialized despite established in 1980s, is one of the appropriate eco-friendly technologies as a substitute of firewood as well as potential in smoke reduction. Briquette burning, which preferably requires improved stoves could reduce up to 90% smoke. Only one commercial industry and very few research institutes, NGOs and private sectors are involved in development of this technology.

Though the smokehood and ventilation could reduce substantial amount of smoke from the kitchen, only one research institute, RECAST and an INGO, Practical Action Nepal have been involved in research and dissemination of smokehoods. However, the project of Practical Action Nepal could achieve substantial reduction of PM and CO in rural household of Rasuwa district, more research and dissemination is needed to draw any conclusion on the effectiveness of this technology.

3.2 Recommendations

For the effective implementation of program in the future in reducing IAP and increase livelihood of people, following guidelines have been drawn.

1. Efficient government policy, planning and implementing strategy with effective public awareness activities on health hazards due to indoor smoke
2. Conduction of promotional activities, awareness campaigns including home visits, video show, training and workshops at community and districts level. Dissemination of information materials like posters, pictorial manual (most preferably in local language and with local contact address) informing health hazards due to IAP
3. Promotion of joint effort of the households, community, local governments and central government with the involvement of donor agencies.
4. Compulsory session/training on health hazards of smoke to promoter and users with adequate supply of promoter's/user's manual. Provision of incentive (in terms of monthly remuneration) to promoter. Training to local artisans/entrepreneurs on product manufacturing and business management considering their feedback. Similarly, provide support to forecast market, develop business plans for the entrepreneurs and support them in identifying and disseminating promotional strategies.
5. Focus the program in wood deficit areas. Creation of awareness of replacement demand among the users as older ICS lost efficiency.
6. Government assists in dissemination; technical advice; quality control; and monitoring and evaluation. Extended government or donor support for at least five years for the development of local institutions and local expertise.
7. Recognition of organizations working intensively in smoke reducing/alleviating technology; and provision of technical research and development support with adequate funding for capital investment and training. Effort to scale up the best practices and continuation of research to improve the design and efficiency
8. Provision of subsidy and payments on installment as well as subsidy to the organizations and manufacturers involved in mitigating IAP. Likewise, formation of

locally managed revolving fund groups and increase access to credit facilities through these funds

8. Assesses potential market through market survey and increase access of beneficiaries group to appropriate technologies/product to mitigate IAP
9. Encouragement of the active participation of woman and *dalit* (disadvantage group); and promotion of income generating activities
10. Strong network/coordination with organizations and individuals with similar goals and works to bring about effective policies changes that favor mitigation of indoor air pollution and health related problems. Formation and active involvement of regional forum for technology transfer.
11. Ease of lighting with output power adjustments, in case of stoves. ICS program might be more effective if it is implemented by adopting a decentralized approach by integrating planning activities with local government authorities like DDC and VDCs. The decentralized approach of the program shall provide strong roles for DDC to plan natural resources in its development plan.
12. Encourage to use metal stove because of its high efficiency. As far as possible, swift to alternative renewable technology, such as biogas and solar cooking technology.

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Annex 1: List of organization involved in mud-brick improved cooking stoves

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Alternative Energy Promotion Center/Energy Sector Assistance Program, AEPC/ESAP (Government), 1996	PO Box 6332 Dhobighat, Lalitpur, Nepal Tel: 01 5528335/5539327 (AEPC) 01 5536843/5539391 (ESAP) Fax: 01 5542397/5539392 E-mail: energy@aepc.gov.np esap@mos.com.np Website: www.aepcnepal.org	OH: Dr. Govinda Raj Pokharel Executive Director Mr. Arne Andersen (ESAP) Country Representative CP: Mr. Surya Kumar Sapkota surya.sapkota@aepc.gov.np Ms. Karuna Bajracharya (ESAP) karuna.bajracharya@aepc.org.np	Type: Single, two (same and raised surface; with and without grate; and also at waist height) and three potholes (institutional and multifunction). But maximum stoves are 2^{nd} pothole raised two potholes stoves Number: Around 200,000.	35 mid hill districts
Center For Energy and Environment, CEE (NGO), 1997	PO Box, 10736, Anam Nagar, Kathmandu, Nepal Tel: 01 4242993 Fax: 01 4220161 E-mail: cee@mail.com.np	OH: Dr. Krishna Raj Shrestha Chairman CP: Dr. Krishna Raj Shrestha	Type: Two potholes stoves Number: 110	Kaski
Center for Environmental and Agricultural Policy Research, Extension and Development, CEAPRED (NGO)	PO Box 5752, Naya Basti, Lalitpur, Nepal Tel: 01 5546542/5520272 Fax: 01 5524165 E-mail: info@ceapred.org.np Website: www.ceapred.org.np	OH: Dr. Pius Raj Mishra Executive Director CP: Mr. Binod Sharma	Type: Two and three potholes until 2005 Number: 2905	Baitadi, Sankhuwasabha
Center for Rural Technology, Nepal, CRT/N (NGO), 1989	PO Box 3628, Tripureshwor, Kathmandu, Nepal Tel: 01 4256819/4260165 Fax: 01 4257922 E-mail: info@crtnepl.org Website: www.crtnepal.org	OH: Mr. Ganesh Ram Shrestha, xecutive Chairman CP: Mr. Rajan Thapa Mr. Damokar Karki Ms. Rakshya Pandey	Type: Single, two and three pothole stoves with chimney and some institutional stoves Number: 153, 000 (program of AEPC/ESAP)	Mid hill districts
Community Health Initiative Project, CECI (NGO), 1998	PO Box 8973, Kathmandu, Nepal Tel: 01 4414430/4419412/4426791 Fax: 01 4413256 E-mail: info@ceci.org.np Website: www.ceciasia.org	OH: Mr. Keshab Koirala Country Representative CP: Mr.Harihar Sapkota harihars@ceci.org.np	Type: Single, two and three potholes Number: 3000	Surkhet, Dailekh, Dadeldhura, Baitadi

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Child Welfare Scheme Nepal, CWSN (NGO), 1997	PO Box 231, Child Welfare Scheme, Pokhara-6, Hallanchok lake side Pokhara, Nepal Tel: 61 520793/534325 Fax: 61 534325 E-mail: nima@cwsn.org Website: www.cwsn.org.np	OH: Mr.Devendra Gurung Chief Program Coordinator CP: Ms. Nima Gurung	Type: One pothole, two potholes (same and raised surface), multipurpose Number: N/A, VDC wise	Kaski
Department of Women Development, DWD, (Government), 1982	Pulchowk, Lalitpur, Nepal Tel: 01 5526779/5547013/5523827 Fax: 01 5521214 E-mail:	OH: Mr. Bishow Prakash Pandit Director General CP: Ms. Meena Aryal meenaaryal@hotmail.com	Type: Two potholes Number: Around 10000	Palpa, Dhankuta, Doti, Dailekh and Gulmi
Development Project Service Center – Nepal, DEPROSC – NEPAL, (NGO), 1993	PO Box 10953, Kathmandu, Nepal Tel: 01 4262396/4244723 Fax: 01 4262396 E-mail: info@deprosc.wlink.com.np Website: www.deprosc.org.np	OH: Mr. Pitambar Prasad Acharya Executive Director CP: Ms. Rita Koirala	Type: Two potholes Number: 4802 until 2004	Lamjung, Dhading Rautahat, Tanahun, Makwanpur, Dadeldhura,
Environmental Management Action Group, EMA – GROUP (NGO), 1990	PO Box 5530, Kathmandu, Nepal Tel: 01 6260090 Fax: 01	OH: Bal Krishna Raj Joshi Chairman CP: Mr. Surendra Lal Shrestha	Type: Two potholes Number: 30	Kahtmandu
Human Welfare and Environment Protection Center, HWEPC (NGO), 1991	Ghorahi, Dang Tel: 82 560240/691720 Fax: 82 560240 E-mail: hwepcdang@ntc.net.np Website: www.hwepcdang.org.np	OH: Mr. Kiran Kumar Regmi CP: Mr. Shreeman Neupane	Type: Two potholes Number: more than 3000	Dang
Nepal Red Cross Society, NRCS, (Community Development), 1963	PO Box 217, Tahachal, Kathmandu, Nepal Tel: 01 4272761/4279650/4280289 Fax: 01 4271915 E-mail: cdp@nrcs.org Website: www.nrcs.org	OH: Mr.Ramesh Kumar Sharma President CP: Mr. Madhukar Shrestha	Type: Two potholes Number: 6000	Khotang, Dhankuta Okhalhunga, Dang, Siraha, Sunsari, Dadeldhura, Sankhuwasabha, Solukhumbu, Kanchanpur,
Research Centre for Applied Science and Technology, RECAST (R & D, University), 1997	PO Box, 1030, Tribhuvan University, Kirtipur, Nepal Tel: 01 4330348 Fax: 01 4331303 E-mail: truecast@mail.com.np Website:	OH: Prof. Mohan Bikram Gyawali Executive Director CP: Dr. Sushil Bajracharya	Type: Single; two and three pothole (same and raised surface), institutional (Single, two and three pothole; lapsi and khuwa chulo); Two potholes (with smokehood)	NA

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Rural Energy Development Program, REDP (Government), 1991	PO Box 107, Jawalakhel, Lalitpur, Kathmandu, Nepal Tel: 01 5544146/5547609 Fax: 01 5544576 E-mail: redpktm@mos.com.np Website: www.redp.org.np	OH: Mr. Kiran Man Singh National Program Manager CP: Mr. Kiran Man Singh	Type: Two potholes and institutional ICS (IICS) Number: 254 (IICS) 9795 (Two potholes)	Darchula, Baitadi, Mugu Taplejung, Dadeldhura, Bajura, Bajhang, Myagdi, Parbat, Doti, Baglung, Tanahun, Dhading, Tehrathum, Panchthar, Achham,Sindhupalchowk, Kavre, Dolakha, Solukhumbu, Dailekh, Okhaldhunga, Pyuthan, Sankhuwasabha Humla,
Rural Reconstruction Nepal, RRN (NGO), 1989	PO Box 8130, Lazimpat, Kathmandu, Nepal Tel: 01 4415418/4422153 Fax: 01 4418296 E-mail: rrn@rrn.org.np Website: www.rrn.org.np	OH: Dr. Arjun Kumar Karki President CP: Dr. Bal Bahadur Parajuli Mr. Tanka P. Upreti	Type: CRT model (Single, two and three pothole) but maximum two potholes, CRT model ICS from 1996 Number: 2000	Sankhuwasabha, Panchthar, Bhojpur
Rural Community Development Society RUCODES, (NGO), 1991	Dhulikhel 5, Kavre, Nepal Tel: +977 11 490035 Fax: +977 11 490035 E-mail: rucodes_dk@ntc.net.np Website: www.rucodes.org	OH: Mr. Hari Bhakta Khoju Chairperson CP: Mr. Upendra Man shakya shakyaup30@ntc.net.np	Type: Single, two and three pothole, commercial and institutional Number: 25000	Sindhupalchowk, Dolakha, Kavre, Ramechhap, Kathmandu, Nuwakot
Support Activities for Poor Producers of Nepal SAPPROS, (NGO), 1991	PO Box 8708, Kuiyo Gaun, Thapathali, Kathmandu, Nepal Tel: 01 4244913/4242318 Fax: 01 4242143 E-mail: sappros@stp.com.np Website: www.sappros.np	OH: Mr. Sri Krishna Upadhaya Executive Chairman CP: Narendra Bahadur K. C. Director	Type: Two potholes CRT model Number: 181	Dhading, Humla Chitwan
SELF NEPAL (NGO), 1996	PO Box 8973, Kathmandu, Nepal Tel: 01 016207047 Fax: 01 E-mail: solvenepal@gmail.com Website: www.deprosc.org.np	OH: Mr. Ram Bhattarai President CP: Mr. Arjun Bhattarai	Type: Single, two and three pothole Number: 500	Ilam, Panchthar

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Society of Local Volunteers Effort Nepal SOLVE – NEPAL, (NGO), 1989	PO Box 5556, Subidhanagar, Kathmandu, Nepal, (Contact office) Dhankuta 6, Nepal (Head office) Tel: 01 4468960 Fax: 01 4468960 E-mail: solve@hons.com.np Website: www.solvenepal.com	OH: Mr. Rajendra Pradhan Executive Director CP: Ms. Jyoti Pradhan, Dhankuta	Type: Two potholes Number: 900	Dhankuta

Annex 2: List of organization involved in dissemination metal stoves

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Community Health Initiative Project, CECI, (NGO), 1998	PO Box 8973, Kathmandu, Nepal Tel: 01 4414430/4419412/ 4426791/4426793 Fax: 01 4413256 E-mail: info@ceci.org.np Website: www.ceciasia.org	OH: Mr. Keshab Koirala Country Representative CP: Mr.Harihar Sapkota harihars@ceci.org.np	Type: Two and three potholes CRT designed metal stoves Number: 6460	Jumla
Center for Rural Technology, Nepal CRT/N, (NGO), 1989	PO Box 3628, Tripureshwor, Kathmandu, Nepal Tel: 01 4256819/4260165 Fax: 01 4257922 E-mail: info@crtnepl.org Website: www.crtnepal.org	OH: Mr. Ganesh Ram Shrestha Executive Chairman CP: Mr. Rajan Thapa Mr. Damodar Karki Ms. Rakshya Pandey	Type: CRT/N type metal stoves (Three potholes, rocket, RT, DK, Bayupankhi, Briquette) Number: 100 metal and 300 bayupankhhi stoves	Metal stoves in high hill districts, Bayupankhi and Briquette stoves in semi urban areas
Foundation for Sustainable Development, FoST, (NGO), 2002	PO Box 10776, Golkopakha, Thamel, Kathmandu, Nepal Tel: 01 4361574/4351225 Fax: 01 E-mail: fost@ntc.net.np Website: www.fost-nepal.org	OH: Mr. Sanu Kaji Shrestha Chairman CP: Mr. Sanu Kaji Shrestha	Type: Bayupankhi stoves with perforation at top and bottom of inner wall Number: 1200 to 1500	NA

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Mechanical Department, Kathmandu University (Public Private Research), 1991	PO Box 6250, Dhulikhel 7, Kavre, Nepal Tel: 11 661399 Fax: 01 E-mail: zahnd@wlink.com.np	OH: Prof. Suresh Raj Sharma Vice Chancellor CP: Mr. Alex Zahnd	Type: 3 potholes Jumla design smokeless metal stove Number: 4500	3000 in Jumla, Humla Mugu, 1500 in mid hills of Pokhara
National Structure and Engineering Pvt. Ltd., 1972	Patan Industrial Estate, Lalitpur PO Box 20157 Kathmandu, Nepal Tel: 01 5521405/5542393 Fax:	OH: Mr. Gopal Mittal Executive Director CP: Mr. Navaraj Adhikari	Type: As per demand Number: NA	NA
Nepal Academy of Science and Technology, NAST (formerly RONAST), (Research and Development), 1982	PO Box 3323, Khumaltar, Lalitpur, Nepal Tel: 01 5547715/5547717/5547721 Fax: 01 5547713 E-mail: info@nast.org.np Website: www.nast.org.np	OH: Prof. Hom Nath Bhattarai Vice Chancellor CP: Dr. Indira Shakya	Type: Beehive Briquette Stoves Number:	NA
Nepal Yantrasala Energy Pvt. Ltd., 1976	Patan Industrial Estate, Lalitpur PO Box 8975 Kathmandu, Nepal Tel: 01 5522167/5527857 Fax: E-mail: nyenergy@hons.com.np Website: www.nyenergy.com	OH: Mr. Shyam Raj Pradhan Executive Director CP: Mr. Shyam Raj Pradhan	Type: As per demand Number: NA	NA
Sindhu Urga Kendra (Private), 2003	Muni Bhairab Marg, Tinkune, Kathmandu, Nepal Tel: 01 2054100/4467966 Fax: 01 4467966 E-mail: mass@mail.com.np	OH: Mr. Hasta Bahadur Pandit Managing Director CP: Mr. Hasta Bahadur Pandit	Type: Production of metal stoves and bayupankhi stoves Number: 5000	Urban and semi urban area; and area with access of electricity
Structro Nepal Pvt. Ltd., 1971	Patan Industrial Estate, Lalitpur PO Box 228 Kathmandu, Nepal Tel: 01 5521192/5526161 Fax: 01 5542118 E-mail: structo@wlink.com.np	OH: Mr. Urgin Sherpa Executive Director CP: Mr. Rajendra Pradhan	Type: As per demand Number: NA	NA
Sustainable Technology – Adaptive Research & Implementation Center/Nepal, STARIC/N (Private), 2004	PO Box 2433, Kathmandu, Nepal Tel: 01 6222332 Fax: 01 E-mail: staricn@vianet.com.np Website: www.staric.com.np	OH: Prof. Dr. Chandra Bahadurr Joshi Executive Director CP: Mr. Pawan Shrestha	Type: Ujeli metal stove with thermoelectric generator Number: NA (still in field test)	NA (Field test in Rasuwa)

Annex 3: List of organization involved in briquetting technology

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Foundation for Sustainable Development, FoST, (NGO), 2002	PO Box 10776, Golkopakha, Thamel, Kathmandu, Nepal Tel: 01 4361574/4351225 Fax: 01 E-mail: fost@ntc.net.np Website: www.fost-nepal.org	OH: Mr. Sanu Kaji Shrestha Chairman CP: Mr. Sanu Kaji Shrestha	Type: Bio-briquette and also from household waste such as from paper, grass, leaves, sawdust, baggasse etc. Quantity: NA	NA
Integrated Development Society, Nepal (IDS-NEPAL) (NGO), 2000	PO Box 6413, Baluwatar, Kathmandu, Nepal Tel: 01 4427329 Fax: 01 4467966 E-mail: idsnepal@wlink.com.np Website: www.idsnepal.com.np	OH: Dr. Dinesh Chandra Devkota Chairperson CP: Mr. Rajeshwor Acharya	Type: Beehive briquette Quantity: 6000kg Bishankunarayan), 1750kg (Kamdi), 3000kg (Tuture), 750kg (Panchpokhari)	Bishankunarayan, Kamdi, Tuture, Panchpokhari
Mhyaipi Briquette Industries (MBI), (Private), 1994	Shivabasti, Shiva Mandir, Kawasoti, Nawalparasi, Nepal City office: Cha 3, 840, Nayabazar, Kathmandu, Nepal Tel: 01 +977 78540200 Fax: 01 E-mail:mbi1994sure@hotmail.com Website:	OH: Mr. Surendra Gorkhali Executive Director CP: Mr. Surendra Gorkhali	Type: Production of rice husk briquette Quantity: 3000 ton	Urban and semi urban areas
Nepal Academy of Science and Technology (NAST, formerly RONAST) (Research and Development), 1982	PO Box 3323, Khumaltar, Lalitpur, Nepal Tel: 01 5547715/5547717/5547721 Fax: 01 5547713 E-mail: info@nast.org.np Website: www.nast.org.np	OH: Prof. Hom Nath Bhattarai Vice Chancellor CP: Dr. Indira Shakya	Type: Beehive briquette Number: NA	NA
Research Centre for Applied Science and Technology (RECAST) (Research and Development, University) 1997	PO Box 1030, Tribhuvan University, Kirtipur, Nepal Tel: 01 4330348 Fax: 01 4331303 E-mail: truecast@mail.com.np Website:	OH: Prof. Mohan Bikram Gyawali Executive Director CP: Dr. Krishna Raj Shrestha	Type: Beehive briquette Quantity: NA	NA

Annex 4: List of organization involved in smokehood

Name and type of organization with year of establishment	Address; Tel & Fax Number; Email address and Website	Organization head (OH) with designation and contact person (CP)	Type & number of ICS disseminated	Implemented area
Practical Action Nepal (Formerly ITDG) (INGO), 1979 in Nepal (Originally in UK in 1966)	PO Box 15135, Pandole Marg, Lazimpat, Kathmandu, Nepal Tel: 01 4446015/4434482 Fax: 01 4445995 E-mail: info@practicalaction.org.np Website: www.practicalaction.org	OH: Mr. Achyut Luitel Country Director CP: Ms. Jun Hada Mr. Min Bikram Malla Thakuri	Type: Smokehood Number: 280	Rasuwa
Research Centre for Applied Science and Technology (RECAST) (Research and Development, University) 1997	PO Box 1030, Tribhuvan University, Kirtipur, Nepal Tel: 01 4330348 Fax: 01 4331303 E-mail: truecast@mail.com.np Website:	OH: Prof. Mohan Bikram Gyawali, Executive Director CP: Dr. Sushil Bajracharya	Type: Smokehood Number: NA	NA