Technology for Healthy Life

PRACTICAL ACTION
March 2009

Inventory of Innovative Indoor Air Pollution Alleviating Technologies In Nepal

PRACTICAL ACTION
Technology challenging poverty

ISBN 978-9937-8135-1-8

Preface

Indoor Air Pollution (IAP), results form househlod (HH) cooking and heating when low quality solid fuels is used in poorly ventilated kitchens. IAP can be generated from different sources besides solid fuel burning. IAP is responsible for an array of respiratory related diseases. In developing countries, IAP is the fourth leading cause of death and was responsible for the deaths of over 1.5 million people in 2002, predominately women and children (WHO 2006). IAP is a major environmental health concern in Nepal as 85 per cent of HHs still depend on solid biomass fuels for cooking and heating. In 2002, IAP was responsible for the death of 7,500 people in Nepal (WHO 2007).

Current energy use and availability trend in Nepal indicates that use of solid fuel will continue to dominate for the next several years. There are various successful and innovative technologies promoted in Nepal to reduce indoor smoke generated from the solid fuel burning. However, due to lack of adequate information, demand for such technologies/products is very low. Nepal has diverse cooking practices hence different types of technologies are required to eliminate IAP in Nepal. Experience shows that the success of technologies depends on various aspects - availability and price of fuels, socio-cultural, ethnic values and practices, geographic and climatic conditions, cooking behaviours and practices, size/design of kitchen, economic status etc.

This report is a compilation of information on innovative IAP alleviating technologies that is promoted in Nepal. We hope that this report will serve as an important reference for practitioners, researchers, academicians, private promoters and consumers to access general information on various kinds of innovative technologies that significantly reduces IAP with easily available resources in Nepal's local markets. This report can be used by the readers to facilitate their decision making on appropriate choice of technology suitable for their own use or for further dissemination. It is also expected to help reduce duplication and assist the planners and decision makers to plan for new innovations in the future. However, this reference material is not sufficient to design a stove or manufacturing guidelines.

We are grateful to Dutch Government (DGIS) for their financial support. This book is a collective effort of many individuals. I would like to thank Mr. Uttam Dhakal for his contribution for collecting field information, verifying and preparing the draft of this report. We are also grateful to Prof. Dr. Jagan Nath Shrestha, Director, Center for Energy Studies, Institute of Engineering, TU for reviewing this report and providing valuable comments and feedback. Similarly, we are also thankful to Alternative Energy Promotion Center, Ministry of Science and Technology, Government of Nepal for contributing their valuable time in verifying the information provided in this book. The roles of Ms. Jun Hada and Mr. Min Bikram Malla from the Programme - Improving Access to Infrastructure Services, Practical Action Nepal Office are equally commendable in coordinating and providing their inputs to finalise this report. I would like to thank Mr. Upendra Shrestha and Ms. Shradha Giri from Fundraising and Communications Unit for their contribution to give this book a final shape for publication. Finally, I would like to thank those organisations and individuals who provided necessary information to prepare this report.

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Contents

LIST OF PHOTOGRAPHS

Acronyms

AEPC	Alternative Energy Promotion Center
ALRI	Acute lower respiratory infection
amsl	Above mean sea level
ARECOP	Asia Regional Cook Stove Programme
ARI	Acute respiratory infection
BSP	Biogas Support Programme
BSP-N	Biogas Sector Partnership Nepal
CBO	Community Based Organisation
CEE	Center for Energy and Environment
CES	Center for Energy Studies
CFDP	Community Forest Development Programme
CO	Carbon monoxide
COPD	Chronic obstructive pulmonary diseases
CRT/N	Center for Rural Technology/Nepal
DANIDA	Danish International Development Agency
CWSN	Child Welfare Scheme Nepal
EJ	Exa Joule
ESAP	Energy Sector Assistance Programme
FAO	Food and Agricultural Organisation
FoST	Foundation of Sustainable Technology
GHG	Greenhouse gas
GJ	Giga joule
GO	Government Organisation
GoN	Government of Nepal

HH	Household
IAP	Indoor air pollution
ICIMOD	International Center for Integrated Mountain Development
ICS	Improved cooking stoves
IICS	Institutional improved cooking stoves
IDS - N	Integrated Development Society - Nepal
INGO	International Non Government Organisation
IOE	Institute of Engineering
LPG	Liquefied petroleum gas
LPO	Local Partner Organisation
kWH	Kilowatt hour
MGJ	Million Giga joule
MOPE	Ministry of Population and Environment
NA	Not available
NAST	Nepal Academy of Science and Technology
NGO	Non Government Organisation
NICSP	National Improved cook stoves programme
NORAD	Norwegian Agency for Development Cooperation
NRCS	Nepal Red Cross Society
NRs.	Nepalese rupees (1 US$ equivalent to NRs. 78 as of February 2009)
PM	Particulate matter
ppb	Parts per billion
ppm	Parts per million
RECAST	Research Center for Applied 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 Programme
UNICEF	United Nations Children Fund
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat
WHO	World Health Organisation
WTC	Women Training Center

Chapter one
BACKGROUND

1.1 Energy scenario of Nepal

Nepal is a landlocked country – East, West and South bordered by India and the Northern side bordered by China. Nepal is predominantly mountainous, a total area of 147,181 sq. km with tropical plains in the South (*Terai*) and the Himalayas in the North having a mean width of 193 km. The mountainous region, which is sparsely populated covers about one third (35 per cent) of the total land area of which only two per cent is suitable for cultivation. The hilly region makes up 42 per cent of total land of which one-tenth is suitable for cultivation. *Terai*, densely populated region accommodates 47 per cent of total population with 23 per cent of total land area including fertile land and dense forest (CBS 2001).

Nepal is the highest traditional fuel consuming country in Asia because of its high dependency on traditional biomass fuels, mostly firewood, limited extent of charcoal and crops and animal residues (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). Worldwide total energy consumption is around 451 EJ out of which 10.6 per cent is based on traditional biomass (Godfrey Boyle 2004). Global estimation of biomass users is more than two billion who use wood, charcoal, crop residues and dung as their primary source of energy. Majority of people in developing countries use traditional biomass for their cooking, space heating and preparing animal food. However, the global use of biomass is declining but 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 their main source of energy (Thapa 2006).

In Nepal, overall energy resources can be categorised into three types viz. traditional, commercial and renewable. The total primary energy consumption of Nepal in Fiscal Year 2005/06 was 8,478 Tons of Oil Equivalent (TOE). Out of total consumption, traditional energy resources alone contributed 85.5 per cent of total primary energy consumption; which clearly depicts the dependency of the country on traditional resources for energy. Traditional energy resources include fuelwood, agricultural residues and animal residues sharing 89.41, 6.66 and 3.93 per cent respectively (WECS 2006). Of the rest, commercial energy resources which include petroleum fuel, coal and electricity shared 13.54 per cent. Contribution of renewable energy resources is only 0.61 per cent compared to traditional and commercial resources. Another noticeable factor to consider during sector wise consumption is that the major fraction of total energy consumed by HHs is 89.21 per cent. Other sectors viz. industries, commercial use, transportation, agriculture and others consumed 4.51, 1.51, 3.71 and 0.81 per cent respectively (Economic Survey, FY 2006/07).

The national population growth is 2.25 per cent however; the growth rate in urban and rural areas of Nepal is 2.30 and 1.70 per cent respectively. The main source of energy for 94.1 per cent rural HHs is firewood. In urban areas, the main sources of energy are firewood, kerosene and other commercial energy resources which contribute about 39, 35 and 25 per cent 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 per cent of Nepal's rural population. HHs in rural hilly areas consumes about 6 tons of firewood during summer and 7.6 tons in winter. In *Terai*, HHs consume 3.7 tons of firewood in summer and 5.4 tons in winter (Winrock 2004). It is estimated that residential cooking, which account about 65 per cent 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 to 8, 3, 2, 1 and 21 per cent respectively. The end use energy activity of urban HH for cooking, lighting, heating/cooling, agro processing, animal food processing and other activities account to 51, 10, 10, 3, 8 and 14 per cent respectively (WECS 2005). In mountainous region, out of total HH energy consumption, cooking and space heating utilise 32 and 56 per cent respectively; the remaining 12 per cent is consumed for lighting, use of electrical appliances, water boiling and agro-processing activities. Likewise, energy consumption for cooking and space heating in hilly region is 40 and 36 per cent respectively; and the remaining 24 per cent is consumed for lighting, electrical appliances, water boiling and agro processing activities (CRT/N 2005).

1.2 Indoor air pollution (IAP) and its effect

Combustion is a complex sequence of chemical reactions of fuel and oxidant accompanied by the production of heat or both heat and light in the form of either glow or flames. Smoke which is a result of incomplete combustion depends on the type of wood or other biomass burning, the temperature of the fire, wind conditions, and more importantly 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 vapour (Ban et al. 2004) and the indoor concentration of such pollutants is established by the rates of their production and removal from the environment (Saldiva and Miraglia 2004). One of the four greatest risks causing deaths and diseases in the world's poorest countries is smoke from solid fuel combustion affecting more than two billion poor people (Warwick and Doig 2004).

The fine particles in smoke can go deep into the lungs and these particles alone or in combination with other air pollutants can cause pre-existing lung diseases to worsen. The technology to burn the solid fuels in three-stone or rudimentary stoves results in poor combustion efficiency with increased level of IAP. Poverty with availability of biomass at no monetary cost, lack of problem recognition by policy-makers, lack of funds at government level to address the problem, and inferior status of women and children in many poor communities are some of the major reasons for not receiving focal attention to IAP (Ballard-Tremeer 1997, cited by Bates et al. 2005).

IAP causes various health hazards 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 and cardiovascular diseases (Warwick and Doig 2004). The leading cause of human death and disability around the world are chronic bronchitis and 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 shown significant increase in the rate of lung and laryngeal cancers (Smith and Liu 1993, Clifford 1972 cited by Saldiva and Miraglia 2004). Homes of underdeveloped world have pollution level 100 times higher than the developed which possess serious ambient pollution issues. IAP causes catastrophic health problems especially in women and children (two groups that spend the most time indoors cooking and standing near fires) attributing to 1.8 million deaths per year - roughly three deaths in a minute (Ban et al. 2004). Of the total deaths, 56 per cent are children below five years (Bates et al. 2005). IAP kills more children annually than malaria or HIV/AIDS and claims nearly one million children's lives each year.

In regional and global scale, the adverse effects of unsustainable use of biomass fuel especially fuel wood is immensely contributing to global warming resulting in increased concentration of greenhouse gases (GHGs). This accounts to damages on the earth system including increase in average temperatures accompanied by change in rainfall pattern, vegetation pattern or extreme weather conditions collectively known as climate change. As large populations rely on biomass fuels for cooking in Asia and Sub-Saharan Africa, large GHG concentration has been traced in these areas. Likewise, in the North-Eastern United States, wood used for heating contributes to GHG emission (Bond et al. 2004). Burning of fossil fuels and extensive use of biomass are the major sources of GHG emission in Nepal. Increasing combustion efficiency or switching to cleaner energy sources are two possible ways to reduce GHG emission (Bond et al. 2004).

The major tasks of rural Nepalese women are to collect firewood, cook and care for their children and families. Because of continuous depletion of forest resources, women spend several hours a day on foot collecting fuel wood and are thus vulnerable to all kinds of risks including climatic and physical drudgery. In addition, spending hours cooking in poorly ventilated kitchens increases eye infections and other respiratory problems (Winrock 2004).

Limited information is available on indoor air quality in Nepal. A study in 18 villages by Davidson et al. (1986) revealed that the total suspended particle (TSP) in a room where firewood was used as fuel was 8,800 $\mu g/m^3$, and the levels of CO and N_2O were 21 ppm and 368 ppb respectively (WHO & Nepal Health Research Council 2002). The level of emission in Nepal is much higher than the national and international standards. The national ambient air quality standard for TSP and PM10 for 24 hour average in Nepal is 230 and 120 $\mu g/m^3$ respectively and 8 hour average CO standard is 10,000 $\mu g/m^3$ (MOPE 2001). The WHO guideline for PM concentration is 50 $\mu g/m^3$. Similarly, the standards for average CO concentration are 9 ppm for 8 hours, 26 ppm for 1 hour and 87 ppm for 15 minutes. The survey conducted in high hills of Nepal in 2001 by Practical Action found that the average concentration level of $PM_{2.5}$ in the hilly homes was 1264 $\mu g/m^3$ which is more than twenty times higher than that of Air Quality Standard set by WHO. In the same year, the levels of CO concentration were measured as 320 PPM and 195 PPM for 15 minutes average in winter and summer respectively which were also above the safe standard.

Hessen et al. also monitored 24 and 8 hours concentration of TSP and CO in 34 HHs in Jumla using traditional stove. It was found that the TSP concentration was 8420 and 5000 $\mu g/m^3$, and CO concentration was 13.5 and 23.42 ppm for 24 and 8 hours respectively (Winrock 2004).

Acute Respiratory Infection (ARI) is one of the leading causes of death in Nepal. The rural Nepalese children living in poorly ventilated conditions are 100 to 400 per cent more likely to suffer from ARI than children living in better indoor environment. Likewise, women who cook using biomass fuel are nearly four times likely to suffer from chronic bronchitis compared to their counterparts in developed nations (Ban et al. 2004). About 3.13 per cent people are affected by ARI with 22.8 per cent affected children in Nepal. IAP is one of the major causes of such high occurrence of ARI (http://www.moh.gov.np). Chronic bronchitis falls in eighth position amongst other diseases in Nepal. Pandey et al.(1987) examined 240 rural children less than two years of age for six months and found a significant relationship between number of hours spent near the fire (as reported by their mothers) and the incidence of moderate to severe ARI cases. A survey conducted in Jumla in 1981 revealed that the mortality rate in 0 - 1 year age group is one of the highest ever reported from anywhere in the world. The total mortality rate due to ARI was 488.9 per 1000, and 333.3 per 1000. It has been reported that one of the various reasons for high mortality rate could be respiratory related infections caused by IAP (Pandey 2003).

An epidemiological study conducted in 1979 in a rural community in hilly region of Nepal revealed a significant positive correlation between the prevalence of chronic bronchitis and average exposure time to IAP both amongst smokers and nonsmokers. A house to house survey in Sundarijal (north of Kathmandu) with a sample of 3,258 individuals showed that 12 per cent of the adults (>20 years) were infected with chronic bronchitis and 3.1 per cent were associated with emphysema. Similarly, 51 and 38 per cent of women had chronic bronchitis and emphysema respectively. The study also revealed that chronic bronchitis was three times more common in smokers than nonsmokers (Winrock 2004). A study carried out in four different areas of Nepal - urban Kathmandu representing urban areas; Sundarijal and Bhadrabas villages of Kathmandu district representing rural hilly region; Parasauni of Bara district representing plain region; and Chandannath of Jumla district representing mountainous region revealed the crude prevalence rate of chronic bronchitis at 11.3, 18.3, 13.1, and 30.9 per cent respectively (Pandey 2003).

The average life expectancy in Nepal is 62.6 years of age (UNDP, Human Development Report 2007/2008). Reduction in indoor smoke reduces respiratory related diseases which can help improve the life expectancy of people. Various organisations in Nepal are introducing different types of technologies to increase fuel efficiency. The invention of Improved Cooking Stoves (ICS), briquette burning technology and introduction to chimney and smokehoods along with the use of renewable energy technology, such as solar cookers and bio-gas has helped reduce indoor smoke considerably.

The negative effects on human health due to solid fuel burning is serious and commands extreme attention seeking substantial mitigation efforts from national and local governments. The reduced level of lethal smoke would lead to a healthier life for billions of people. Therefore public awareness regarding the health risks associated with prolonged exposure to smoke is crucial. Poor people are unable to switch to cleaner fuel, such as LPG, kerosene or biogas due to their economic conditions. The international community, UNDP, and a number of non government organisations including Practical Action are working directly with poor communities to find better solutions and scale up their efforts to get sufficient support and funding with high level international political backing.

1.3 Scope of the study

This study mainly focuses on the preparation of an inventory of innovative IAP reducing technologies that could be useful to organisations or individuals to get informed and make appropriate decisions. It is also expected that this documentation of inventory will help plan for new innovations for the future referring to these earlier inventions.

1.4 Objectives

The main objective of this study is to compile the information available on various innovative technologies to help support reduce IAP in Nepal.

The specific objectives of this study are to:

- Analyse the advantages and disadvantages of each innovative technology
- Analyse the effectiveness and efficiency of each technology with respect to acceptability, pollution reduction, fuel saving and time saving
- Identify and recommend appropriate technologies for different socio-cultural settings, climatic conditions, geography, fuel types and cooking behavior

1.5 Methodology

The study was carried out using primary as well as secondary information. For primary information, various organisations and people involved in development, promotion and dissemination of HH energy technologies were interviewed using formatted questionnaire. Similarly, various published and unpublished reports, technical manuals, bulletins and brochures were reviewed. The following methods were adopted to derive majority of information in this study:

- Relevant literatures mainly technical manuals/ publications related with traditional as well as innovative IAP reduction technologies were collected and reviewed. Some materials were also collected from websites. Likewise, description of the technology with detailed sketches, figures and photographs were collected and analysed
- Various stakeholders (I/NGOs, private sector, promoters of technologies, projects and programmes, government, academic/research institutions, manufacturers, etc) involved in promotion of smoke alleviating products were identified and interviewed
- Direct observation of technologies and users at the field conducted
- Analysed the prospects, constraints, effectiveness and efficiency (with respect to acceptability, pollution reduction, socio-cultural settings, weather, geography, cooking behavior and fuel and time saving) of each technology

1.6 Limitation of the study

This study is limited only to those HHs that use solid fuels such as firewood, cattle dung and agricultural residues as a source of energy for cooking and space heating. Due to a limited time, questionnaires were sent to organisations located outside Kathmandu valley because interactions with the respondents in some cases were not enough. Some problems identified at the field level could not be collected from organisations outside the valley as those organisations only supported local NGOs and did not possess adequate user level information. However, interviews, survey questionnaires and informal discussions were used to derive information as much as possible on various technologies as described in this report.

Chapter Two
INNOVATIVE TECHNOLOGIES IN NEPAL: A REVIEW

The Government of Nepal has launched National ICS Programme to achieve substantial reduction in IAP, increase fuel efficiency, decrease cooking time and reduction in deforestation. Likewise, to reinforce government's priority different organisations and institutions have developed and promoted various IAP reducing technologies in Nepal. The intervention of ICS made of mud bricks, metals, briquettes, chimneys and smokehood technologies are identified as some of the most successful technologies in reducing IAP at HH level particularly for those using firewood and agricultural residues for cooking and heating. As majority of the rural HHs do not have options to substitute biomass fuel, the appropriate technological intervention for efficient use of biomass based energy has become very important for sustainability. However few prominent renewable energy technologies - biogas and solar cooking are promoted and disseminated as an alternative to solid biomass energy. The biogas technology is very successful in Nepal. This study depicts the importance of biogas and solar cooking technologies as an alternative to biomass energy.

In summary, this study is a compilation of various technologies developed and promoted with the objective of reducing IAP and finding alternatives for efficient fuel use in rural HHs of Nepal. The technologies are:

- Improved Cooking Stoves (ICS)
    - Mud-brick ICS
    - Metal ICS
- Briquette
- Smokehood
- Solar cooking
- Biogas

Chapter Three
COOKING STOVES

In Nepal, large segment of population still depend on simple and primitive energy resources in HHs and rural industries. The use of biomass energy in HHs and small industries have resulted in IAP induced diseases and polluted the atmosphere. For example, comparative monitoring study conducted by Nepal Environmental and 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 HHs had 6.0 and 2.4 times greater levels of PM10 concentration than LPG and kerosene burning houses respectively (MOPE 2001).

ICS was first introduced as Hyderabad smokeless stove in a Bikas Pradarshani (exhibition) in 1956 held at Bharatpur, Chitwan. A multi-pot stove developed in India was of high mass, shielded fire and had a chimney to let smoke out from the kitchen. The stove also had adjustable metal dampers to regulate the fire. Further dissemination of ICS only started in early 70s, when main emphasis was on improving fuel efficiency to prevent deforestation. During the time, Women's Training Centre (WTC) promoted Lorena stove, a large mud stove with a number of rings. WTC provided Lorena stove construction training to women. In late 70s, RECAST was involved in improving these stoves and renamed them as Nepali chulo.

Traditional HH stoves

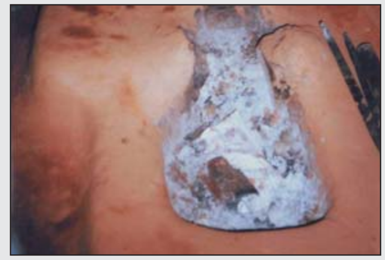

Three-stone cook stove


Chulo


Agena (tripod)


Three-stone cook stove


Bhuse stove


One pothole stove


One pothole stove


Two potholes mud-stone stove


Three potholes stove

Traditional institutional stoves

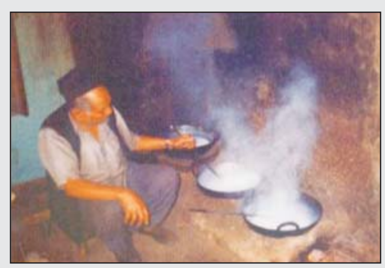

One pothole stove in *Terai*


One pothole stove


Two potholes stove


Two potholes stove


Two potholes stove


Khuwa making stove


Lapsi stove


Bread making stove


Two potholes and tandoori stove

Photograph 3.1: Traditional cook stoves in Nepal

Source: CRT/N 2006

Detailed scientific assessment of cook stove performance in terms of combustion efficiency and design methodology began in early 80s, after the government included ICS in its sixth five-year plan. Ceramic insulation and double wall stoves replaced the Lorena and other mud stoves initiated by RECAST, funded by government and other agencies like UNDP and FAO. Community Forestry Development Project (CFDP) distributed a large number of ICS in rural areas of Nepal. Agricultural Development Bank introduced ceramic cook stoves and the new Nepali *Chulo* with support from UNICEF. Likewise, Earthquake Rehabilitation Project also constructed large-scale HH mass mud/stone stoves in the eastern part of Nepal during late 80s.

The history of ICS development in Nepal reveals that various international donors had a strong influence for ICS promotion. These donor led ICS programmes could not address the real needs of various users due to lack of long-term development objective, institutional arrangement and development of human resources as required. As a result, ICS programmes could not sustain without continued external funding support.

New initiatives for ICS dissemination started during the 90s, where locally adaptive stoves built from cheaper and easily available local materials were promoted. The study of SECCON (2000) revealed that the ceramic insulated stove; double wall stove; new Nepali *chulo* (UNICEF Model); improved Tamang stove; mud/brick stove; two potholes raised mud/brick stove; RECAST mud stove; and smoke recyclable stoves were some types of pottery liner stoves disseminated until the 90s. At present, the sun dried mud-brick stoves are cast on site by trained stove promoters, however during the inception; it was initially made with mud and stone with burnt clay pipe chimney. Among the various models, Tamang stove (two potholes) is widely used in the hilly areas because of its high acceptability and demand based approach.

In Nepal, the simple and primitive metal stove (inverted U type) was also used in the past. The history of *bhuse chulo* began in 80s. Few CRT model metal stoves were disseminated in late 90s. The metal rocket stoves intervention was started in 1996 but its promotion began only in 2003. Foundation for Sustainable Development (FoST) was actively involved in promotion/dissemination of rocket stoves. Since late 90s Jumla design smokeless metal stoves are promoted in Jumla, Humla and Mugu. It is also promoted in some mid hills of Kaski. At present various types of *bayupankhi* (air induced) metal stoves is promoted/disseminated in peri-urban and urban areas of Nepal.

3.1 National ICS programme

The ninth five-year plan (1997-2002) provided policy guidelines to encourage development and application of energy saving devices as well as promotion and dissemination of efficient alternative energy technologies. Consequently, National ICS Programme (NICSP) was launched in 1999 with support from Energy Sector Assistance Programme (ESAP). The programme is implemented through Alternate Energy Promotion Centre (AEPC) which is the coordinating body of Government of Nepal for the promotion of renewable energy technologies. The general objective of NICSP is to establish a sustainable framework and strategy to avail technically and socially appropriate ICS in rural communities based on local capacity building and income generation. In the tenth plan (2002-2007), development and promotion of ICS was further emphasised. The NICSP was first initiated in five mid-hill districts promoting various models of mud-brick ICS. It now covers more than 40 mid-hill districts and is planning to expand further to cover the remaining high hills as well as the *Terai* districts. Since the initiation of ESAP Phase II from April 2007, the scope of ICS component has also been widened to cover other biomass energy technologies/solutions (other than mud-brick ICS) like metallic ICS, biomass briquettes and gasifier. Within the current interim plan (2007–2010), the government plans to build 300,000 ICS along with the development and promotion of other biomass energy technologies.

The major activities of AEPC/ESAP NICSP include:

- To develop and distribute appropriate Information, Education and Communication (IEC) materials to the relevant organisations, programme and national institutions
- To identify the partner organisations and technical service providers at central and local level, to organise training of trainers (TOT) on ICS and technical training for district level development organisations
- To identify organisations and institutions to conduct adaptive and participatory research on biomass energy technologies, and establishment of national level biomass forum

It is estimated that until now AEPC/ESAP has promoted more than 200,000 mud-brick ICS. Besides AEPC/ESAP, various other I/NGOs, CBOs are also promoting and disseminating ICS. Since the Phase I of ESAP, 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) are identified as service providers for the facilitation of National ICS programme. With the expansion of NICSP coverage, some additional NGOs namely, REDA, BNA, RDSC, REMREC, RESDTN, and RDSC are also responsible for providing the services. The ICS programme is implemented through district based local partner organisation (LPO) identified by service providing organisations. The Regional Renewable Energy Service Centre (RRESC) of AEPC/ESAP facilitates the training and disseminates information for partner organisations. The institutional linkage of NICSP to AEPC/ESAP is shown in Figure 3.1.

29.8, 30.5 and 9 per cent respectively. Users shifting to ICS benefited by less time spent cooking (23 minutes a day), reduced levels of smoke (which ultimately reduces the expenditure on health by NRs. 463 per HH), firewood saving (23.5 percent), easy cooking and clean kitchen environment (non-hazy environment, good lighting, and less soot on walls, floor and ceiling). During the field monitoring visit, 99.7 per cent of ICS were in operation with 91.1 per cent in daily use. Among all the users 73.6 per cent ICS users were satisfied with the stove's performance. ICS users also used their saved time from cooking for other income generating activities.

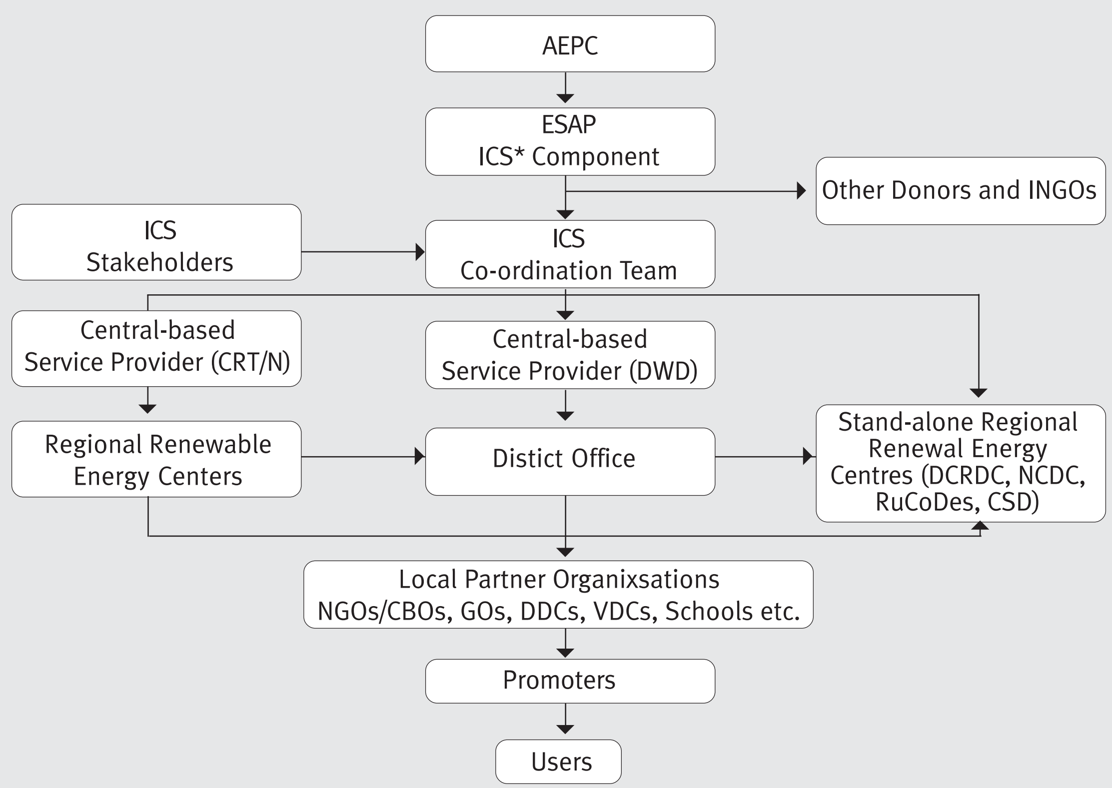


Figure 3.1: NICSP implementation modality and organisation linkage chart Source: AEPC/ESAP 2006

The objectives behind the innovation of mud-brick ICS and metal stoves are to improve the health of rural people by reducing IAP, fuel wood consumption, dependency on forest resources for domestic energy consumption, cooking and fuel-wood collection time, drudgery of rural women and improve sanitation by involving rural people with income generating activities.

The implementation of ICS programme replaced the tripod, three stone and traditional mud stove users by

Pandey et al. (1987) monitored 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 HHs with traditional stoves (without chimneys) and ICS in rural hilly region of Nepal. The monitoring was conducted between November 1986 and March 1987. It was found that the level of concentration of RSP, CO, HCHO was 8,200 µg/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 μg/m^3, 10.8 ppm and 0.6 ppm for ICS respectively. Ried et al. (1986) compared the concentration level of CO and TSP of traditional stoves without chimneys and ICS with chimneys in middle hill districts of Nepal. The data in table 3.1 clearly depicts that exposure of RSP, CO and TSP is significantly reduced with the use of ICS compared to traditional ones.

In order to reduce IAP, construction of better ventilated rooms is also 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 *agena* (traditional cooking stoves) and ICS was 3920 μg/m^3 and 1130 μg/m^3 respectively. Similarly, mean personal exposure to CO in traditional and ICS was 380 ppm and 67 ppm respectively, which implies that ICS reduces indoor TSP and CO concentration by 71 and 82 per cent respectively (Raut 2006).

HHs were relieved from problems and diseases caused by smoke. The overall positive impact on health reduced the medical expense by 75 per cent. The average ICS operating hours in these districts were 3.7 hours (TRUST 2004). The cost of useful heat per MJ (considering 1 kg of fuel wood = 16.5 MJ) in ICS ranges from NRs. 0.37 to 0.44 compared to NRs. 0.95 in traditional 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 when using kerosene (SECCON 2000). Field test in Dalchoki VDC of Lalitpur district further proved that use of ICS saved 20 - 25 per cent fuel wood compared to traditional stove (WP/ IDC/ Sulpiya 1997 cited by SECCON 2000).

3.2 Mud-brick improved cooking stoves

During the dissemination of ICS, NICSP mainly focused on developing public awareness on health impact caused by IAP. There is no direct subsidy for ICS users. ICS users receive training, promotional and information materials

Table 3.1: 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 TSP	280 ppm 3170 μg/m^3	70 ppm 870 μg/m^3	75 73	Reid 1986
Beni	CO TSP	310 ppm 3110 μg/m^3	64 ppm 1370 μg/m^3	79 56	Reid 1986
Mustang	CO TSP	64 ppm 1750 μg/m^3	41 ppm 920 μg/m^3	36 47	Reid 1996
Bardibas	CO TSP	82.5 ppm 8200 μg/m^3	11.6 ppm 3000 μg/m^3	86 63	Pandey 1990

Source: SECCON 2000 (cited from Sharma 1995)

The impact study report on effectiveness of ICS programme in Doti, Dang, Kavre, Udaypur, Ilam, Kathmandu, Syangja, Baglung, Surkhet, Sindhuli and Dadeldhura revealed that 90 per cent HHs used two potholes mud-brick ICS. In Dadeldhura, 48 per cent were found using one pothole stove. Three potholes mud-brick ICS were found sparsely in Sindhuli, Baglung and Surkhet. About 65 per cent stoves were found near window, whereas, 23 per cent were found near the door. In Ilam, stoves were found separately placed in a shed. The report also revealed the promoter's vital role (70 per cent) in the adoption of ICS followed by their neighbour's inspiration (18 per cent). All users were provided with the information on repair and maintenance and 59 per cent were provided with user manual. As per the expectation of ICS, 90 per cent reported saving time (fuel wood collection and cooking time) and majority of

as indirect subsidy. The mud-brick ICS is installed by trained ICS local promoters on request from the user as per his/her preference - one, two or three potholes with different sizes. The trained promoters are paid by end users. The efficiency of traditional and mud-brick ICS normally varies from 6 to 10 per cent and 12 to 20 per cent respectively and the reasons for variation in efficiency are deviation in construction of ICS from design, and also the type and moisture content of fuel. *(Dr. Riddhi Bir Singh, Associate Professor and Coordinator, Bio-fuel studies, Institute of Engineering, Tribhuvan University)*.

The materials required to build the mud-brick ICS stoves are - soil (*chimtyayelo*, i.e. sticky soil), rice husk, dung and water. Soil, dung and rice husk are mixed in proportion of 5:1:2 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 before casting bricks. The prepared paste is then put 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 starts with preparation of bricks and soil paste. Soil paste is used to join the bricks and to fill up the small opening to make it air tight. A layer of stones is fixed on the floor and a gap of two inch is maintained between the kitchen wall and stove wall. The gap is filled either with husk or ash for insulation. Metal plate or metal rods/rings is placed around the pothole for additional strength to prevent the stove from cracking while cooking.

The outlet of the chimney, which is usually made of metal (varying in shapes and sizes) is extended outside through the hole of the kitchen wall. The chimney height is maintained at 5 feet because longer chimney sucks the flame and hot air thereby reducing the eifficiency of the stove and the shorter chimney cannot create sufficient draft. During construction, a small hole is made on the stove at chimney side to remove soots deposited in the chimney. Chimney should be bend free to prevent pressure loss and ensure proper draft.

Chimney should be cleaned off from soots at least once in 15 to 25 days. 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 kitchen window should face the wind direction for proper combustion as well as removal of smoke from the kitchen as shown in Figure 3.2. Various types of mud-brick ICS are described below.

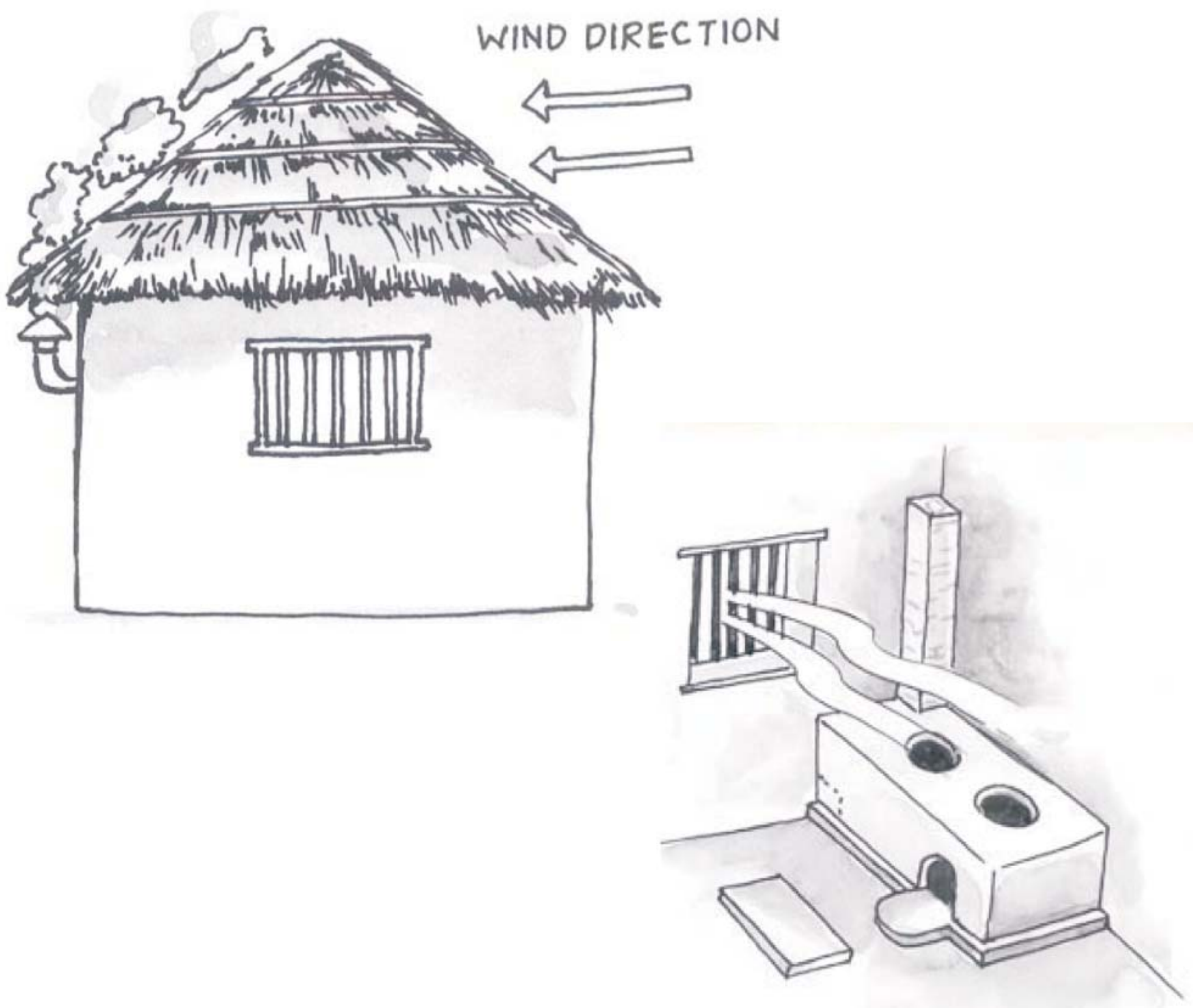


Figure 3.2: Kitchen design consideration

3.2.1 One pothole ICS

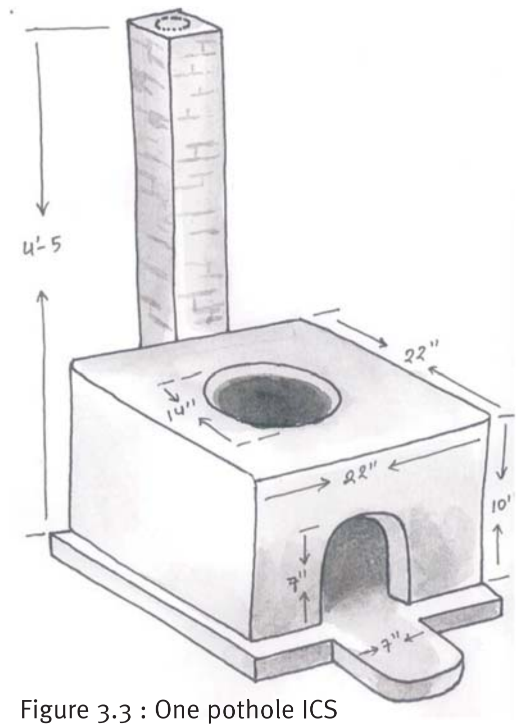


Figure 3.3 : One pothole ICS
Source : AEPC

Year of dissemination	Early 1990s onwards
Cost	NRs. 150 to 200 (but varies with size and base construction)
Quantity disseminated	Around 20,000
Technological description	Simple design
Disseminated regions	Disseminated in mid hills as well as in *Terai*. Though accepted in *Terai*, model adaptation is needed because majority of HHs have thin wall and thatched roof. It is also common to cook outside in some districts of *Terai*, in those places; model is suitable without any modification.
Advantages	Flexibility in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Can be used extensively for cooking including kundo (animal feed). Bigger stove can be used to cook food for large number of people by constructing pothole with larger diameter.
Disadvantages	Constructed only by trained promoters and not available in the market. Time consuming because of one pothole. Not suitable for space heating.
Major organisations involved in promotion/dissemination	NICSP of AEPC/ESAP with support from GOs, I/NGOs and CBOs.

3.2.2 Two potholes ICS

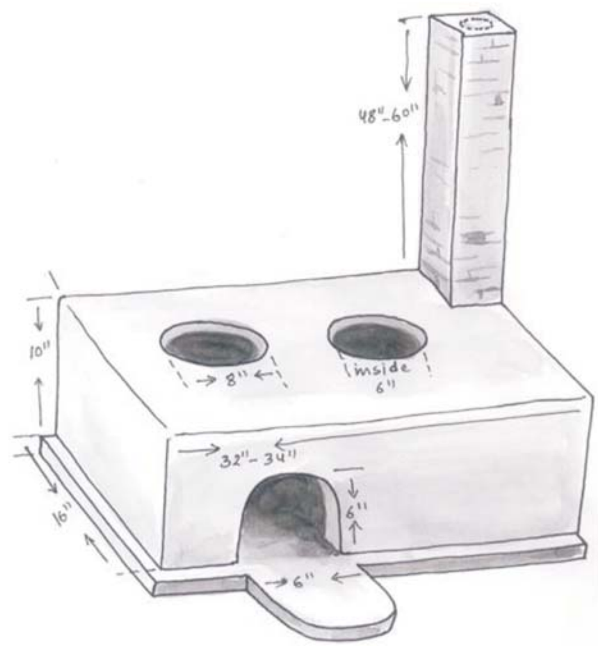


Figure 3.4 Two potholes (Tamang) ICS

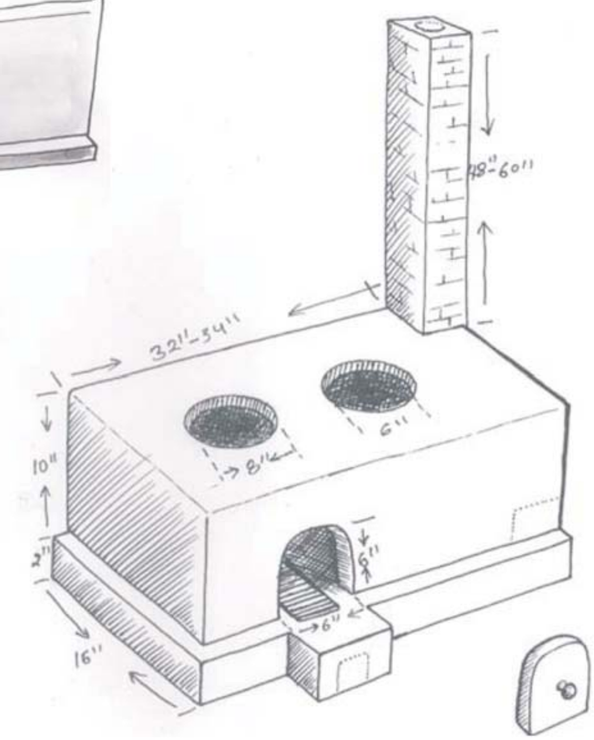


Figure 3.5 Two potholes ICS with raised second pothole

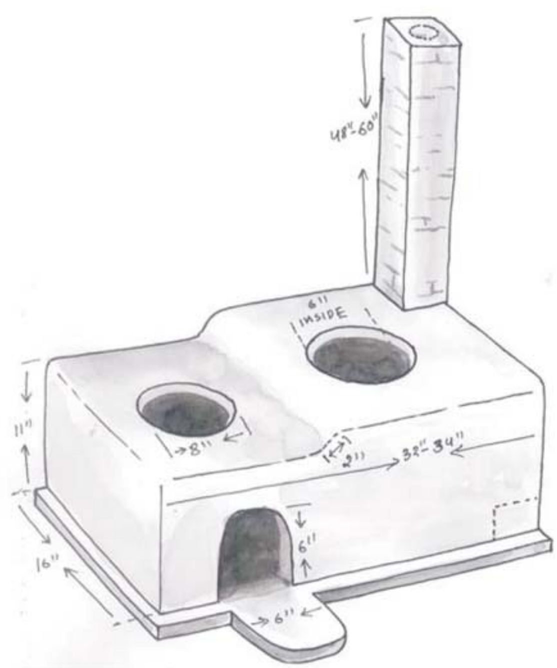
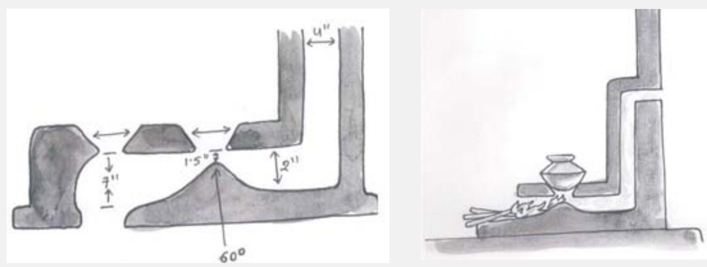
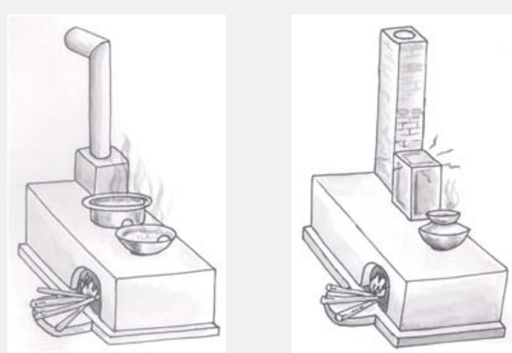
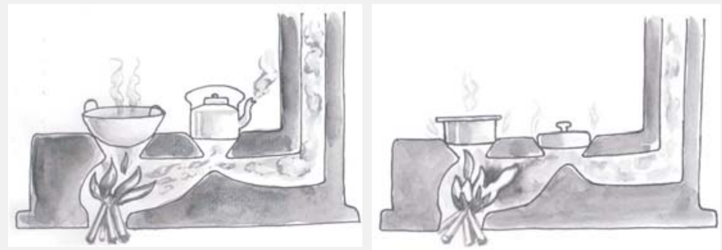


Figure 3.6 Two potholes ICS with grate
Source : AEPC

Year of dissemination	Early 90s onwards
Cost	NRs. 150 to 250 (but varies with size, base construction and geographical location)
Quantity disseminated	More than 200,000 from 2000 onwards were disseminated after improvement in chimney and combustion chamber (by NICSP supported by ESAP and coordinated by AEPC). The second pothole raised model is more accepted because of better combustion and suitability for using two bigger pots. These types of stoves cover more than 85 per cent of total disseminated mud-brick ICS.
Technological description	These stoves have only one fuel inlet below the first pothole. A baffle is used at 60º to the horizontal and its peak point lies just below the second pothole so that the flame and hot gas is directed to the bottom of the second pot. The construction of baffle is shown in Figure 3.7.  Figure 3.7: Baffle in two potholes mud-brick stove Two potholes stove with grate facilitates increased combustion efficiency with proper air circulation (air is pre-heated before reaching to the fuel). The provision of grate makes the stove more suitable to use agricultural residues and facilitate ash collection. It is recommended to rotate pots while cooking to prevent smoke leakage. Metal chimney can also be used in mud-brick stoves. In temperate climate, metal tin is placed in the second pothole for space heating. Figure 3.8 shows ICS with metal chimney and use of metal tin for space heating.  Figure 3.8: Metal chimney and use of tin for space heating If rear pothole is not used for cooking/heating, it is advisable to use this pothole for water heating or to cover it as shown in Figure 3.9.

	 Figure 3.9: Use of two potholes stove
Disseminated regions	Very well accepted in mid hills. Though accepted in *Terai*, model adaptation is needed because majority of the house have thin wall and thatched roof. In *Terai*, the stove with grate is more accepted because of its appropriateness to burn agricultural residues.
Advantages	Flexible in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Time saving because of two potholes compared to one pothole stoves (two items can be cooked at a time).
Disadvantages	Constructed only by trained promoters. Not available in the market. Not suitable for space heating unless a metal chimney or a tin box is used which can be expensive. Sometimes back draft from the chimney may occur. Not portable
Major organisations involved in promotion/dissemination	NICSP of AEPC/ESAP with support from GOs, I/NGOs and CBOs.

3.2.3 The second pothole raised two potholes ICS at waist height

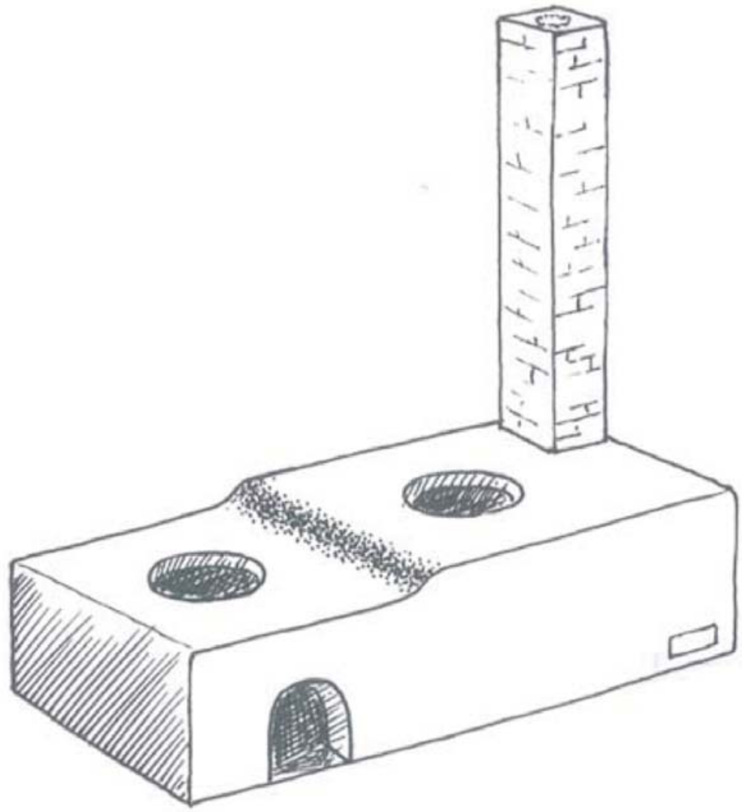


Figure 3.10: The second pothole raised two potholes ICS at waist height Source: AEPC

Year of dissemination	Early 90s onwards
Cost	NRs. 150 to 250 (but varies with size, base construction and local wage rates).
Quantity disseminated	Few
Technological description	Similar to the second pothole raised two potholes stove.
Disseminated regions	Mid hills as well as in *Terai.*
Advantages	Flexible in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Time saving because of two potholes. Easy to repair and maintain. Relieves from back pain.
Disadvantages	Constructed only by trained promoters and not available in the market. Not suitable for space heating.
Major organisations involved in promotion/dissemination	NICSP of AEPC/ESAP with support from GOs, I/NGOs and CBOs.

3.2.4 Three potholes multipurpose ICS

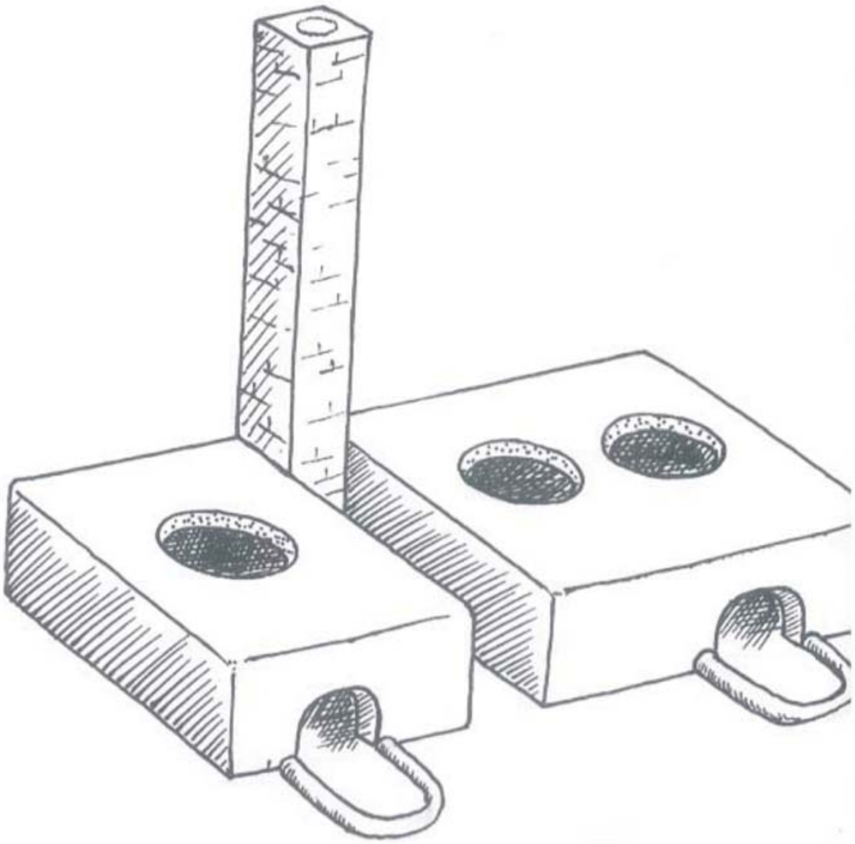


Figure 3.11: Three potholes multipurpose ICS Source: AEPC

Year of dissemination	Early 90s onwards
Cost	NRs. 150 to 250 (but varies with size and base construction)
Quantity disseminated	Few
Technological description	NA
Disseminated regions	Mid hills as well as in Terai, especially in mid hills. The third pothole is used to burn charcoal for heating purpose.
Advantages	Flexibility in design (stove and pothole size), low cost, easy construction and smoke removal from kitchen. Higher efficiency and 40 per cent fuel wood saving and time saving compared to traditional fuel wood stoves.
Disadvantages	Constructed only by trained promoters and not available in the market. Not suitable for space heating.
Major organisations involved in promotion/dissemination	NICSP of AEPC/ESAP with support from GOs, I/NGOs and CBOs.

3.2.5 Three potholes institutional ICS (IICS)

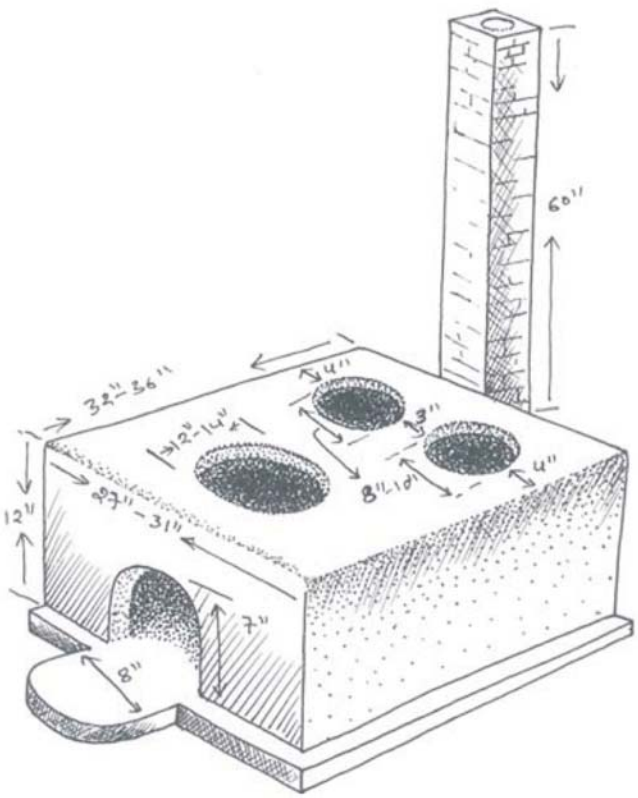
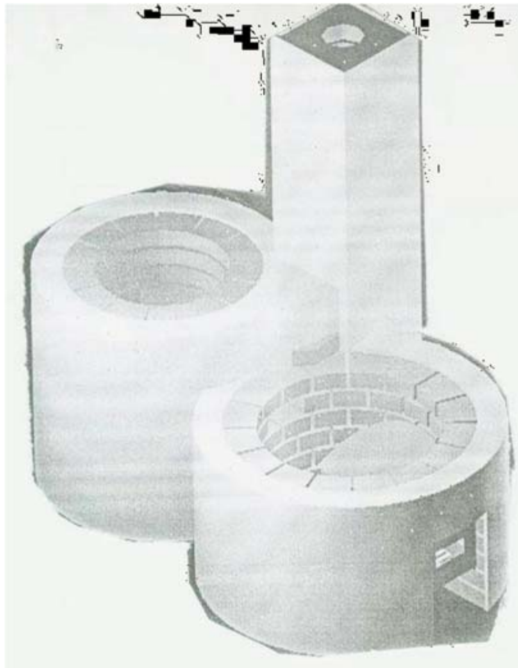


Figure 3.12: Three potholes institutional ICS Source: AEPC

Year of dissemination	Early 90s onwards
Cost	NRs. 250 to 700 (varies with size and base construction)
Quantity disseminated	Around 1000
Technological description	A grate is placed in the first chamber and two horizontal bars which serves as top grate and support for smaller diameter pots. In order to fit the pots larger than the pothole diameter, pot rests are recommended. Efficiency varies from 15 to 25 per cent.
Disseminated regions	Terai and especially in mid hills.
Advantages	High efficiency and fuel saving (35-40 per cent). Cooks three items at a time, suitable in restaurants and institutions (barrack, hostels, roadside hotels etc). Saves 20 to 30 per cent fuel wood compared to traditional stoves.
Disadvantages	Only trained promoters can construct. Not suitable for space heating.
Major organisations involved in promotion/dissemination	CRT/N, REDP and some other organisations.

3.2.6 ESAP model institutional ICS



Photograph 3.2: Two potholes IICS Source: AEPC

Year of dissemination	2004 onwards
Cost	NRs.7000
Quantity disseminated	175
Technological description	This stove is made of special mud-brick iron pot rings on both potholes constructed to fit the cauldron tightly. The diameter of first and second pothole is 56 and 33 cm respectively. About 80 per cent heat is produced in the first hole while remaining 20 per cent is 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 a gate at fuel entrance made of mild steel. The gate is used to regulate the draught and air supply for efficient combustion.
Disseminated regions	In four pilot district schools - Jajarkot, Surkhet, Salyan and Makawanpur which have a day-meal feeding programmes.
Advantages	High efficiency and fuel saving. Fire can be extinguished whenever needed.
Disadvantages	High cost and unavailability in the market. Single pot cooking is expensive.
Major organisations involved in promotion/dissemination	Disseminated by AEPC/ESAP through CRT/N, Sundar Nepal Sanstha and other local NGOs in Surkhet, Jajarkot, Salyan and Makawanpur.

3.2.7 Lapsi stove

Photograph 3.3: Lapsi stove   Source: AEPC

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 41x39.2x18 inches. The construction materials 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 pasted inside the combustion chamber to repair cracks. The half sunk pot is usually made up of half cut kerosene drum. Fuel (Lapsi seed) is fed through a hollow metal tube.
Disseminated regions	Sanga and Kavre districts because of abundant production of *Lapsi*.
Advantages	Highly efficient and fuel saving.
Disadvantages	Not available in the market. Especially designed to use with Lapsi seeds, so it may not be suitable to use with other types of fuel material.
Major organisations involved in promotion/dissemination	RECAST, Practical Action and CRT/N.

3.2.8 Mud rocket stove

Photograph 3.4: Mud rocket stove Source: CRT

Year of dissemination	Still in demonstration phase
Cost	About NRs. 300
Quantity disseminated	NA (only few demonstration in Makawanpur, Dhading and Nuwakot districts)
Technological description	This demonstration model was built by CRT/N with 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 12x12x30 cm and 10x12 cm respectively. The efficiency is about 25 per cent (CRT/N, 2006).
Disseminated regions	Mid hills and *Terai*.
Advantages	No chimney but less smoke.
Disadvantages	Requirement of smaller pieces of fuel and can cook only one item at a time. Not suitable for smaller sized pots.
Major organisations involved in promotion/dissemination	Still under demonstration.

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

Suitability of different models of stoves depends on geographical areas and climatic conditions. Therefore, efforts must be made to match the specific needs of geographically diverse group of people. From the above findings, it can be concluded that the raised two potholes stove with grate are more suitable in mid hill regions of Nepal as it is neither too hot nor too cold. Acceptance of two potholes stoves with grate in the combustion chamber are high in *Terai* as people burn substantial amount of agricultural residues. Single pothole and rocket type mud-brick stove is also suitable in *Terai*. However, design adaptation is necessary for *Terai* because majority of houses have thin walls and thatched roofs.

In general, the dissemination of mud-brick ICS is very successful due to the following reasons:

i Government and donor support for raising awareness, training, demonstration and programme implementation
ii Training provision to the promoter and demonstration on advantage of chimney and ICS as a whole
iii Acceptability in a typical kitchen of a rural HH
iv Flexibility to construct in various forms (one, two or three potholes) and sizes according to the user's preference
v Local artisan or trained personnel can construct ICS using locally available material
vi Active participation of local NGOs, CBOs, VDCs and LPO for dissemination
vii Low construction cost (NRs. 150 to 250), easy construction, operation and maintenance
viii More efficient (12 to 20 per cent) compared to traditional stoves (6 to 12 per cent),
ix Reduction of IAP, which ultimately reduces eye irritation, ARI, COPD, infant mortality and other diseases
x Reduction of deforestation through efficient use of fuel wood (25 to 40 per cent fuel saving compared to traditional stoves), and
xi Reduction in cooking time (0.5 to 1 hour per day) as two items can be cooked at a time

However, there are still some difficulties in the effective implementation of ICS due to various reasons such as:

i Health risk associated with IAP, fuel and time saving is not a priority for users due to lack of awareness
ii Beliefs in reducing the pest and termite effects from smoke
iii Inconvenient to use large pots (unsuitable for agro-processing and alcohol brewing)
iv Requirement of different design for different climatic and geographical regions. For instance, unsuitability of mud stove for space heating in cold regions
v Tunnel, baffle, fuel exit hole, chimney height and pot rings are not well maintained by users resulting to increase in IAP
vi In some rural HHs, kitchens are either in the attic or first floor and in some Rai communities, stoves are constructed in the middle of a kitchen (or *aangan*), making it difficult to construct a chimney
vii The promoted ICSs are different than the traditional stoves which sometimes faces adoption problem due to discomfort while using it
viii Most of the programmes are executed on project based approach rather than market based approach so commercialisation of the product is rare
ix Lack of coordination among promoters
x Migration of trained promoters, especially for women due to remoteness of villages
xi Lack of adequate monitoring of ICS use and its performance

3.3 Metal stoves

The major advantages of the HH metal stoves are smoke alleviation/reduction and fuel saving which ultimately reduces biomass consumption through efficient combustion. On the contrary, it is time consuming to prepare small and consistent fuel woods as small pieces dry faster compared to big sized fuel woods which leads to better combustion. The efficiency of metal stoves is 18 to 32 per cent higher compared to traditional and improved mud stove. The reasons for variation in efficiency are deviation in construction of stove from design, type and moisture content of fuel, various types of metal stoves disseminated in Nepal are discussed below:

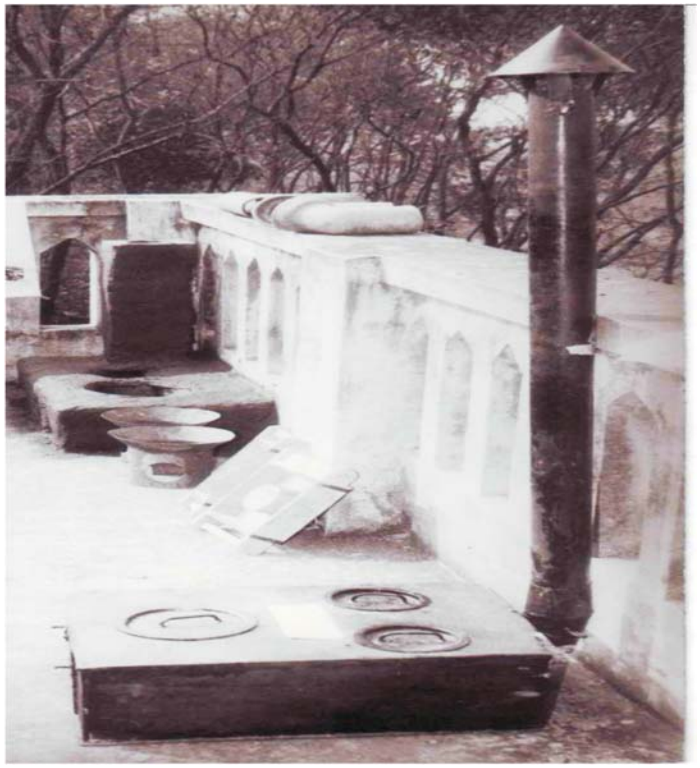
3.3.1 Jumla design smokeless metal stove

Photograph 3.5: Jumla design smokeless metal stove Source: CRT

Year of dissemination	1998
Cost	About NRs. 7500 (manufacturing and transportation cost attributes to NRs. 3000 to 4500 respectively) but cost is subsidised to farmers for NRs. 2500.
Quantity disseminated	3000 in Jumla, Humla and Mugu through Karnali Community Skill Training Project and presently through a local NGO - RIDS - Nepal. 1500 in mid hills of Kaski.
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. Stove wall is made of 1.5mm MS sheet and its cooking top surface is made with 4mm thick MS sheet. It weighs about 40kg. The stove has three potholes along with a slot for baking roti. Also, a nine litre capacity stainless steel tank is attached in chimney for water heating. Bottom of the stove is filled with double mud to prevent heat loss. Adjustable air vent in the main door allows regulation of draught air for combustion and damper in the fuel pipe is used to transfer heat efficiently towards the cooking pots. The average cooking efficiency may vary from 14 to 22 per cent. Life expectancy is 15 years and is suitable for use above 2000 m altitude.

	This model has been further improved in Mechanical Department, Kathmandu University as KU 1 and KU 2 stoves.
Disseminated regions	Jumla, Humla, Dolpa and mid hills of Kaski. The design was based on available local resources, food availability and eating habits of high altitude communities.
Advantages	Cooks three items at a time and bakes bread too. Good for water heating and space heating. Suitable for seven member family size. Fuel wood consumption is 40 per cent lower compared with other locally available traditional stoves. Appreciation and request from the villagers and donor support are some of the major reasons for wider dissemination of this technology.
Disadvantages	Heavy, expensive and fabrication is possible only in metal workshops.
Major organisations involved in promotion/dissemination	Mechanical Department, Kathmandu University (KU).

3.3.2 CRT promoted metal stove



Photograph 3.6: CRT promoted metal stove Source: CRT/N

Year of dissemination	1994/95
Cost	About NRs. 4500 in 2000/01
Technological description	This stove has three potholes, one in the front and two in the rear. The size of the front larger pothole is 28 cm in diameter and the rear smaller potholes are 15 cm each. The thickness of wall and top which is made of mild steel sheet is 2 and 4 mm respectively. It has a chimney to create draft and for smoke exit. Efficiency may vary from 14 to 22 per cent.
Disseminated regions	Jumla, Humla, Dolpa and Kalikot are colder climatic regions where metal stoves also function as space heaters.
Advantages	Cooks three items at a time. Effective for space heating.
Disadvantages	Heavy and expensive. It can be fabricated only in metal workshops which are usually not available locally.
Major organisations involved in promotion/dissemination	ACAP, CRT/N, CECI CSD and other I/NGOs.

3.3.3 WWF and SNV promoted metal stove

Photograph 3.7: WWF and SNV promoted metal stove

Quantity disseminated	12 in Dolpa and 12 in Solukhumbu.
Technological description	This stove has two potholes in series, one larger than the other. The diameter of the larger pothole in the front is 25 cm and the smaller pothole is 20 cm. The thickness of wall and top is 2 and 3 mm respectively. It has a chimney to let smoke out. Efficiency may vary from 29 to 39 per cent.
Disseminated regions	Karnali and Sagarmatha region.
Advantages	Cooks two items at a time. Effective for space heating. Collapsible and easily assembled with a metal chimney (assembly manual is also available). Light weight and low cost.
Disadvantages	Fabricated only in metal workshops which are usually not available locally.
Major organisations involved in promotion/dissemination	WWF, SNV, STARIC/N.

3.3.4 Bayupankhi (air induced) stoves


Fan at side


Front view


Side view


Front view


Back view

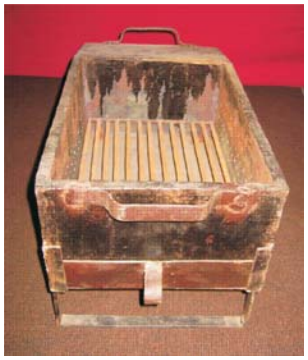
Photograph 3.8: Bayupankhi stove Source: CRT/N

Year of dissemination	2003 - initially promoted by Sindhu Urja Kendra (P) Ltd. (the patent right holder).
Cost	Varies from 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 with metallic sheets and have double walls with 3cm air gap in between. The inner wall has perforations for distribution of air in the combustion chamber. 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 to the fan to supply primary and secondary air and can be operated by using a battery. Fans are sometimes connected to 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 a fan located at the bottom of the stove, glass wool is placed in the lower portion of base as an insulation to prevent fan from overheating and burning. Because of its efficient combustion, it consumes less than 1 kg of fuel wood to prepare a meal for five to six persons. The efficiency of this type of stove ranges from 25 to 30 per cent. Big sized 'Jumbo bayupankhi stove' is suitable for larger institutions.
Disseminated regions	Urban and semi-urban areas.
Advantages	Highly efficient, portable and fast cooking. Significant smoke reduction compared to traditional stoves.
Disadvantages	Requirement of smaller size fuel materials and electricity to operate the fan.
Major organisations involved in promotion/dissemination	Private companies and local workshops.

3.3.5 Bayupankhi barbecue stove

Front view



Ash removal tray

Fan place

Photograph 3.9: Bayupankhi barbecue stove

Source: Sindhu Urja Kendra

Year of dissemination	2003 - Initially promoted by Sindhu Urja Kendra (P) Ltd. the patent right holder.
Cost	Varies from NRs. 1250 to 5000 depending on its size.
Quantity disseminated	Around 7000.
Technological description	This is a rectangular shaped stove fitted with metal bars to hold fuels. It has a fan and a ash removal tray slot in two opposite sides.
Disseminated regions	Urban and semi-urban areas.
Advantages	Uniform heating. Can be used with fuel wood, charcoal, briquette and agricultural residues.
Disadvantages	Requirement of smaller size fuel materials and electricity to operate the fan.
Major organisations involved in promotion/dissemination	Private companies and local workshops.

3.3.6 Rocket stove

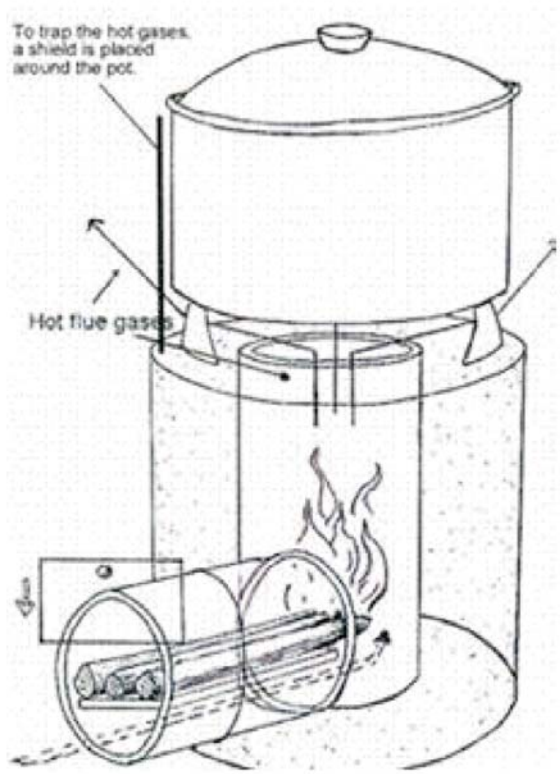
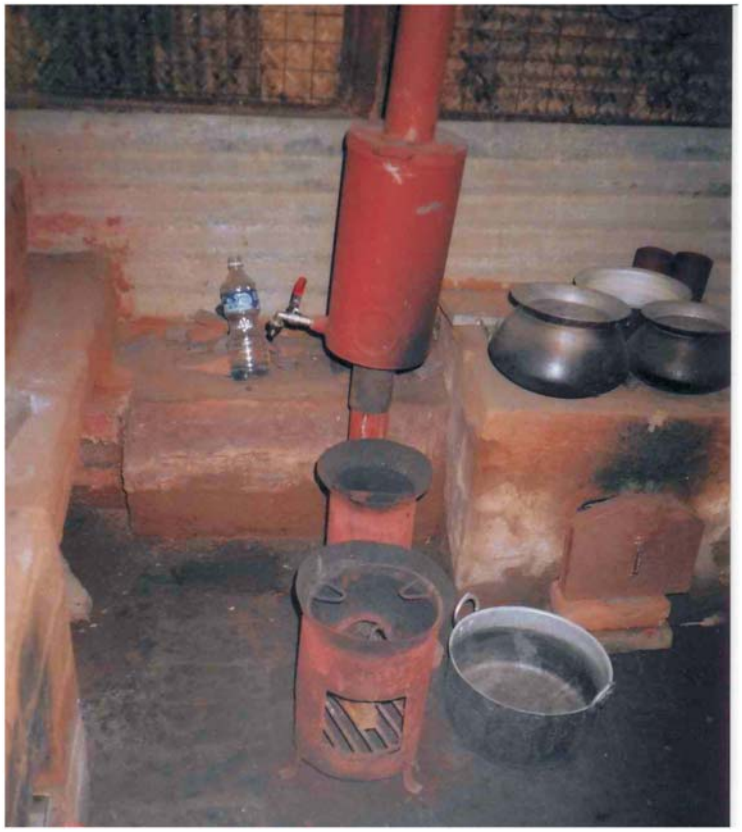


Figure 3.13: Rocket stove Source: htpp://members.efn.org/~apro/AT/attitlepage.html

Year of dissemination	2003
Cost	NRs. 1200 to 1500
Quantity disseminated	Few
Technological description	This is usually an ash insulated double wall metallic stove which can be built from tin cans or metallic bucket. Elbow style is one of the key designs of this stove which can be constructed from metal pipe or 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 varies from 25 to 30 per cent.
Disseminated regions	High hills.
Advantages	Portable, low emission and good combustion.
Disadvantages	Requirement of smaller size fuel material. Expensive and requires metal workshop for fabrication.
Major organisations involved in promotion/dissemination	FoST, CRT/N.

3.3.7 CRT/N DK model stove

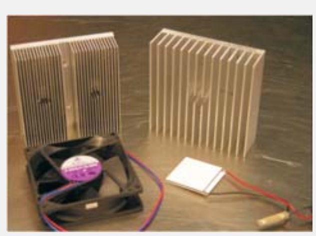


Photograph 3.10: CRT/N model DK metal stove, 2006

Year of dissemination	NA
Cost	NRs. 2500
Quantity disseminated	Very few (manufactured only on demand/request).
Technological description	Two potholes with water jacket are retrofitted in the metal chimney. Warm water heated during cooking can be used for dish washing and for other purpose. It weighs around 12 kg and its average efficiency is about 25 per cent.
Disseminated regions	High hills and mountains.
Advantages	Warm water is obtained along with cooking. Comparatively light in weight and has water heating facility.
Disadvantages	Expensive and can be fabricated only in metal workshops which is usually not available locally.
Major organisations involved in promotion/dissemination	CRT/N.

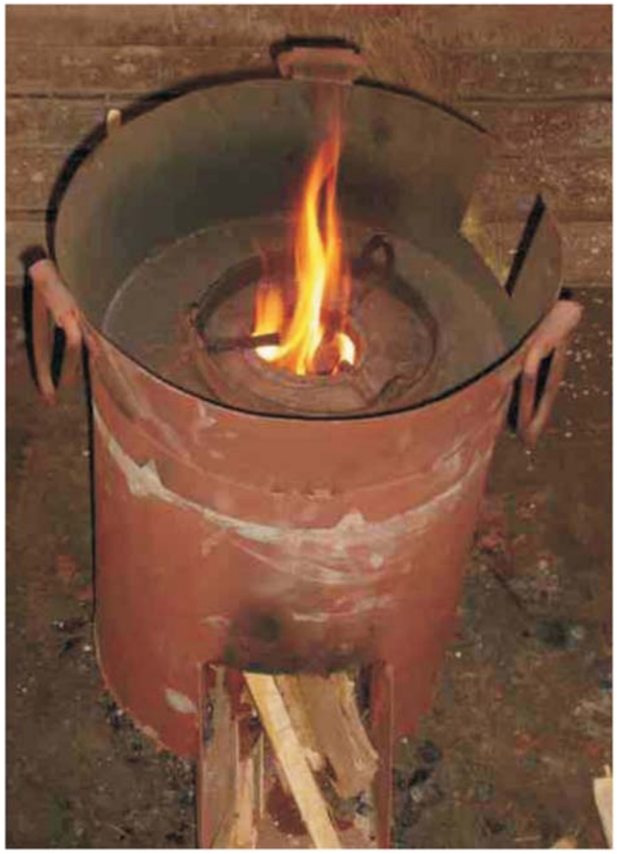
3.3.8 Ujelii chulo (stove)

Photograph 3.11: Ujelli chulo with TEG (left) and room after installation of Ujelli chulo (right) Source: STARIC/N

Year of dissemination	Still in demonstration (field test) phase.
Cost	Not finalised as modification in field is being carried out.
Quantity disseminated	NA
Technological description	Proven technology of integrating a thermoelectric generator (TEG) into fuel efficient, low emission wood stove. Simple, quiet and reliable thermoelectric cells produce electricity based on temperature differences across them. It is typically suitable for applications in which power requirement is 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 of illuminating the entire room.  Photograph 3.12: Module, hot and cold heat sink and fan Source: STARIC/N

	Two finned heat sinks (left of Photograph 3.12) 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 consumes 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; thus net system peak output is 16 watts.
Disseminated regions	Not available, but expected to be suitable in high hills and mountains. Suitable for space heating.
Advantages	Dual purpose technology. Light weight and clean cooking with lighting facility. Less fuel wood consumption.
Disadvantages	Expensive and O&M requirement high. May not be suitable in mid hills and terai as metal promote space heating.
Major organisations involved in promotion/dissemination	Sustainable Technology - Adaptive Research and Implementation Center (STARIC/N).

3.3.9 CRT/N RT model stove



Photograph 3.13: 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. It is based on rocket stove principle. Its efficiency ranges from 22 to 24 per cent.
Disseminated regions	High hills and mountains.
Advantages	Very less cooking time and can be used as space heater. Suitable for agricultural residues and honey comb charred briquette. Accommodates various sizes of pots.
Disadvantages	Requirement of smaller sized fuel material and fabrication possible only in metal workshops.
Major organisations involved in promotion/dissemination	CRT/N.

3.3.10 KU 2 design metal stove (in demonstration phase)

Photograph 3.14: KU 2 design metal stove Source: KU

Year of dissemination	Still in demonstration phase.
Cost	NRs. 3700 to 4500
Quantity disseminated	Very few.
Technological description	There is two and one pothole in the primary and secondary chamber respectively. Eight liter water tank is attached with primary chamber. It weighs about 37 kg and is the improved version of KU-1 model; however it is still under field testing.
Disseminated regions	High hills and mountains.
Advantages	Highly efficient with clean combustion.
Disadvantages	Expensive and fabrication is possible only in metal workshops.
Major organisations involved in promotion/dissemination	CRT/N.

Information of various organisations involved in promotion and dissemination of metal stoves is given in Annex 2.

According to findings, air induced (bayupankhi) stove is more efficient as it reduces the fuel consumption by 40 per cent, followed by metal stove (around 25 per cent) and mud-brick ICS (around 20 per cent). Likewise, bayupankhi stove reduces cooking time by one hour per day, whereas metal and mud-brick stoves reduces cooking time by 0.5 to 1 hour. In high hills, due to severe cold climate, mainly metal stoves are suitable. Jumla design smokeless metal stoves is very popular in Karnali zone and some mid hill areas of north Kaski. It is expected that the KU-2 design metal stove will be accepted by the users if it gives the same performance in the field as in lab tests. Portable type metal stoves are also suitable in these regions. Ujelli stove with TEG could be one of the solutions because of its dual function but the reliability of technology is still a question. The portable type high efficient bayupankhi (air induced) stove is most suitable in places with electricity.

In general, the dissemination of metal stoves is very successful due to following reasons:

- Government and donor agencies are working together to raise awareness
- Provision of subsidy in distribution (only for metal stoves distributed in high hills for areas 2000m ASL, 50 per cent of total cost not exceeding NRs. 2500 subsidy by AEPC); in case of mud brick stoves, only indirect subsidy like local capacity development through trainings is provided
- Suitable for typical rural HH kitchen
- Involvement of NGOs and CBOs including private sector in dissemination
- Efficiency is high compared to traditional ones (20 to 32 per cent)
- Availability of options - 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
- Advantage of space heating in high hills and mountains
- Highly effective in IAP reduction because of better combustion. Fuel saving is 25 to 40 per cent compared to traditional stoves and time saving is 0.5 to 1 hour per day

However, there are still some hindrances in the effective implementation of this intervention due to the reasons below:

- Expensive as rural people may not be able to afford it even with the subsidy provided by AEPC/ESAP
- Users are not aware of IAP and detrimental effects associated with it; also fuel and time saving is not a priority/concern for users
- Beliefs in reducing the pest termite effects from smoke and inconvenience while using large pots (not suitable for agro-processing, preparing animal food and alcohol distillation)
- Variation in quality of stove due to use of different types of raw materials and skills
- Need of metal workshop/factory for fabrication locally. Requirement of small and most preferably consistent sized fuel wood
- Requirement of electricity (or solar or battery) particularly for bayupankhi stoves
- High risk of child burning due to metal being good heat conductor
- Lack of proper maintenance, which results in low IAP reduction, fuel and time saving
- Less efficient, if only one meal is cooked at a time in a three potholes stove
- Dissemination is based on project targets rather than having a good market based approach
- Lack of coordination among promoters

For successful dissemination of mud-brick ICS and metal stoves, following are the recommendations:

- Information materials informing on health hazards due to IAP in the forms of posters and pictorial manuals need to be effectively disseminated for awareness creation and demand generation
- The programme should be focused in areas where collection of fuel is difficult
- Potential market of improved stoves must be recognised through market survey to commercially promote the technology
- Feedback from the local artisans should be considered during the designing phase
- Government should assist in dissemination, technical advice, quality control, and monitoring and evaluation of ICS programme implementation
- Government or donor support should be extended for at least five years for the development of local institutions and local expertise

Chapter Four
BRIQUETTING TECHNOLOGY

Biomass briquette is less-polluting with high density and energy concentrated dry (completely or negligible moisture content) shaped biomass fuels converted from low density and high moisture content bulky materials. It is made (without any binding chemicals) by chopping and grinding and pressed under certain temperature and pressure. Because of their definite shape and size, briquettes are very convenient to store and transport. Biomass briquette produces less smoke compared to fuel wood, which can be further reduced by designing the efficient cook stoves. Singh and Heejoon (2003) mentioned that briquette fuel consists better physio-mechanical properties and combustion properties. Advantages of briquette include higher heating values, lower emission of sulphur dioxide and oxides of nitrogen among others.

Nepal produces substantial amount of agricultural and forest residues (rice husk, rice straw, bagasse, cotton stalk, jute sticks, almond shells, sawdust etc) which have low bulk density and high moisture content. Woody residue such as sawdust and non-woody plant biomass such as crop harvesting, processing residues and cattle dung are important alternative source of energy in wood deficit areas. Various types of residues used in manufacturing of briquettes are given in Table 4.1.

Biomass briquette is a good substitute of wood and coal and can potentially replace wood/coal/kerosene/ LPG at HH levels. Biomass briquette manufacturing plants are of various forms/types varying from HH and community level to highly commercial scale, which may also help to generate local employment along with safer environment.

Depending upon the nature, scale and materials used in production, briquettes are found in various shapes and sizes. Briquetting technology was first introduced in Nepal by heated-die screw-press Taiwanese machine in the late 1980s. Mhyaipi Briquette Industry located in Kawasoti, Nawalparasi, Nepal, is producing biomass briquette made of rice husk at a commercial scale. But the factory runs only six months in a year with 25 per cent of its full production capacity. Other biomass briquettes made of woody residue such as sawdust and non-woody residue such as crop/ vegetable residue (rice husk) have also been introduced. Banmara, (Eupatorium Adenophorum), is a fast growing herb considered a weed which is found all year round has been introduced as a raw material for producing briquettes. Research organisations, such as RONAST and Integrated Development Society (IDS-N) are involved in developing and disseminating the beehive briquette made of banmara. Foundation for Sustainable Technologies (FoST) is involved in research and demonstration of briquette production mainly through the HH wastes.

Table 4.1: Raw materials for briquette in Nepal

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

Various types of briquettes are described below:

4.1 Rice husk briquettes

Photograph 4.1: Rice husk briquettes Source: Mhyaipi Briquette Industry

Year of dissemination	Briquette industry was established during the 1980s in Nepal but subsequently closed down due to the high cost of screw and briquette manufacturing materials (such as rice husk) and availability. Mhyaipi Briquette Industry has been producing briquette in Nepal since its establishment in 1994.
Cost	NRs. 10 per kg (25cm briquette weighs 1 kg).
Quantity produced	3000 tons.
Manufacturing process and technical description	These briquettes are produced in a heated-die screw-press machine. 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 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 combustion air supply which enhances combustion efficiency. It has an ash content of 18 per cent and is less volatile compared to firewood (2 per cent). These briquettes can be burnt in any stoves and bayupankhi (air induced) stove is most suitable due to its double combustion. But bayupankhi stove requires electricity or battery to run the fan.
Advantages	This type of briquette is suitable for both cooking and space heating and is suitable for all geographic and climatic condition. It makes barbecue preparation effortless. This type of briquette saves at least 10 per cent fuel in comparison to LPG, kerosene and reduces smoke up to 80 per cent compared to fuel wood. Its use is more suitable in institutions compared to domestic purpose.
Disadvantages	Includes high kindling time and difficult to extinguish once it burns. Initial investment is high to produce commercially.
Major organisations involved in promotion/dissemination	Mhyaipi Briquette Industries P Ltd.

4.2 Beehive briquettes


Photograph 4.2: Dried beehive briquettes Source: RONAST

Year of dissemination	Research started in 1980s which was then promoted by ICIMOD. JICA and former RONAST were also involved in research. IDS replicated and disseminated briquettes in 2004.
Cost	NRs. 6 at production site (in 2004), cost varies with retailers. In Kathmandu valley the price ranges from NRs. 12 to 15.
Quantity produced	Around 13,000 kg.
Manufacturing process and technical description	*Banmara* has tremendous negative impact on forest as it can not be used as fodder and foliage for cattle. On the other hand, it has low moisture and ash content suitable to produce fuel. Besides *banmara,* the raw materials used for beehive biomass briquette are clay, dung and lime. Clay has good binding and compaction property - alumino-silicate compound and is named 'benthonite clay.' Dung contains digested/undigested starch which has both binding property and fuel value, and mixing with other materials possibly enhances fuel quality. Lime or calcium oxide (CaO) is exothermic in nature which emits heat and diminishes the emission of oxides from nitrogen and sulphur dioxide acting as a disulfurising agent. It is also a good additive to lower smoke emission from fuel (Beehive Briquette Project, 2005). *Banmara* sun dried for a week is cut into one foot long pieces which are then charred in a drum or pit. The recovery of charcoal in pit burning is comparatively better. Once the moisture is driven out and sufficient temperature is reached inside the pit, it is covered with a plain metallic sheet to prevent further supply of air which is a necessity for charring process. It is left overnight to cool and the formed charcoal is powdered by either electric or manual driven grinder machine on the following day and is mixed in different proportion with dung, clay, and lime.


Sun dried banmara


Benthonite Clay


Preparing mixture


Charring banmara


Grinding charcoal


Dried briquettes


Briquetting mould


Preparing briquette

Photograph 4.3: Materials and production of beehive briquette
Source: RONAST

Water is added to the mixture to form a paste which is then 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 five days. It is difficult to maintain consistence in weight as the compaction is done manually. The materials and procedure required for producing beehive briquette is shown in Photograph 4.3.

The cylindrical type briquettes are common with a height of 5.5 inches in diameter. There are 19 evenly distributed holes of 1 cm diameter along the direction parallel to the cylindrical axis, which facilitates proper supply of air for better combustion. It weighs 0.5 kg and its color varies from gray to black. It burns for 60 to 90 minutes.

Disseminated regions	Bishankhunarayan of Lalitpur; Nawadurga and Kamdi of Banke; Marsangidhi and Turture of Tanahu; and Panchpokhari and Shantinagar of Jhapa. Suitable in all areas where raw material is easily available.
Advantages	Easy to handle, transport and store as an alternative environment friendly fuel and less polluting. Furthermore, it has a good business potential because of low investment requirement. Suitable for slow heating (simmering) and cooking, space heating and more applicable in barbecue preparation. Suitable for all geographic and climatic condition.
Disadvantages	The production is stopped during monsoon since raw materials need to be completely dry before charring. Lack of adequate funding for capital investment and training are the barriers to implement this technology at a large scale.
Major organisations involved in promotion/dissemination	IDS-N, NAST and RECAST.

4.3 Briquette from HH and agricultural waste

Year of dissemination	2002
Cost	NA
Quantity produced	NA
Manufacturing process and technical description	Briquette can be made from HH waste, such as, paper, grass, leaves, saw dust, slurry and dung. The briquette made of paper is easy to ignite and less smoky and the paper also works as a binding material. A cylindrical mould of about 90 mm diameter and 300 mm height is used to 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 grinded in some cases where water is added to make a paste. The paste is put in a mould and compacted up to certain extent that it cannot be pressed by bare hands. FoST has developed two types of heavy duty pressing machines. First type is a lever press machine which requires two persons to operate, one operating the pressing device and another to prepare the mould. The second type is simple one that can be operated by a single person. The briquettes produced from manual press machine have comparatively low density. Normally, this type of briquette is more porous than firewood and produces less smoke. The manual compaction device is more suitable for HH level uses. Highly compacted briquettes are less porous which can emit dense smoke in ordinary cooking stove but the compaction has no effect in bayupankhi stoves due to proper air fuel mixture. Designed pressing machine could produce a rectangular shaped briquette cake of approximately 18 x 2 x 2 inch size.
Suitable regions	Suitable in all areas.
Advantages	Eco friendly, which reduces deforestation and save environment. These briquettes can reduce smoke significantly, and save fuel expenditure up to 40 per cent compared with traditional fuel wood stoves.
Disadvantages	NA
Major organisations involved in promotion/dissemination	FoST.

4.4 Beehive briquette stoves

Mud clay stove 1
Stove dimension:
Length : 28 cm
Breadth : 28 cm
Height : 24 cm

Mud clay stove 2
Stove dimension:
Length : 31 cm
Breadth : 31 cm
Height : 19 cm

Clay stove
Stove dimension:
Diameter : 24 cm
Height : 19 cm

Clay stove with mental ring
Stove dimension:
Diameter : 26.5cm
Height : 23 cm

Double wall metal stove
Stove dimension:
Diameter : 24 cm
Height : 21 cm

Metal stove with clay lining
Stove dimension:
Diameter : 20 cm
Height : 23 cm

Clay stove

Photograph 4.4: Beehive briquette stoves Source: CRT/N, 2006

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 are metal sheet, metal rod, clay, mud and cement. Clay, cement and rice husk are kneaded together. The construction of these stoves except the double wall metal stove is simple. These models are affordable and are especially suitable to use with beehive briquettes, and other fuels such as charcoal and wood. Ignition chamber is below the grid which separates it from fuel chamber. The fuel burning is totally dependent 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 provides strength to the stove and also acts 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 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 resulting to lower efficiency. Application of insulation (e.g. clay) on the inner side of stove saves heat loss and hence enhances efficiency of the stove by letting out little smoke. It is usually ignited outside in the open place; once the flame is stable it is taken inside. Efficiency ranges from 20 to 23 per cent.
Disseminated regions	Urban and semi-urban areas.
Advantages	Portable, easy to handle, suitable for space heating and easy to fabricate. Smoke is reduced significantly compared to traditional stoves. Barbecue preparation is made easier.
Disadvantages	NA
Major organisations involved in promotion/dissemination	CEE, CRT/N, FECOFUN, RECAST and other NGOs and CBOs.

The information of organisations involved in briquette technology is listed in Annex 3.

The findings conclude that the briquette technology is cheaper, simple, and easier to disseminate at HH and community level. This technology proves to be an alternative source of fuel wood and at the same time creates local employment. It also saves time for user from collecting fuel wood if promoted appropriately. It is efficient in reducing IAP and saves fuel. Briquettes made from *banmara* and HH wastes contribute in reduction of deforestation and hence reduce degradation of environment as a whole. Nepal is an agricultural country and provides abundant agricultural residues making it possible for year round availability of raw materials for briquette production.

The major constraints for commercialisation of briquette manufacturing industries are - increase in the price of raw materials (rice husk, saw dust, etc), unavailability of raw materials in time, lack of long-term marketing strategy, lack of spare parts and proper training for operation and maintenance of machines, high electricity consumption, shorter lifetime of screw machines, unsuitable to use in traditional stoves, lack of technical research and development support to the biomass briquette manufacturers and lack of direct subsidy for adoption and promotion of technology. In addition, it takes time to manufacture especially during monsoon due to lack of proper shading and drying area.

To promote the biomass briquette technology at wider scale, following steps should be considered:

- i There should be an effective government policy, planning and implementing strategy with public awareness activities
- ii Organisations that are working intensively in biomass briquette technology promotion and production should be recognised and provided with fiscal and tax or subsidy incentives
- iii Research and development support should be provided to the biomass briquette and appropriate biomass briquette firing stove researchers/manufacturers
- iv Provision should be made for adequate funding for capital investment and training
- v Donor agencies' role in disseminating the technology in the community level should be reconsidered

Chapter Five
SMOKEHOOD

Smokehood is a structure placed over a cooking stove to remove the smoke produced during incomplete combustion of fuel wood from the kitchen. Smokehood can be of various dimensions depending on the stove size and kitchen design. RECAST, a research and development organisation is working to improve smoke hood design. Practical Action Nepal Office has also designed a smoke hood model in Rasuwa in a participatory way, which is suitable for high-hill areas.

Previous studies, researches and experiments show that smokehood reduces the level of IAP significantly. 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 the improved cooking devices with and without chimney, briquette and pellets, charcoal and other alternative fuels for source based intervention. For living environment based intervention, they considered hood/ fireplace and window/ventilation outlets. 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 (briquette), 75 (pellets) and 10 (charcoal) per cents respectively using improved cooking stoves with chimney. For living based intervention, hood/fireplace and window/ventilation outlets reduce the exposure level up to 50 and 15 per cents respectively. Likewise, the exposure level was reduced up to 50 per cent using pot lids.

Smoke extraction through smokehoods, ventilation through windows and eaves spaces, and improved combustion through improved stoves were three interventions that were promoted during the implementation of Smoke, Health and Household Energy Project in Kenya and in Nepal by Practical Action. Smokehoods were successful in terms of smoke alleviation especially where windows were installed at the same time, providing a good draught to optimise combustion. Smokehoods work irrespective of weathers and have variations in geometry. Moreover, smokehoods are effective and can be adapted easily at local levels. The simple, cost effective and efficient smokehood introduced by Practical Action for the Maasai women in the Kajoado region of Kenya was successful in reducing smoke level inside the kitchen by 80 per cent. The windows facilitated the use of hoods as cold and heavy air replaced hot air and also helped in combustion when windows were opened. (Smoke, Health and Household Energy project, 1998-2001, Practical Action).

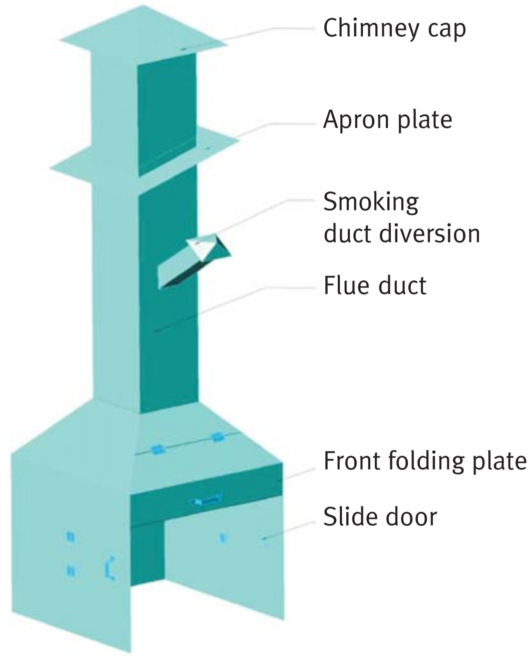
The smokehoods promoted by Practical Action Nepal Office are shown below:

A. First design

B. Second design

C. New design (I)

D. New design (II)



E. Improved smokehood

Photographs 5.1: Smokehoods promoted (with technical modifications) in Gatlang by Practical Action Nepal Office

Source: Practical Action Nepal

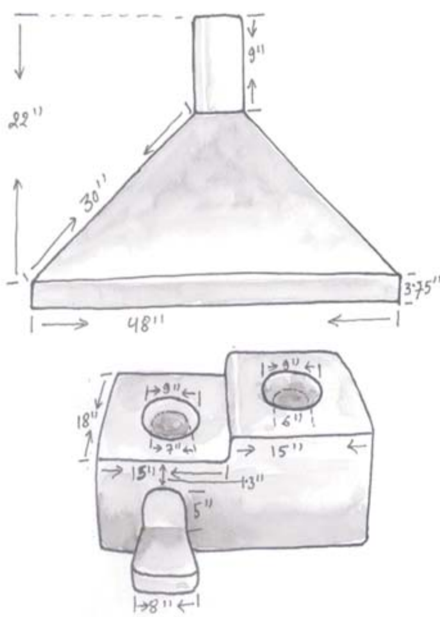


Figure 5.1: Smokehood researched at RECAST

Source: RECAST

Year of dissemination	2001 by Practical Action Nepal Office.
Cost	NRs. 5000 in year 2005/06.
Quantity disseminated	600 in Rasuwa by Practical Action Nepal Office.
Technological description and other improvements in traditional stove	Besides smokehoods made from metal sheet constructed by trained local artisans, the project also carried out other necessary activities such as wall insulation of kitchen 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 combustion. Other public awareness activities such as fuel drying and reduction of personal exposure time during cooking and sitting nearby fire were also conducted.
Disseminated regions	Rasuwa, northern part of Nepal. No climatic and geographical limitations (suitable in all areas).
Advantage	The technology is suitable irrespective of weather and variation in geography. It is simple and easily replicable. The technology is accepted in rural areas, as rural populations still believe that smoke reduces pest and termite and can dry wet crops. The intervention is effective in reducing IAP level. There is 66 per cent reduction in PM resp. level and 76 per cent reduction in CO level after the intervention (Malla 2008). In addition, it is successful in reducing fuel wood consumption by 25 per cent leading to significant time saving because the project also works in the improvement of stoves along with the introduction of smokehoods.
Disadvantages	Investment cost is high for rural people.
Major organisations involved in promotion/dissemination	Practical Action Nepal Office, RECAST for initial inverted funnel type design.

Based on the success of Practical Action's intervention, few guidelines have been drawn for the effective implementation of smokehood in the future:

1. Recognition of smokehood by government (AEPC) to be included as one of the effective technologies for IAP reduction
2. Requirement of effective government policy and planning
3. Promotional activities, awareness campaigns including home visits, video presentation, training and workshops at community and district level
4. Training of local entrepreneurs on product manufacturing and business management
5. Joint effort of the HHs, community, local governments, central government, and involvement of donor agencies for wider uptake
6. Effort to scale up the best practices and continuation of research to improve the design and efficiency
7. Increase access of beneficiary groups to technologies/product and finances
8. Provide support to forecast market, develop business plans for the entrepreneurs and support them in identifying and disseminating promotional strategies

Chapter Six

BIOGAS TECHNOLOGY

Biogas is a combustible gas produced by anaerobic fermentation of organic materials by the action of methanogenic bacteria. This odorless gas is 20 per cent lighter than air and burns with blue flame as LPG. Biogas contains methane and carbon dioxide and has the proportion of methane (50 to 70 per cent), carbon dioxide (30 to 40 per cent), hydrogen (5 to 10 per cent), nitrogen (1 to 2 per cent), water vapor (about 0.3 per cent) and traces of hydrogen sulphide. Retention time of biodegradable material varies depending upon temperature and type of materials used to feed in the anaerobic digester. Generally biogas in Nepal refers to the gas produced from animal excreta. However, it can also be generated from human excreta, wastewater from industries, byproduct of food wastes from food industries, municipal wastes, energy crops like hyacinth and other various organic products. The waste materials of plants and animal origin consist mainly of carbohydrates, lipids, proteins and small amounts of metabolites generally insoluble in water. If biodegradable organic materials are decomposed or fermented in anaerobic condition, combustible methane gas is produced by the bacterial action. The typical biogas plant called GGC 2047 model is promoted in Nepal by Biogas Support Programme (BSP) shown in Figure 6.1.

Livestock plays an important role in the Nepalese farming system; with 2.7 million HHs owning cattle and buffalo (estimate 2001). The technical potential of biogas plants in Nepal is about 1.9 million; 57 per cent in plains, 37 per cent in hilly areas and 6 per cent in mountainous regions (BSP 2004). There is a huge potential of biogas production throughout the country which can generate 71,383 Giga Joules of energy considering the average yield of 1.7 cum biogas per day from the types of plants widely adopted in Nepal (1 Cum biogas = 22.1 MJ from Source: SESAM/Rehling: Energy and Development, p. 18).

It is reported that 157,675 biogas plants have already been installed in 67 districts by December 2006 under BSP. Until 2005, BSP covered 2593 VDCs of the total 4000 VDCs. About 98 per cent of the constructed plants are in operation. A total of 102,719 toilets were constructed and is connected to biogas outlets. About 1 million people are directly benefiting and about 11,000 are employed. In order to provide financial assistance for the establishment of biogas plants, 130 micro finance institutions are mobilised. Likewise, 60 private biogas companies are strengthened and 16 biogas appliances manufacturing workshops are developed so far (BSP 2007).

The government is prioritising the importance for biogas promotion in plan since seventh five year plan (1985 to 1990). The tenth five year plan (2002 to 2007) has taken a long term approach for commercialisation of biogas sector and has a target to install 200,000 (revised to 175,000) biogas plants.

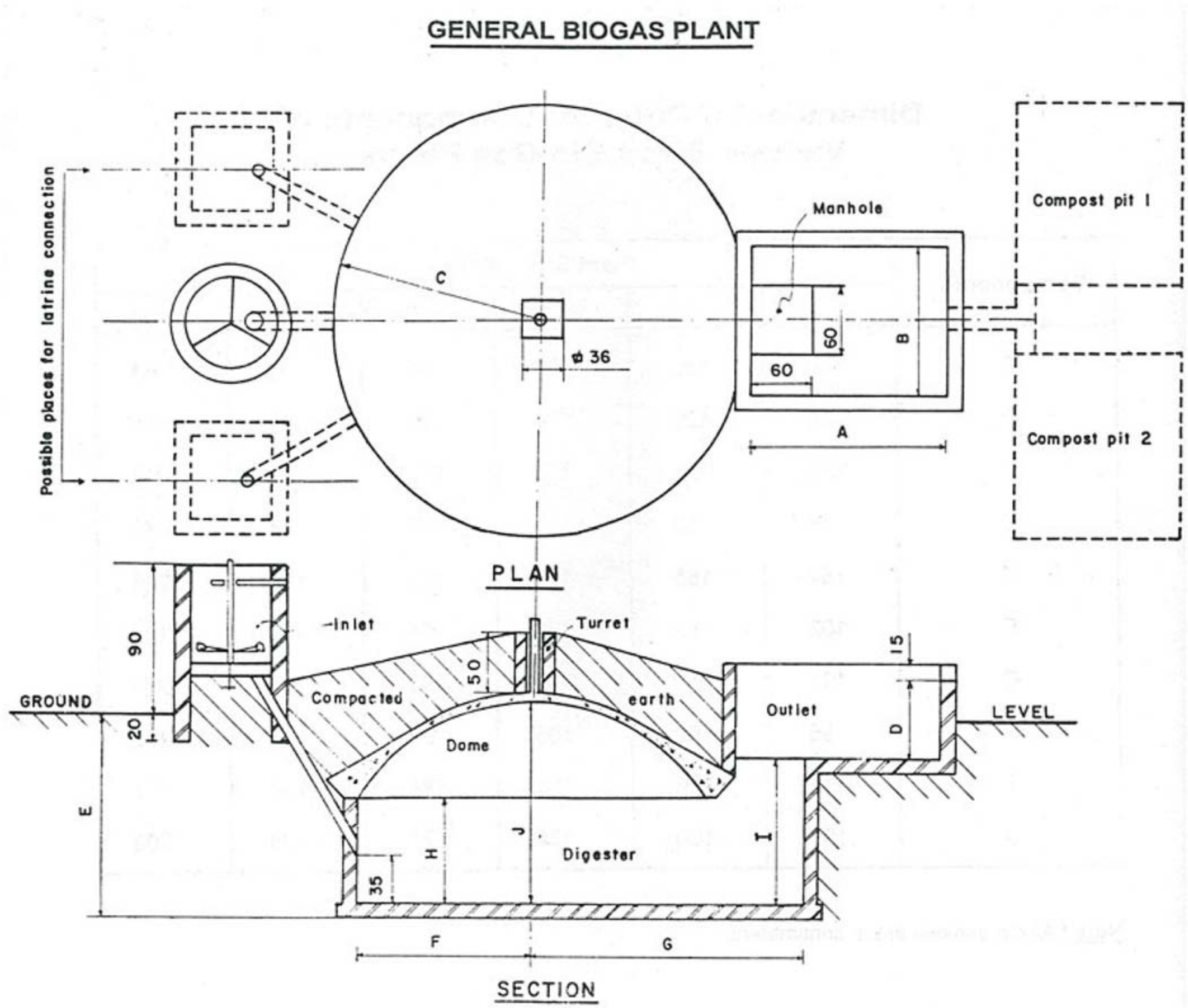


Figure 6.1: GGC 2047 model biogas plant

There are different practical models of biogas plants. Floating drum digester, fixed dome digester and deenbandhu model are common types 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 to use up to 2100 m altitude. The cost of this model with 6 cu. m. is NRs. 24,621 in 2005/2006. The present policy of the government has a provision of capital subsidy to the biogas users based on geographical area and the size of the plant as shown in Table 6.1.

Major organisations working on biogas technology in Nepal:

- Alternative Energy promotion centre (AEPC)/MOEST is implementing Biogas Sector Partnership Nepal (BSP-N) programme
- Centre for Renewable Energy (CRE)
- Center for Appropriate Technology Nepal
- Nepal Biogas Promotion Association (NBPA) representing more than 65 private companies

Please see the list of organisations involved in the biogas promotion at Annex 5.

The reason for limited biogas plants installation in high hilly mountainous region is the low average ambient temperature as the optimum temperature for biogas

Table 6.1: Government subsidy rate for biogas user (for 2006/07)

Source: BSP 2007

Region	4 and 6 m3	8 and 10 m3
20 Terai districts	NRs. 6,500	NRs. 6,000
40 Hill districts	NRs. 9,500	NRs. 9,000
15 Remote hill districts	NRs. 12,500	NRs. 12,000
Specified low penetrated districts (in Terai and Mid-hills, altogether 18) will be provided with additional subsidy of NRs. 500 per plant		

production is about 30-40°C and the production virtually ceases below 10°C. A research is undertaken to develop appropriate biogas plant designs for altitude higher than 2,100m. Two plants were installed during the 3rd Phase in Khumjung and Lukla of Solukhumbu district with greenhouse technology. However, despite the merit of the design and technology, the project cost was very high. Four years ago, three other simpler new designs were tested in Beni VDC of Solu district with much lower project cost. One of the three designs, a simple addition of heap composting on top of the digester is found to be the most appropriate and cost effective design. This design is thus widely promoted between 2,100 to 3,000m altitude as part of the regular national programme with subsidy. The GGC-2047 design with heap composting technology was approved for commercial dissemination last year. Till date, some 40 biogas plants with heap composting are constructed in upper part of Rasuwa district and more are under construction. Some 30 plants with such heap composting are installed in Solukhumbu district. The results are satisfactory. BSP-Nepal is going to undertake more promotional work in remote districts of Karnali and other areas like Manang and Mustang for construction of biogas plants with heap composting technique. Further research was initiated in 2007 in Rasuwa district (Langtang area) between 3,000 to 3,850m using modified GGC-2047 (improved design with provision of multiple feeding, heap composting and warm water feeding).

Likewise, an initiative is taken to establish the biogas plant that works on batch feeding mode. Feeding material is loaded once or twice a year to produce gas throughout the year. This kind of biogas plant introduced in Nepal is called Puxin model biogas plant which is a kind of hydraulic pressure biogas plant. More than 50 such plants are installed in different districts and most of these plants are working satisfactorily. The schematic diagram of Puxin model biogas plant is shown in Figure 6.2.

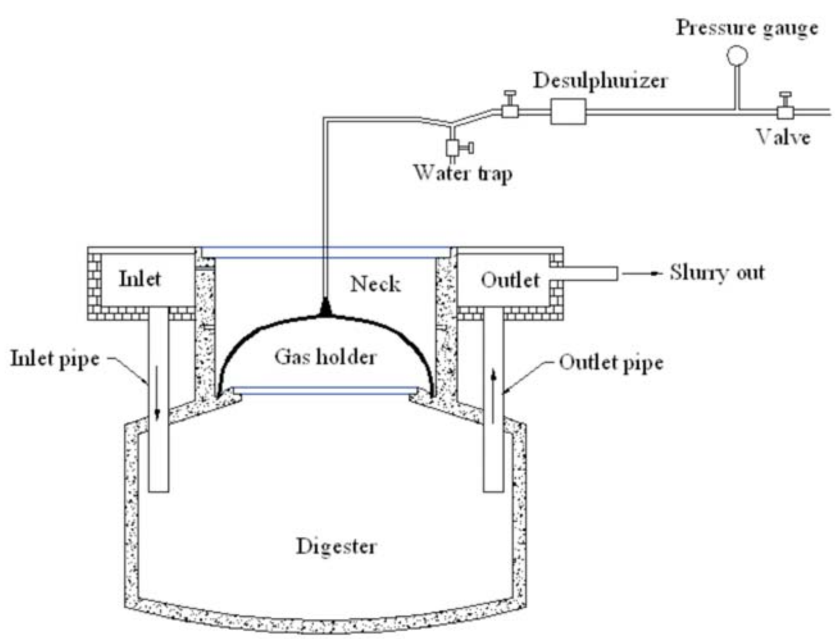


Figure 6.2: Schematic diagram of Puxin model biogas plant

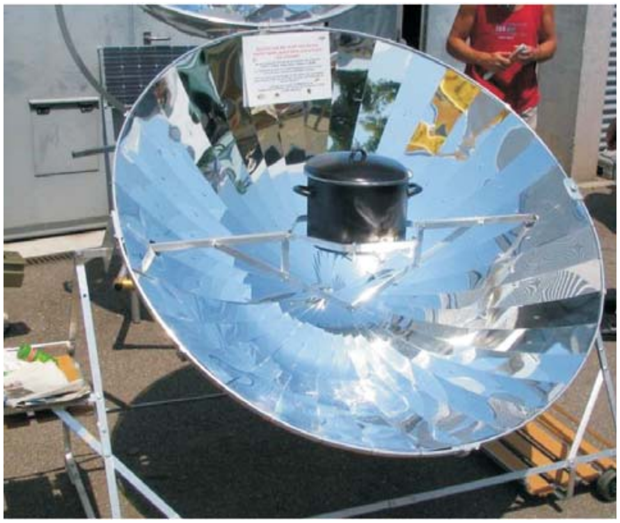
Chapter Seven

SOLAR AND ELECTRIC COOKING TECHNOLOGY

7.1 Solar cooking technology

The energy of solar radiation can be utilised in various forms of thermal as well as photovoltaic use. 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 at sea level unless it is pressurised by any cooking vessel. An oven will cook just fine as long as it heats up to about 90°C or so. Higher temperatures cook larger quantities, cook faster, and allow for cooking on marginal days. The temperature reached by box cookers depends primarily on the number and size of the reflectors used. The common types of solar cooker in Nepal are shown in Photograph 7.1.

The parabolic solar cooker has a parabolic profiled reflector and an absorber where the raw food is loaded. Solar radiation incident on the larger surface of reflector is focused on to the absorber, so the absorber receives



Parabolic type solar cooker
Source: www.crtnepal.org

Box type solar cooker
Source: www.solarcooking.org

Photograph 7.1: Common types of solar cookers in Nepal concentrated radiation, thus higher temperature is obtained. The absorbent surface is coated black to absorb maximum radiation.

Box type solar cooker is a tray usually made up of black coated aluminum sheet which is covered by transparent glazing. Most of the box type solar cooker has a reflector to increase the solar radiation on to the tray. Raw food is loaded inside the tray in separate cooking pots.

A single-reflector box cooker is the advantage of slow and even cooking for large quantities of food. Variations include slanting the face toward the sun and the number of reflectors. Such cooker usually tops out at around 150°C. A single-reflector box cooker takes about twice the time to cook compared to a conventional oven. With a single-reflector box cooker, once the food is cooked, it just stays warm and doesn't scorch.

Cooking with the parabolic cooker is similar to one burner conventional stove. The concentrated sunlight is directly reflected on the bottom of the pot. In this type of solar cooker, higher temperature is obtained, thus cooking time required is lower compared to box type solar cooker. As there is a possibility of burning food due to high temperature, food should be stirred at regular interval. Typical parabolic type of solar cooker (1.4 m in diameter and 28.6 kg) developed by CRT/N takes 1 hour to boil 10 liters of water, 30 minutes to cook 0.5 kg of rice and 45 minutes to cook chicken and other meat items. Parabolic cookers must be tracked every 10 to 30 minutes depending on the focal length to obtain maximum solar radiation.

Allart Ligtenberg, an Engineering Manager started to work on solar cooker in collaboration with CRT/N since 1992 and is recognised as the pioneer of solar cooker in Nepal. The technology is further disseminated through awareness, demonstration, food testing, pilot projects, media exposure and the distribution of informational handouts. Initially, Ligtenberg and CRT/N sensitised and encouraged NGOs, community leaders, environmentalists and scientists to send their representatives to solar cooking workshops. 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 and tourist areas. Nepal Government provided partial subsidy for its promotion. So far, about 1000 units of SK 14 parabolic solar cooker is disseminated in various parts of the country through collaborative efforts with the government and other various development partner organisations. CRT/N has plans to promote 2500 solar cookers within next five years alongside eco-tourism areas of Nepal. The use of each solar cooker for 4 - 5 hours a day and seven months a year can save about 2300 kg of fuel wood yearly on an average.

Realising the usefulness of solar cooker and recent increase in fuel price, Nepal government has provided 50 per cent (but not exceeding NRs. 4000) subsidy to solar cookers (box type and SK 14 parabolic type) as per policy on renewable energy subsidy delivery mechanism.

Despite the high cost, there is a high potential for this technology in Nepal because of average solar intensity of about 4.7 $KWh/m^2/day$ (AEPC, UNEP/GEF 2006). With increased cost of other energy sources and scarcity of fuel wood, solar cookers can be the ultimate substitute for cooking which is also a renewable source of energy and is pollution free. The major organisations 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
- Krishna Grill and Engineering (P) LTD

7.2 Bijuli Dekchi (electric cooker)

Year of dissemination	1992
Cost	NA
Quantity disseminated	83 in Ghandruk as of 1994 (average 2 per HH, one for cooking purpose and another for heating water).
Technological description	It is a low wattage cooker with a combination of provision for storing heat in the form of water. Heated water is used for cooking and washing purpose. 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 insulation reducing heat losses through the side and the base. A low wattage heating element is attached to the bottom of the inner pan. A thermo switch which turns the Dekchi into an automatic rice cooker 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. Low-high switch in the cooker regulates the night time heating of water at half the original watt of the cooker.
Disseminated regions	Ghandruk and Chomrong (at 1750 to 2050 m altitude)
Advantages	Low cost, locally manufactured, repairable' and smokeless.
Disadvantages	Not feasible due to socio-economic factors, dietary habits. Requirement of electricity. Availability of fuel wood in abundance, non reliable electric supply, limited power and high cost of subscription are some of the major constraints in wider dissemination of this technology.
Major organisations involved in promotion/dissemination	Practical Action Nepal Office, Development and Consulting Services, Butwal.

Chapter Eight
CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

Nepal, challenged by the growing population, is heavily dependent on traditional biomass fuels which contributed to about 88 per cent of total energy consumption. Nepal was one of the lowest per capita energy consumption (about 15 GJ) countries in 2005 and large fraction of the energy consumed was used for cooking (65 per cent) followed by space heating and other activities.

Burning of solid biomass fuel in traditional inefficient stove emits hundreds of pollutants which are very harmful for human health. Smoke in homes is the major contributing factors of many diseases for large segment of population as well as the cause of GHG emission. The negative effects on human health and on local and global environment necessitate 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 improved technologies that are disseminated for those HHs who use firewood and agricultural residues as a source of energy for cooking and heating including space heating. These technologies are 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 required for model adaptation because of the house structure in *Terai*. In Nepal, mid hill and high hill ranges from 1300 to 2500 and 2500 to 5000 m amsl respectively. Metal stoves are more suitable above 2000m altitude due to its heating requirements. Metal stoves are more efficient than mud-brick stoves because it requires fairly small size fuel, as these fuels are comparatively dry and aid in proper combustion. 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 reduces the fuel collection time along with IAP. Similarly, bayupankhi stoves, smokehoods and improved ventilation can be other suitable options. They can reduce substantial amount of IAP from the kitchen.

Briquette technology is one of the eco-friendly technologies substituting firewood and significantly reducing smoke compared to fuel wood burning traditional stoves. Unfortunately, it could not be industrialised despite being developed and promoted in 1980s. Only one commercial industry and very few research institutes, NGOs and private sectors are involved in development of this technology.

Other renewable technologies, such as biogas, solar and electric cookers are the cleanest forms of cooking energy.

Study findings suggest that success of technologies depend on various factors including availability, affordability, adaptability and acceptability of the technology by the target groups. Therefore, while introducing these technologies, one has to consider fuel price, socio-cultural and ethnic values, geographic and climatic conditions, cooking behaviors, operation and maintenance requirement, durability and the size of the kitchen as well as local level innovations.

8.2 Recommendations

For effective promotion of these technologies, following recommendations have been drawn:

i Effective government policy, planning to be set with clear strategies for each of these technologies backed by fiscal incentives

ii Promotional activities, awareness campaigns including home visits, video presentations, trainings and workshops at community and districts level should be initiated

iii For creating demand among target groups, information on health hazards due to IAP in the forms of posters, campaigns, pictorial manuals backed by evidences is necessary

iv Coordination between HHs, communities, private promoters, local and central government with the involvement of donor agencies must be strengthened to scale-up successful technologies

v Adequate training should be provided to local artisans/entrepreneurs on product manufacturing and business management considering consumer feedback. Similarly, support should be provided to the entrepreneurs to forecast market, develop business plans and identify and disseminate promotional strategies

vi The briquette programmes should focus in firewood deficit areas

vii Government should provide support in dissemination, technical advice, quality control, and monitoring and evaluation. Extended government or donor support for the development of local institutions and local expertise is required

viii Provision of technical research and development support with adequate funding is needed for technology design and promotion

ix Effort should be made to scale-up the best practices and continuation of research to improve the design and efficiency

x Provision of subsidy and loan should be provided to increase the demand of improved technologies. Supply side should be strengthened. Easy loans should be provided to the manufacturers for starting up businesses to promote technology. Likewise, formation of locally managed revolving fund groups and increased access to credit facilities through these funds should be encouraged to support user HHs to buy chosen technology and products

xi Assessment of potential markets through market survey and increasing access of beneficiaries group to appropriate technologies/products

xii Encourage active participation of women and *dalits* (disadvantage group), and promotion of income generating activities. Scaling-up of successful technologies should be backed by income generating activities

xiii Need to form strong network/coordination with organisations and individuals with similar goals and work together to bring about effective policy changes that favor mitigation of IAP and technology transfers

xiv IAP mitigation technology should be integrated into mainstream development programmes both at district and national levels

Chapter Six
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www.solarcooker.org

Annexes

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

Annex 2: List of organisations involved in dissemination of metal stoves

Annex 3: List of organisations involved in briquetting technology

Annex 4: List of organisations involved in smokehood promotion/production

Annex 5: List of biogas related organisations

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

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
Alternative Energy Promotion Center/Energy Sector Assistance Programme, AEPC/ESAP (Government), 1996	PO Box 14237 Khumaltar, Lalitpur, Nepal Tel: 01 5543044/5539327 (AEPC) 01 5539390/5539391 (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. Neils Juhl Thomsen (ESAP) Chief Advisor 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 2nd pothole raised two potholes stoves Number: More than 200,000.	42 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, Executive Chairman CP: Mr. Rajan Thapa Mr. Damokar Karki Ms. Rakshya Pandey	Type: Single, two and three potholes stoves with chimney and some institutional stoves Number: 153, 000 (programme of AEPC/ESAP)	Mid hill districts

cont...

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
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
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 Programme 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	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, Tanahaun, Makawanpur, Dadeldhura,
Environmental Management Action Group, EMA – GROUP	PO Box 5530, Kathmandu, Nepal	OH: Bal Krishna Raj Joshi Chairman	Type: Two potholes Number: 30	Kathmandu

cont...

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
(NGO), 1990	Tel: 01 6260090	CP: Mr. Surendra Lal Shrestha		
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 Okhaldhunga, 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: recast@mail.com.np	OH: Prof. Mohan Bikram Gyawali Executive Director CP: Dr. Sushil Bajracharya	Type: Single, two and three potholes (same and raised surface), institutional (Single, two and three potholes, lapsi and khuwa chulo), Two potholes (with smokehood)	NA
Rural Energy Development Programme, 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 Programme 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, Tanahaun, Dhading, Tehrathum, Panchthar, Accham,Sindhupalchowk, Kavre, Dolakha, Solukhumbu, Dailekh, Okhaldhunga, Pyuthan, Sankhuwasabha Humla

cont...

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
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 potholes) 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 potholes, commercial and institutional Number: 25000	Sindhupalchowk, Dolakha, Kavre, Ramechap, 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 E-mail: solvenepal@gmail.com Website:www.deprosc.org.np	OH: Mr. Ram Bhattarai President CP: Mr. Arjun Bhattarai	Type: Single, two and three potholes Number: 500	Ilam, Panchthar
Society of Local Volunteers Effort Nepal SOLVE – NEPAL, (NGO), 1989	PO Box 5556, Subidhanagar, Kathmandu, Nepal, (Contact office) Dhankuta 6, Nepal (Head office)	OH: Mr. Rajendra Pradhan Executive Director CP: Ms. Jyoti Pradhan, Dhankuta	Type: Two potholes Number: 900	Dhankuta

Annex 2: List of organisations involved in dissemination of metal stoves

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and 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 bayupankhi 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 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
Mechanical Department, Kathmandu University (Public Private Research), 1991	PO Box 6250, Dhulikhel 7, Kavre, Nepal Tel: 11 661399 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	OH: Mr. Gopal Mittal Executive Director CP: Mr. Navaraj Adhikari	Type: As per demand Number: NA	NA

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Annex 2: List of organisations involved in dissemination of metal stoves

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
Nepal Academy of Science and Technology, NAST (formerly RONAST), (Research and Development), 1982	PO Box 3323, Khumaltar, Lalitpur, Nepal Tel: 01 5547715/5547717 Fax: 01 5547713 E-mail: info@nast.org.np Website: www.nast.org.np	OH: Prof. Hom Nath Bhattarai Vice Chancellor	Type: Beehive Briquette Stoves Number: NA	NA
Nepal Yantrasala Energy Pvt. Ltd., 1976	Patan Industrial Estate, Lalitpur PO Box 8975 Kathmandu, Nepal Tel: 01 5522167/5527857 E-mail: yenergy@hons.com.np Website:www.nyenergy.com	OH: Mr. Shyam Raj Pradhan Executive Director CP: Dr. Indira Shakya	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 Patan Industrial Estate, Lalitpur	OH: Mr. Hasta Bahadur Pandit Managing Director CP: Mr. Shyam Raj Pradhan	Type: Production of metal stoves and bayupankhi stoves Number: 5000	Urban and semi urban area, and area with access of electricity
Structure Nepal Pvt. Ltd., 1971	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. Hasta Bahadur Pandit	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 E-mail: staricn@vianet.com.np Website: www.staric.com.np	OH: Prof. Dr. Chandra Bahadurr Joshi Executive Director CP: Mr. Rajendra Pradhan CP: Mr. Pawan Shrestha	Type: Ujelli metal stove with thermoelectric generator Number: NA (still in field test)	NA (Field test in Rasuwa)

Annex 3: List of organisations involved in briquetting technology

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
Foundation for Sustainable Development, FoST, (NGO), 2002	PO Box 10776, Golkopakha, Thamel, Kathmandu, Nepal Tel: 01 4361574/4351225 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. Number: 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 Number: NA 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 E-mail:mbi1994sure@hotmail.com	OH: Mr. Surendra Gorkhali Executive Director CP: Mr. Surendra Gorkhali	Type: Production of rice husk briquette Number: 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: recast@mail.com.np	OH: Prof. Mohan Bikram Gyawali Executive Director CP: Dr. Krishna Raj Shrestha	Type: Beehive briquette Number: NA	NA

Annex 4: List of organisations involved in smokehood promotion/production

Name and type of organisation with year of establishment	Address, tel and fax number, email address and website	Organisation head (OH) with designation and contact person (CP)	Type and number of ICS disseminated	Implemented area
Practical Action Nepal (INGO), 1979 in Nepal (Originally in UK since 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	Type: Smoke hood 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: recast@mail.com.np	OH: Prof. Mohan Bikram Gyawali, Executive Director CP: Dr. Sushil Bajracharya	Type: Smoke hood Number: NA	NA

Annex 5: List of biogas related organisations

Organisation name	Contact details
1. All Nepal Biogas Company (Pvt) Ltd.	Banepa – 9, Kavre Tel: 011 – 63677 / 9851055209 info@allnepalbiogas.com
2. Biogas Bistar Company (Pvt) Ltd.	Bharatpur – 10, Hakim Chowk, Chitwan Tel: 056 – 523878/523515, 9845023743
3. Butwal Gobar Gas Company (Pvt) Ltd.	Butwal – 12, Base camp, Rupandehi Tel: 071 – 541973 /545848
4. Bageshori Gobar Gas (Pvt) Ltd. (Previous Baral Gobar Gas)	Pokhara Nagarpalika – 8, Newroad Tel: 9846023112
5. Bhairabi Gobar Gas Udhyog (Pvt) Ltd.	Chaughada Bazar – 7, Nuwakot Tel: 010 – 69257 PCO
6 Baikalpik Urja Bikash Company (Pvt) Ltd.	Bharatpur – 12, Chitawan Tel: 056 – 525331
7. Gobar Gas Tatha Krishi Yantra Bikash (Pvt) Ltd.	New Baneshwor, Kathmandu Tel: 01 – 4462582
8. Gramin Gobar Gas Tatha Urja Bikash (Pvt) Ltd.	Dumre, Tanahu Tel: 065 – 80016
9. Gorakhkali Gobar Gas Tatha Urja Bikash	Prithivi Narayan – 3, Shaktichowk, Gorkha Tel: 064 – 420618
10. Himalayan Gobar Gas Tatha Gramin Sewa (Pvt) Ltd.	Bharatpur – 10, Chitwan Tel: 056 – 530667
11. Integrated Energy Development Company (Pvt) Ltd.	Kumroj, Chitwan Tel: 056 – 20224
12. Jansewa Gobar Gas Company (Pvt) Ltd.	Chaubiskoti, Bharatpur, Chitwan Tel: 056 – 28471
13. Janta Gobar Gas Nirman Tatha Baikalpik Urja Bikash Anusandhan Kendra	Bharatpur – 10, Chitwan Tel: 056 – 524987
14. Janabhavana Gobar Gas Udyog (Pvt) Ltd.	Bidur – 1, Dhunge, Nuwakot Tel: 010 – 560123
15. Janapriya Gobar Gas Company (Pvt) Ltd.	Barakalpur – 2, Imiliya, Kapilvastu
16. Kamana Gobar Gas Company (Pvt) Ltd.	Bhoteodar, Lamjung Tel: 066 – 29444/ 29304

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Organisation name	Contact details
17. Khanal Gobar Gas Sewa Kendra (Pvt) Ltd.	Damauli, Vyas Nagarpalika, Chapaghat, Tanahu Tel: 065 – 60421
18. Kishan Gobar Gas Udyog (Pvt) Ltd.	Dhunge, Bidur, Nuwakot Tel: 010-60435, KTM ph. 4360130
19. Kamala Gobar Gas Company (Pvt) Ltd.	Anarmuni – 4, Birtamod, Jhapa Tel: 023 – 541094, 542461 (shop), 42308 (Res)
20. Krishi Bikash Gobar gas Company (Pvt) Ltd.	Biratnagar, Morang. Tel: 021 – 528799
21. Laligurans Gobar Gas Company (Pvt) Ltd.	Makar – 4, Bardaghat, Nawalparasi Tel: 078 – 580181
22. Lamjung Gobar Gas Nirman Tatha Gramin Batabaran Samrachhyan (Pvt) Ltd.	Besisahar – 2, Lamjung Tel: 061-539550/9841206315
23. Lokpriya Gobar Gas Tatha Saurya Shakti Bikash (Pvt) Ltd.	Mainroad, Itahari – 1, Sunsari Tel: 025 – 581876/26 – 520060
24. Manaslu Gobar Gas Company (Pvt) Ltd.	Damak, Jhapa Tel: 023 – 80397
25. Maheshmati Gobar Gas Udyog (Pvt) Ltd.	Dharke Bazaar, Dhading Tel: 010 – 529119, 4284609
26. Mankamana Gobar Gas Sewa Kendra (Pvt) Ltd.	Pokhara – 8, Kaski Tel: 061 – 535432
27. Mechi Gobar Gas Company (Pvt) Ltd.	Biratchowk, Indrapur – 3, Morang Tel: 021 – 545007/9842024372
28. Nepal Biogas Company (Pvt) Ltd.	New Baneshwor, Kathmandu Tel: 01 – 470062
29. Nepal Gobar Gas Bistar Tatha Bikash Company (Pvt) Ltd.	Dumre, Tanahun Tel: 065 – 80016
30. Nil Kamal Gobar Gas Company (Pvt) Ltd.	Bharatpur – 10, Chitwan Tel: 056 – 523688/520786
31. Panchthar Gobar Gas Company (Pvt) Ltd.	Phidim – 1, Panchthar Tel: 024 – 20212
32. Paschimanchal DhaulagiriGobar Gas Tatha Sewa (Pvt) Ltd.	Aanandaban – 3, Manigram, Rupandehi Tel: 071 – 560691

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Organisation name	Contact details
33. Public Gobar Gas & Rural Development Company (Pvt) Ltd.	Sukranagar – 10, Butwal, Rupandehi Tel: 071 – 43122, 987021237
34. Pragati Gobar Gas Sewa Kendra (Pvt) Ltd.	Main Road, Vyas – 11, Tanahun Tel: 065-560573/560873
35. Rapti Gobar Gas Company (Pvt) Ltd.	Hetauda – 4, Makawanpur Tel: 057 – 521825
36. Rastriya Gobar Gas Nirman Tatha Sewa (Pvt) Ltd.	Bharatpur – 10, Chitwan Tel: 056 – 521563, 524275, rggbha@mos.com.np
37. Shiva Shakti Gobar Gas (Pvt) Ltd.	Fikkal Bazaar, Ilam Tel: 027 – 540250
38. Sital Gobar Gas Company (Pvt) Ltd.	Tam Nagar, Butwal – 14, Rupandehi Tel: 071 – 545766
39. Sana Krishak Samudaik Gobar Gas Company (Pvt) Ltd.	Indrapur, Morang Tel: 021 – 545359
40. Tribeni Gobar Gas Company (Pvt) Ltd.	Kawasoti – 5, Nawalparasi Tel: 078 – 540313
41. Bhrikuti Gobar Gas Company (Pvt) Ltd.	Jeetpur – 4, Kapilbastu Tel: 071 – 562238(R)/ 071 – 549478
42. Biogas Construction & Energy Development (Pvt) Ltd.	DDC Road, Gulariya, Bardia, Banke Tel: 084 – 420524
43. Dipshikha Urja Bikash Company (Pvt) Ltd.	LNP – 7, Talchowk, Kaski Tel: 061 – 560406
44. Gandaki Gobar Gas Sewa Kendra (Pvt) Ltd.	Prithvichowk, Pokhara – 8, Kaski Tel: 061 – 523145
45. Gharelu Gobar Gas Tatha Prabidhi	Mahendra Rajmarga, Chauraha, Butwal – 10 Rupandehi Tel: 071 – 540827
46. Bikash Company (Pvt) Ltd.	Achham Tel: 987020852
47. Gorkha Urja Bikash Company (Pvt) Ltd.	Prithvi Narayan – 3, Harmatari, Gorkha Tel: 064 – 420552/9841319627
48. Hamro Gobar Gas Company (Pvt) Ltd.	Pourahi – 5, Rautahat Tel: 9841278899

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Organisation name	Contact details
49. Hetauda Gobar Gas Company (Pvt) Ltd.	Hetauda – 4, Makwanpur Tel: 985067246/057 – 522824
50. Himal Energy Development Company (Pvt) Ltd.	Kumroj – 1, Harnari, Chitwan Tel: 056 – 560659/5554616
51. Kantipur Gobar Gas Company (Pvt) Ltd.	Kamalamai NagarPalika – 6, Sindhuli Tel: 047 – 520405
52. Kamadhenu Baikalpik Urja Company (Pvt) Ltd.	Shurunga – 5, Jhapa Tel: 023 – 550046
53. Lekbeshi Saurya Urja Tatha Gobargas Sewa Company (Pvt) Ltd.	Tamghas – 1, Naya Bazar, Gulmi Tel: 079 – 520207/520166
54. Makalu Gobar Gas Company (Pvt) Ltd.	Tamthok – 8, Sankhuwasabha Tel: 026 – 520513
55. Mahila Samuhik Bikash Company (Pvt) Ltd.	Rautahat – 1,Chandranigahapur, Chitwan Tel: 046 – 570058/055-540393
56. Motherland Energy Group (Pvt) Ltd.	Gangabu, Kathmandu Tel: 9841271677
57. Machapuchre Bio Biogas Tatha Gramin Bikash Company (Pvt) Ltd.	Vyas – 2, Damuli, Tanahun Urja, Tanahu Tel: 9846021700
58. Munal Gobar Gas Company (Pvt) Ltd.	Damak – 11, Jhapa Tel: 023 – 582170/540042
59. Nipurn Gobar Gas Company	Bhoteodar, Lamjung Tel: 064 – 520754//061 – 561144
60. New Deep Public Gobar Gas and Urja Company (Pvt) Ltd.	Ghorahi, Dang
61. Pathibhara Gobar Gas Company (Pvt) Ltd.	Ilam – 3, Ilam Tel: 027 – 521107/9852680057
62. Public Urja Bikash Company (Pvt) Ltd.	Itahari – 4, Sunsari Tel: 025 – 581639/582250
63. Ramechhap Gobar Gas Company (Pvt) Ltd.	Manthali – 6, Ramechhap Tel: 2111117
64. Ratna Joti Gobar Gas Tatha Urja Bikash company (Pvt) Ltd.	Bandipur – 1, Tanahun Tel: 065 – 580011

cont...

Organisation name	Contact details
65. Rastriya Baikalpik Urja Prabardhan Tatha Bistar Company (Pvt) Ltd.	Dhumbharahi, Kathmandu – 4 Tel: 4481166/2071124
66. Sulav Biogas and Alternative Energy Development Service Centre	Vyas – 7, Chapaghat, Tanahu Tel: 065 – 60421 (R)
67. Sudurpaschimanchal Gobar Gas Tatha Urja Bikas Company (Pvt) Ltd.	Mahendranagar – 18, Kanchanpur Tel: 099-525096/524064
68. Sarbodaya Urja Tatha Gobargas Company (Pvt) Ltd.	Besisahar – 2, Lamjung Tel: 61 – 539167
69. Suryodaya Gobar Gas Company (Pvt) Ltd.	Ramilo, Morang Tel: 9842021937
70. Bikash Company (Pvt) Ltd.	Kamalamai N.P. – 11, Biman, Sindhuli
71. Taplejung Gobar Gas Company (Pvt) Ltd.	Phuling – 4, Taplejung Tel: 024 – 460031
72. Gorakha Urja Bikash Company (Pvt) Ltd.	Prithivi Narayan – 3, Harmatari, Gorkha Tel: 064 – 420552/9841319627

Source: Alternative Energy Promotion Centre (AEPC), Nepal

INVENTORY OF INNOVATIVE INDOOR AIR POLLUTION ALLEVIATING TECHNOLOGIES IN NEPAL

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