

**ENERGY, ENVIRONMENT AND CLIMATE CHANGE ISSUES:  
NEPAL**

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## Energy in Nepal

|   |        |
|---|--------|
| <b>Demography and economy</b>                   |        |
| Area (million sq. km)                           | 0.147  |
| Population (million persons), 1998              | 23.6   |
| GDP (10 <sup>9</sup> US\$), 1997                | 5.0    |
| <b>Energy data</b>                              |        |
| Total commercial energy consumption (PJ), 1995  | 23.0   |
| Total traditional energy consumption (PJ), 1995 | 234.0  |
| <b>Electricity data (1998)</b>                  |        |
| Total generation (GWh),                         | 1373.0 |
| Total installed capacity (MW)                   | 319.0  |
| Hydro-power (MW)                                | 261.0  |
| Multi-fuel & diesel (MW)                        | 58.0   |
| Imported power (MW)                             | 60.0   |

This book looks at Nepal, and how the different energy resources and technology options affect the environment, especially through the production of greenhouse gases.

The options analysed are:

- Energy-efficient options for mitigating emissions of greenhouse gases from the electricity sector
- Biomass as an energy source, and technical options for greenhouse gas emission reduction

These options were chosen because of the large contribution they can make to the overall greenhouse gas mitigation.

## Part I: Energy-efficient options for mitigating emissions of greenhouse gases from the electricity sector

### Power Sector in Nepal

#### *Current situation - early stages of electrification*

Nepal is in the early stages of electrification, with only about 15% of the population connected to an electricity supply. The residential and industrial sectors accounted for 39% and 41% respectively of the total electricity consumption in 1998. The load factor (ratio of average demand to peak demand) is low (i.e. 50% in 1996) because of the relatively high share of residential demand for lighting. Overall, efficiency of electricity use is very low, owing to the predominance of low-efficiency appliances.

#### *Anticipated growth - rapid expansion anticipated*

Electricity consumption in Nepal is expected to grow at 12% per annum during 1996-2010. Power sector development accounted for 8-20% of the total development outlay of the country during 1985-95, and is heavily dependent on foreign capital.

Improvements in energy efficiency are considered to be one of the major options available for the mitigation of greenhouse gases. This part of the study assesses the potential of selected efficient electrical appliances for reducing the power generation requirements and mitigating carbon dioxide (CO<sub>2</sub>) emissions. The table below shows the range of energy-efficient appliances considered.

| <b><i>Efficient appliances considered for power reduction and greenhouse gas emission mitigation</i></b> |  |   |
|--|--|---|
| <b>Sector</b>  | <b>Existing appliance</b>                    | <b>Efficient appliance</b>  |
| <b>Residential</b>   | Incandescent lamps<br>40W-100W               | Compact fluorescent lamps (CFLs) 13 W-23 W and fluorescent lamps (FLs) 18 W-40 W  |
| <b>Commercial</b>  | Incandescent lamps<br>40W-100W               | Compact fluorescent lamps (CFLs) 13 W-23 W and fluorescent lamps (FLs) 18 W -40 W |
| <b>Industrial</b>  | Standard electric motors<br><3.7KW & >3.7 KW | Efficient electric motors<br><3.7KW & >3.7 KW                                     |

In the industrial sector, electric motors were considered, owing to their predominant share (82%) of the sector's electricity consumption. Only lighting appliances were considered in the commercial sector because of limited data.

### **The potential for reduced electricity generation**

The potential for reduced electricity generation can be viewed in two ways:

- Technical potential
- Economic potential
  
- **Technical potential**

The following table shows the generation that could be avoided in the residential, commercial and industrial sectors from a technical perspective, during the time period 1996-2010 if existing low-efficiency appliances were replaced with efficient ones.

| <b><i>Generation avoided by efficient appliances<br/>- technical perspective during 1996-2010</i></b> |                                      |                                 |
|---|--------------------------------------|---------------------------------|
| <b>Sector</b>   | <b>Efficient appliance</b>           | <b>Generation avoided (GWh)</b> |
| <b>Residential</b>  | Compact fluorescent lamps: 13 W-23 W | 4325                            |
| <b>Commercial</b>   | Compact fluorescent lamps:13 W-23 W  | 879                             |
| <b>Industrial</b>   | Energy-efficient motors              | 672                             |
| <b>Total generation avoided</b>   |                                      | 5876                            |
| <b>Total generation (business-as-usual)</b>   |                                      | 44 132                          |

From a technical perspective, the level of electricity generation avoided by using efficient lighting alone is greater than the total amount of electricity generated thermally in Nepal. Using efficient appliances, about 13% of the total generation in the business-as-usual scenario could be avoided, of which the residential sector provides the greatest reductions (i.e. 73.6%).

However, the benefits from the national, utility and user perspectives will differ, owing to the divergence in measures used in the analysis, such as discount rates and electricity price (or costs) from each perspective.

- **Economic potential**

Though technically feasible, technical options do not always make good economic sense. The economic potential looks at the benefits from three perspectives: national, utility and user.

*National perspective*

In this instance, the generation avoided due to efficient appliances is calculated for those cases where the cost of conserved energy is less than the long-run marginal cost of electricity supply at the user's terminal.

In this case, most of the efficient appliances were found to be cost-effective, even where the administrative cost for demand-side management was 20% of the capital cost. As a result, all the reductions in power generation could be realised, at a cost of about US\$ 423 million at 1996 prices.

*Utility perspective*

From the utility perspective, the electricity generation that could be avoided is the total generation avoided if it is found to have a positive net annual benefit for the utility.

From this perspective, all the selected appliances except compact fluorescent lamps in the commercial sector were cost-effective. Thus, from this perspective, the total avoided generation would only be 4997 GWh.

- *User perspective*

This is the electricity generation avoided from the use of an efficient appliance if it is found to be financially cost-effective to the user.

Only the high wattage fluorescent lamps were found to be cost effective in the residential sector, although all were found to be cost effective in the commercial sector. Energy-efficient motors were found to be cost-effective in the industrial sector. From the user perspective, the power generation that could be avoided cost-effectively is 3116 GWh (i.e., 6.9% of the total electricity generation during the period), substantially less than the total power generation that could be avoided in the technical sense.

## Potential for reduction in CO<sub>2</sub> emissions

### Technical potential

The table below shows the mitigation potential of selected efficient appliances during 1996-2010 from a technical perspective:

| <b>CO<sub>2</sub> mitigation potential of efficient appliances<br/>- technical perspective during 1996-2010</b> |  |                      |
|---|--|----------------------|
| Type of efficient appliances  | CO <sub>2</sub> mitigation                               |                      |
|   | CO <sub>2</sub> emissions avoided (10 <sup>3</sup> tons) | % of total emissions |
| Residential lighting  | 1013   | 100                  |
| Commercial lighting and Industrial motors   | 755  | 74                   |

If all incandescent lamps used by households in 1996 were replaced by CFLs and the use of these lamps was maintained at the 1996 level throughout the period 1996-2010, the entire thermal power generated during the period could be avoided with consequent removal of emissions of CO<sub>2</sub>. If efficiency improvements were targeted at commercial lighting and industrial electric motors, over 70% of emissions could be avoided during the period.

### Economic Potential

- *National perspective*

The CO<sub>2</sub> mitigation potential of the selected appliances in the residential, commercial and industrial sectors from the national perspective is the same as that from the technical perspective. Energy-efficient motors are found to be the most cost-effective appliances in terms of CO<sub>2</sub> mitigated per dollar of incremental cost. These are followed by the use of CFLs in the commercial and residential sectors respectively.

- *Utility perspective*

The CO<sub>2</sub> mitigation from this perspective is the same as that from the technical perspective, as shown in the table above.

- *User perspective*

About 97% of the total emissions of CO<sub>2</sub> could be mitigated by using energy-efficient lighting in the residential sector. Similarly, 28% and 37% of the total CO<sub>2</sub> could be mitigated from the commercial and industrial sectors during 1996-2010. EEMs in the industrial sector are most cost-effective in terms of

CO<sub>2</sub> mitigated per dollar of incremental cost. These are followed by efficient lighting appliances in the commercial and residential sectors respectively.

### **Integrated Resource Planning**

In the previous section, the saving potentials of energy-efficient appliances were analysed by comparing the cost-effectiveness of individual appliances only. The structure of power generation was assumed to remain unchanged in evaluating the mitigation potential of environmental emissions. This approach, however, has a limitation, in that the generation and capacity mix are not based on a least-cost power development plan which determines the most economical levels of demand- and supply-side options. This section presents the assessment of the potential of efficient demand-side and supply-side options for mitigation of greenhouse gas emissions for Nepal from the long-term integrated resource planning (IRP) perspective over the period of 2000-2014. Integrated Resource Planning (IRP) is a relatively new approach which is yet to be adopted by the utilities in Nepal.

Using IRP, the cost-effectiveness of both supply and demand options can be brought together. Three scenarios were analysed:

| <b><i>Options analysed using integrated resource planning</i></b> |  |
|---|--|
| <b>Case 1: Traditional resource planning</b>                      | In this case, only supply-side options were considered to meet predicted demand. A discount rate for new plant of 10% has been used  |
| <b>Case 2: Integrated resource planning - base case</b>           | In this scenario, 23 demand-side options were included in the analysis: replacement of<br>- twelve types of lamps - residential sector<br>- eight types of lamps - commercial sector<br>- motors - industrial sector<br>There is no restriction on the penetration for energy-efficient appliances |
| <b>Case 3: Integrated resource planning – restricted case</b>     | As in the scenario above, but with the rate of penetration starting from 10% and ending at 80% at the end of the planning period.  |

## **Results using integrated resource planning**

### *Savings in installed generation*

The integrated resource planning study reveals that efficient demand-side options would save significant amounts of installed generation capacity and electricity generation during the planning horizon (2000-2014). A total of 275 MW installed capacity (16% of the total under TRP) and 827 GWh of electricity generation (11% of the total under TRP) would be avoided during 2000-2014 in the IRP base case.

The demand-side management options in residential sector lighting contribute 71% of the total avoided installed capacity and 56% of the total generation avoided during the planning period.

### *Increased load-factor and system capacity factor*

With an efficient demand-side management option, the weighted average system load factor was found to increase from 57.8% in the TRP to 58.5% in the IRP base case, while the system capacity factor was found to increase from 50.1% in the TRP to 52.0% in the IRP base case.

The system reliability was found to deteriorate with efficient demand-side management options, i.e., annual weighted average system loss of load probability (LOLP) was found to increase from 0.84% in the TRP to 1.02% in the IRP base case.

### *Overall cost reduction*

With the use of demand-side management options, savings in electricity generation as well as installed capacity were found to result in a reduction of total cost by 12.6%.

The average incremental cost of electricity generation is found to decrease from 4.14 US cents/kWh in the TRP to 3.47 US cents/kWh in the IRP base case using integrated resource planning, due to the introduction of efficient DSM options.

### *Reduction in emissions*

Using IRP, it was found that CO<sub>2</sub> emission would be reduced by 42%, SO<sub>2</sub> by 44% and NO<sub>x</sub> by 45% as compared to emissions under TRP.

## **Barriers on efficiency improvements**

### *Macro-level barriers*

These represent policy-related barriers to energy efficiency improvements that exist currently in Nepal.

- Energy planners are biased towards supply-side solutions, such as major electricity generating facilities, ignoring demand-side options.
- There is a lack of government information on energy-saving technologies. The government information programme is confined to TV and radio advertising and wall posters exhorting people to use less electricity.
- Although there are plans to promote energy conservation in hotels and industries through compulsory energy audits and information campaigns, more needs to be done to promote energy-efficient appliances.
- The structure of electricity pricing does not reflect the distribution of costs;
  - subsidies mean that for a large number of user categories, current charges are significantly below the true economic cost of electricity use. Except for commercial customers, all other user classes are receiving subsidized electricity. Subsidy serves as a disincentive to conservation, making energy-efficient appliances less attractive to the user. Some subsidies are not well targeted; over half the residential subsidy goes to higher income households, who could afford the outlay on energy-efficient devices.
  - thermal power provides between 6% and 9% of electricity generation in Nepal. None of the costs associated with environmental damage associated with the emissions from these power stations has been accounted for in the tariff structure.
- Customs duty and sales tax are charged on all electrical goods which are imported. These are charged as a percentage, without reference to their efficiency. Thus the energy-efficient devices, which are intrinsically more expensive, incur a larger absolute tax burden.
- There are no financial institutions that provide loans to purchase energy-efficient technologies; this impedes their adoption.

### *Micro-level barriers*

This part of the study was confined to residential sector lighting in Nepal, and focused on 100 households in the Kathmandu valley. It was found that:

- Those who adopted energy-efficient lighting tended to be younger and better educated than those who did not.

- Those adopting energy-efficient lighting knew the tariff structure for electricity pricing and the correct cost of efficient lamp purchase.
- The status of households did not appear to affect those adopting the lamps; tenants appeared to adopt them to the same extent as house-owners.
- The actual savings, and hence profitability, of fitting energy-efficient lamps cannot be predicted accurately. This acts as a deterrent to potential consumers, who need to know the benefits before committing capital.

These factors suggest that, at household level, lack of adequate information, lack of understanding of available information, and uncertainty associated with the use of energy-efficient lamps are the chief barriers to their adoption.

### **Conclusions**

From both technical and national perspectives, over 13% of the total generation could be avoided during 1996-2010 by the use of selected efficient appliances. Efficient lighting in the residential sector accounts for nearly three-quarters of this savings. However, CFLs in the commercial sector were not found to be cost-effective from the utility perspective. From the user perspective, 13W and 18W compact fluorescent lamps were not cost-effective in the residential sector.

As some energy-efficient lamps were not beneficial from the user perspective, about 97% of the total CO<sub>2</sub> emissions could be mitigated by using energy-efficient-appliances in the residential sector from this perspective. The adoption of efficient electricity pricing could increase the CO<sub>2</sub> mitigation potential of the selected efficient appliances. Similar results could be achieved through the introduction of differential import duty/sales tax for efficient appliances. It should be noted that the analysis has not considered the effect on level of consumption of electricity due to the effective fall in electricity costs caused by efficient devices.

## **Part II: Biomass as an energy source and technical options for greenhouse gas emission reduction**

### **Biomass is a vital energy source**

The total primary energy consumption in Nepal in 1994-95 was about 276.3PJ, of which about 92% was biofuel. The shares of fuelwood, agricultural residues and animal wastes in the total biofuel use for energy were 75%, 16% and 9%, respectively.

A study of the Regional Wood Energy Development Programme (RWEDP) of FAO estimated that there was a gap of about 20 PJ/year between the sustainable supply from the traditional sources of woodfuels and their estimated consumption in 1994. It is estimated that the gap may approach 120 PJ/year by the year 2010; thus, there is an urgent need to pay special attention to the augmentation of woodfuel supply in Nepal.

The deficit in the supply of woodfuels can be reduced and biomass can provide further energy service through:

- end-use efficiency improvement
- use of agricultural residues, currently disposed of by dumping or burning
- plantation in degraded land.

### **Pattern of biomass energy use**

It can be observed in Table 1 that a large quantity of biomass was consumed in traditional devices during the year 1992-93. Stoves and space heating, used in most households, consumed over four million tonnes of oil equivalent (Mtoe) of fuelwood, with about forty kilotonnes of oil equivalent (ktoe) consumed in the improved cookstoves. Nearly 0.9 Mtoe of crop residues and 0.5 Mtoe of dung were consumed in the traditional and improved cooking stoves and in space heating.

In the commercial and industrial sectors, about 112 ktoe of fuelwood, and 9 ktoe of crop residues were consumed. Furnaces and kilns consumed 32 ktoe of fuelwood, while commercial boilers utilized 60 ktoe of fuelwood. In addition, boilers consumed 6.5 ktoe of crop residue (mostly bagasse and rice husk).

**Table 1: Consumption of biomass fuels by end-use, 1992-93**

| Biomass              | Industrial and commercial sectors |                   | Residential sector   |                |
|----------------------|-----------------------------------|-------------------|--|----------------|
|                      | End-uses                          | (toe / Year)      | End-uses   | (toe / year)   |
| <b>Wood</b>          | Boilers                           | 59 748            | Fireplaces   | 195 966        |
|                      | Furnaces, Kilns, Ovens            | 32 175            | Stoves   |                |
|                      | Cooking in commercial sector      | 20 085            | -traditional   | 3 934 212      |
|                      | <b>Total</b>                      | <b>112 008</b>    | - improved   | 39 312         |
|                      |                                   |                   | <b>Total</b>   | <b>4169490</b> |
| <b>Crop residues</b> | Bagasse fired boilers             | 1 537             | Space Heating  | 43 343         |
|                      | Rice husk fired boilers           | 5 133             | Stoves   |                |
|                      | Cooking in Commercial sector      | 1 244             | -traditional   | 868 939        |
|                      | <b>Total</b>                      | <b>7 914</b>      | -improved  | 9 918          |
|                      |                                   |                   | <b>Total</b>   | <b>922 200</b> |
| <b>Charcoal</b>      | Process Heating                   | <b>8 804</b>      | Charcoal stoves in Domestic and commercial sectors for cooking and heating | <b>11 206</b>  |
| <b>Animal wastes</b> |                                   |                   | Space heating  | 23 747         |
|                      |                                   |                   | Stoves   |                |
|                      |                                   |                   | -traditional   | 462 318        |
|                      |                                   |                   | -improved  | 4 950          |
|                      |                                   | Biogas generation | 14 235   |                |
|                      |                                   | <b>Total</b>      | <b>505 250</b>   |                |

**Present biomass energy use is very inefficient and polluting**

*Conservation potential*

The amount of biomass that can be saved through efficiency improvement can serve as a source of additional energy and can potentially substitute fossil fuels to reduce net GHG emission.

Table 2 shows the estimated biomass saving potential in Nepal. The study reveals that about three million tonnes (Mt) of fuelwood, 1.2Mt of agri-residues and 0.75Mt of animal dung can be saved in the domestic cooking sector alone by replacing traditional cookstoves (TCSs) with improved cookstoves (ICSs). In addition, about 70 kilotonnes of fuelwood can be saved from industrial sector.

| Sector           | Type of biomass |               |             |
|------------------|-----------------|---------------|-------------|
|                  | Fuelwood        | Agri-residues | Animal dung |
| Domestic cooking | 3.03            | 1.23          | 0.75        |
| Industrial oven  | 0.01            | -             | -           |
| Boilers          | 0.02            | -             | -           |
| Furnaces         | 0.03            | -             | -           |
| Kilns            | 0.01            | -             | -           |
| <b>Total</b>     | <b>3.10</b>     | <b>1.23</b>   | <b>0.75</b> |

### Emissions from biomass fuels

The estimated emissions from biomass use in Nepal in 1992-93 are shown in Table 3. About 900 kt of carbon monoxide, 220 kt of total suspended particles, 25 kt of sulphur oxides, 20 kt of nitrogen oxides, 110 kt of methane and 18 Mt of carbon dioxide are released annually from biomass combustion in Nepal.

|               | Total emissions (kt) |            |                 |                 |                 |                 |
|---------------|----------------------|------------|-----------------|-----------------|-----------------|-----------------|
|               | CO                   | TSP        | SO <sub>x</sub> | NO <sub>x</sub> | CH <sub>4</sub> | CO <sub>2</sub> |
| Fuelwood      | 603                  | 167        | 2.2             | 15.6            | 88              | 12 530          |
| Agri-residues | 212                  | 32         | 10.1            | 4.0             | 8.0             | 3 547           |
| Animal wastes | 74                   | 20         | 11.8            | 1.4             | 11.9            | 1 588           |
| Charcoal      | 6                    | 0.6        | 0.01            | 0.08            | 0.2             | 64              |
| <b>Total</b>  | <b>895</b>           | <b>219</b> | <b>24</b>       | <b>21</b>       | <b>108</b>      | <b>17 729</b>   |

### Emerging Biomass Energy Technologies (BETs) and their potential role in mitigating GHGs

#### *Biomass combustion*

Combustion of biomass, which currently accounts for about 14% of the global total energy consumption, is likely to assume a much greater importance in the future as the world tries to mitigate the threat of climate change. Currently, practically all developing countries have some form of improved cooking stove programme. The design of cooking stoves varies according to the ethnic groups and geographical regions in Nepal. The most commonly used traditional two-pothole mud stoves have efficiencies of between 12% and 17%. The most

common improved stove is the ceramic insert stove developed by the Research Centre for Applied Science and Technology. Improved stoves have efficiencies of 20-27%.

Practically all biomass-based electricity generation plants employ steam turbine systems. Such electricity generation is established in developed countries, where relatively cheap, waste biomass is available. Most systems are based on low-pressure boilers (about 20-25 bar) with efficiencies slightly below 20%. Modern biomass-powered high-pressure (about 60-100 bar) boiler-turbine systems produce electricity with efficiencies approaching 32%.

Thermal energy, produced by burning biomass and other low-grade fuels, can be used for small-scale power generation using an external combustion engine, such as the Stirling engine. This may be of great interest for rural applications, since there is potential for higher efficiencies than those using gasifier-engine or steam-based power plants of similar capacity.

Although historically disappointing, the technology now appears to be improving. Based on studies in Denmark, the overall electricity generation efficiency of biomass-powered Stirling engines of capacity 36-150 kW is expected to be 21-26%. Some field units are currently being tested in New Zealand and this new generation of Stirling engines may be considered for applications in developing countries in the near future.

Cogeneration is the process of producing two useful forms of energy, normally electricity and heat, using the same fuel source. The process is well established in industries such as pulp and paper, sugar mills etc. Cogeneration is practised in sugar mills worldwide to meet in-house demand for steam and electricity, typically by using low-pressure boiler-steam turbine systems. Through the use of high-pressure systems, mills can produce substantial surplus electricity for selling locally or to the grid.

By the early 1990s, there were altogether about 220 industrial boilers in Nepal. Out of these, 120 were fossil-fuel-fired, 80 were rice-husk-fired and the remaining 20 were wood-fired and bagasse-fired boilers.

#### *Biomass gasification*

Gasification technology is more than a century old. After World War II, interest in gasification technology practically disappeared, as oil became a cheap and

convenient energy source. The energy crisis of 1973 triggered renewed interest, and a number of institutes and organizations built, tested and operated gasifier systems, mostly based on earlier designs.

Over the last 8-10 years, interest in large-scale biomass gasification for power generation has been growing. Efficiencies of over 40% are predicted for such plants. For capacities lower than 5-10 MWe, catalytic gas cleaning and low-tar gasifier designs may make a new generation of such gasifiers feasible. It has been reported that the Research Centre for Applied Science and Technology of Tribhuvan University of Nepal has done some work on downdraft wood and charcoal gasification. However, no gasifier field unit appears to exist.

#### *Biomass carbonization*

Charcoal is used for domestic cooking and other applications. Because of diminishing fuelwood supplies, charcoal-making, from residues which often cause environmental problems if left unutilized, is becoming more attractive. A wide range of devices, developed for carbonizing agricultural and other residues, have found limited acceptance so far. There are five main types of charcoal-making technology used in Nepal: earth mound; earth pit; brick beehive; mud beehive; portable metal kiln.

Recent developments in biomass carbonization include generating energy from the waste gases produced during batch carbonization. The process improves both the overall process energy efficiency and the environment. Another development is torrefaction, a low temperature carbonization process that produces a substitute product for conventional charcoal in some applications. A new technique developed in Hawaii, USA is reported to yield charcoal at 42% to 62% of the original weight, compared to about 15-30% for conventional carbonization.

A technique for producing beehive-shaped charcoal briquettes from leaves, twigs and forestry/agricultural residues has been developed in Nepal. The process consists of:

- carbonizing biomass in a drum
- grinding the charcoal to powder
- mixing the charcoal powder with a suitable binder
- manual briquetting using a mould, and
- drying in the sun.

It is claimed that the briquettes are easy to ignite, burn quite cleanly and could be appropriate for rural areas of Nepal.

#### *Biomass densification*

Depending on the type of equipment used, densification can be categorized into four main types:

- piston press densification
- screw press densification
- roll press densification
- pelletizing.

Products from the first three types of densification are large compared to pellets, and are normally called briquettes.

Densification involves compressing the raw material, which causes two problems; high electrical energy consumption by the driving motor; and wear of machine parts. Two recent developments for reducing wear and energy consumption of densification machines comprise:

- preheating to soften the raw material just before its compaction in briquetting machines.
- the use of a small amount of a thermoplastic material both to lubricate the die of pelleting presses and to improve calorific value of the densified product.

Efforts are also under way to apply advanced surface coating to the screw of briquetting machines that can dramatically increase their life by reducing wear.

The transport network in Nepal is poor, which would suggest that briquetting would be a promising technology as it allows easier transport and storage of fuel. However, dissemination of this technology has not proved successful, and most plants installed in the late 1980s have stopped operating because of a lack of proper market for biomass briquettes. Also, the cost of rice husk, an important raw material, has gone up steeply.

#### *Biogas production*

There are two main types of biogas digesters:

- floating drum
- fixed dome

By 1994, there were estimated to be 13 000 biogas plants in Nepal. Most of these (84%) were of fixed concrete-dome type, with average volume of 10m<sup>3</sup>. By the year 1998, about 50 000 biogas plants were installed in Nepal.

**GHG emission mitigation potential of Biomass Energy Technologies (BETS)**

Efficiency improvement of existing biomass energy systems and deployment of modern BETs can significantly reduce GHG emission, often at a negative cost. The emission mitigation potential is estimated by comparing a typical current situation with an assumed improved situation.

**Table 4: Emission mitigation potential of different technological options for using rice husk efficiently in Nepal (kg x10<sup>6</sup> CO<sub>2</sub> equivalent/year)**

| Technology option  | Energy generation potential | Emission mitigation potential |
|--|-----------------------------|-------------------------------|
| 1: direct combustion to produce steam                    | 5512 TJ                     | 664                           |
| 2: direct combustion for electricity generation (1 MW)   | 249 GWh                     | 259                           |
| 3: direct combustion for electricity generation (2.5 MW) | 287 GWh                     | 299                           |
| 4: direct combustion for electricity generation (12 MW)  | 478 GWh                     | 497                           |
| 5: direct combustion for electricity generation (29 MW)  | 599 GWh                     | 622                           |
| 6: gasification for electricity generation               | 171 GWh                     | 125                           |

The current situation is characterized by inefficient use of residues, with a certain amount disposed of wastefully. Fossil fuels, which could be substituted by residues, are burned, causing GHG emission. In the assumed improved situation, residues are used efficiently, and previously wasted residues are substituted for fossil fuels in a selected type of modern biomass energy system.

Table 4 gives the estimated energy generation potential and total GHG emission mitigation potential for rice husk in different modern energy systems

in Nepal. Most of these technology options offer lower costs of energy generation than comparable fossil-fuel based options.

### **Conclusion**

Energy from biomass constitutes an important part of the total energy supplies in Nepal. The manner in which biomass is currently utilized for energy is, however, far from ideal and is characterised by gross inefficiency and pollution of the environment. Biomass fuels could provide a much more extensive energy service than at present if they were used efficiently. This would help reduce the significant gap between sustainable supply and consumption of woodfuels that exists in Nepal. It would also serve to reduce emission of greenhouse gases through substitution of fossil fuels.

- Biomass energy accounted for about 92% of the total primary energy consumption in 1994-95 in Nepal.
- Fuelwood, agricultural residues and animal wastes accounted for 75%, 16% and 9% respectively of the biomass energy consumption in 1994-95.
- Most of the fuelwood consumed in Nepal is used in traditional stoves (92%).
- The share of biomass used for energy in the different sectors in 1992-93 is as follows:

|                     |        |
|---------------------|--------|
| - domestic sector   | 97.76% |
| - industrial sector | 1.87%  |
| - commercial sector | 0.37%  |

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