Domestic Biogas Production and Use in Nepal – A Simple, Reliable, Clean and Cost-Effective Solution to Provide Energy Security to the Rural Households

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Abstract

Nepal is rich in natural resources with a high potential for energy supply, but it is facing an energy crisis. Electricity supply is unreliable and often in short supply. LPG and kerosene are imported, and therefore expensive and less accessible. Biogas is starting to be used for cooking but only at 17% of the total potential households. Most of the fuel used for cooking in rural areas is traditional fuelwood. It takes time and hardship to collect especially for women, emits unhealthy smoke and can lead to deforestation. As an alternative, biogas, mostly methane, has good potential for cooking and heating. It can be produced in a simple plant digester by anaerobic decomposition of biodegradable organic wastes. Cattle dung and human excreta are the main feedstocks used in domestic biogas plant in Nepal. Biogas can be a highly efficient and low carbon emission fuel as it can replace the excessive use of traditional biomass and reduce the associated adverse impacts on social, health and environmental conditions. Biogas development is one of the government's priority programmes in Nepal to provide reliable, clean and low cost energy supply particularly to rural households. However, the replication of the technology is still slow. Biogas production is lower than its full capacity and cannot cover the energy demand of a typical household all year round, especially during winter. Hence, this study aims to explore the potential solution to increase domestic biogas production and use so that its benefits for energy security and environmental emission reduction can be optimised.

Both quantitative and qualitative research approach were applied. Surveys of biogas households in Nepal were conducted to collect household-level information. Key informant interviews, informal discussions and observations were undertaken to gain insight into the context of overall renewable energy technologies, the production and use of biogas technology, and constraints and opportunities for its wider replication, especially to rural poor households.

Users' socioeconomic conditions, feedstock availability, plant design and cost are the major influencing factors for biogas production. The poor households cannot afford to purchase the system, or own fewer cattle, so less dung is available to feed the plant. Others who have enough cattle for dung are also not feeding the required quantity of dung to produce biogas but use it for field manure. Hence, the plants are under-performing in terms of their technical potential mainly due to the insufficient feedstock used. Agricultural residues are easily available, but do not realise their use with dung for co-digestion to increase biogas production.

This research thus analysed the effect of co-digestion of dung with agricultural residues to increase biogas yield. The cost effectiveness of co-digestion technology is also checked out by using financial analysis. The impacts of improved biogas production on the cost of energy, energy consumption and associated greenhouse gas (GHG) emissions reduction were obtained by using the Long-range Energy Alternative Planning (LEAP) system model.

Co-digestion of dung with crop residues could improve biogas production by approximately 50-150% and would meet most of the household cooking energy demand throughout the year. The increased availability of biogas could help address strategic gender needs by utilising the saved time more than 3.2 hours/day for fuelwood collection and cooking in traditional stoves. From the cost-effective perspective, an average total annual cost of energy after co-digestion is up to 37% cheaper than the existing biogas production condition, and even up to 45% cheaper than the energy cost of non-biogas households. Furthermore, a co-digested biogas plant has the potential to reduce average annual energy consumption by 46-57 gigajoules and GHG emissions, mainly from avoiding deforestation, by16.7-19.3 tCO_2e per household depending on region, compared to a non-biogas household.

This study, however, pointed out some important issues that are to be addressed to make this research outcome more applicable. Mainly, the design of a biogas digester should be suitable for co-digestion and the government subsidy needs to be revised accordingly to cover any potential increase in the cost of the modified plant design. The utilisation of saved time to achieve strategic gender needs can also be a priority. In summary, this study analysed all three impacts together: *energy consumption; cost of energy; and corresponding GHG emissions,* of co-digestion technology. This has not previously been reported in the literature. This study's findings can also be relevant to other developing countries where biogas can be a part of the solutions to provide energy security, gender equality and climate change mitigation.

The recent earthquake in Nepal (on 25/4/2015 a 7.9 magnitude earthquake devastated much of the country along with subsequent aftershocks) has left extremely adverse effects on all social, economic, environment and energy supply conditions. At the time of printing the scale of damage and loss of life is still being estimated, but this is clearly an extremely damaging event. It will take a long time and huge funds and a massive pace of infrastructure development to get the situation back to normal. Nonetheless, let's hope this study's outcome will also add further **importance to the biogas development to uplift the current vulnerable energy supply situation in poor rural households.**

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Abbreviations and Acronyms

ADB/N	Agricultural Development Bank Nepal
AEPC	Alternative Energy Promotion Centre
APCAEM	Asia and Pacific Centre for Agricultural Engineering and Machinery
APERC	Asia Pacific Energy Research Centre
BANZ	Bioenergy Association of New Zealand
BMP	Biochemical methane production
BSP-Nepal	Biogas Support Programme- Nepal
C/N	Carbon-Nitrogen ratio
CBS	Central Bureau of Statistics
CDCF	Community Development Carbon Fund
CDM	Clean Development Mechanism
CES	Centre for Energy Studies
CFC	Chlorofluorocarbon
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COD	Chemical Oxygen Demand
CRTN	Centre for Rural Technology, Nepal
CSPP	Climate-Smart Planning Platform
DDC	District Development Committee
DFRS	Department of Forest Research and Survey
ENPEP	Energy and Power Evaluation Program
FAO	Food and Agriculture Organization of the United Nations
FIRR	Financial Internal Rate of Return
GDI	Gender Development Index
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GGC	Gobar Gas Company
GHG	Greenhouse gas
GJ	Gigajoule
GMP	Greenhouse Gas Mitigation Potential
GoN	Government of Nepal
GPOBA	Global Partnership for Output-Based Aid

GW	Gigawatt
GWP	Global Warming Potential
HDI	Human Development Index
HOMER	Hybrid Optimization Model for Electric Renewables
IDE	International Development Enterprises
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
IRADe	Integrated Research and Action for Development
IUCN	International Union for Conservation of Nature
KfW	Kreditanstalt fuer Wiederaufbau
KVIC	Khadi Village Industries Commission
kWel	Kilowatt electric
kWh	Kilowatt hour
LAPA	Local Adaptation Plan for Action
LEAP	Long Range Energy Alternative Planning
LPG	Liquefied Petroleum Gas
MAED	Model for Analysis of Energy Demand
MARKEL	Market Allocation Model
MDG	Millennium Development Goal
MEDEE	Modèle d'Evolution de la Demande d'Energie
MESAP	Modular Energy System Analysis and Planning
MJ	Megajoule
MSTE	Ministry of Science, Technology and Environment
Mtep	Million tonne equivalent of petroleum
MUHEC	Massey University Human Ethics Committee
MW	Megawatt
N_2O	Nitrous oxide
NAMA	Nationally Appropriate Mitigation Actions
NAPA	National Adaptation Programme of Action
NEA	Nepal Electricity Authority
NEMS	National Energy Modelling System
NPC	National Planning Commission
NRs	Nepalese Rupees
OECD	Organisation for Economic Co-operation and Development
PASA	Practical Action South Africa
PJ	Petajoule

POLES	Perspective Outlook on Long-term Energy System
PPM	Parts per million
PPP	Purchasing power parity
PVC	Polyvinyl Chloride
QDA	Qualitative Data Analysis
REDD	Reducing Emission from Deforestation and forest Degradation
RETs	Renewable Energy Technologies
RERL	Renewable Energy for Rural Livelihood
RESGEN	Regional Energy Scenario Generator
RET	Renewable Energy Technology
SD	Sustainable Development
SDGs	Sustainable Development Goals
SNV	Netherlands Development Organisation
STP	Standard temperature and pressure
tCO_2e	Tonnes carbon dioxide equivalent
TJ	Terajoule
toe	Tonnes of oil equivalent
tCO_2e	Tonnes of carbon dioxide equivalent
TPES	Total Primary Energy Supply
TS	Total Solid
UMN	United Mission to Nepal
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organizations
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States dollar
VDC	Village Development Committee
VER	Voluntary Emission Reduction
VFA	Volatile Fatty Acids
VMP	Volumetric Methane Production
VS	Volatile solid
WECS	Water and Energy Commission Secretariat
WEM	World Energy Model
WHO	World Health Organization
WWF	World Wildlife Fund