# Transfer of Sustainable Energy Technology to Developing Countries as a Means of Reducing Greenhouse Gas Emission: The Case of Bangladesh

A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Applied and International Economics

at Massey University
Palmerston North, New Zealand

Mohammad Ershad Ali

2001

# Abstract

Over the last two decades the world has been becoming increasingly concerned about greenhouse gas (GHG) emissions, global warming, unsustainable development, and poverty in the developing countries. The most acceptable way of mitigating GHG emission is the use of sustainable energy technology (SET) instead of fossil fuel. SET is available in the global market, but is outside the scope of availability for many developing countries. Due to the lack of economic and technical capabilities and wide-spread poverty, developing countries are unable to introduce SET independently, hence a need for appropriate assistance from developed countries. The case study was conducted in Bangladesh, one of the poorest countries in the world, with acute shortages of energy and largely disadvantaged rural population.

The study assessed three energy technologies—biomass, solar, and wind—to identify the most viable options of SET for the rural Bangladesh. The appropriateness of the proposed SETs is assessed on the basis of certain criteria: availability of resources, cost-effectiveness, degree of technological complexity, matching demand and supply, and contribution to reducing GHG emission. It has been found that each SET taken separately, has its limitations. The main barrier for biomass energy technology is the availability of biomass due to scarcity of land, and hence, producing food is preferable to growing trees for fuel. The major limitations for solar and wind energy technologies are high levels of capital investment and technological complexity.

The study proposes a combination of biomass, solar, and wind SETs as a long-term solution of energy crisis in the rural Bangladesh. It suggests relevant policy and types of assistance in the form of investment in education and training, machinery, spare parts, know-how etc. A brief proposal for capacity building has been prepared. It is expected that the proposed SETs will benefit sustainable development, poverty alleviation of rural Bangladesh, and the national socio-economic conditions. The study findings contribute to general knowledge, and are especially useful for developing countries.

# Acknowledgments

I am grateful to almighty Allah who gave me the opportunity to complete this research amidst many difficulties. I owe a great deal to Dr. Peter Read who supervised me throughout the period of this research. His guidance, advice, and comments at every stage of this research were crucial to the success of this research project. Indeed, I feel fortunate and proud of having worked under his supervision. I also acknowledge the invaluable guidance received from my supervisors Professor John Overton and Dr. A.K.Enamul Haque.

It is a pleasure to acknowledge financial assistance provided by the Massey University without which I could not have undertaken this research. I also acknowledge the financial assistance received from the Department of Applied and International Economics. I am greatly indebted to all staff members of this Department.

I gratefully acknowledge the continuous support from my relatives, friends and well wishers in completing this study.

I acknowledge my sincere gratitude to Professor Srikanta Chatterjee, Dr. Nabiul Islam and Dr. Waresul Karim for their kind help and support in completing this study. Without their support and assistance it would have been impossible to complete this research. I also express my thanks to Abdul Wahab, Kamal Ahmed, Ainul Islam and Omar Al Farooque for their friendly co-operation and logistical support in completing my study.

Finally, I am proud of the support and co-operation provided by my wife Julekha who sacrificed a lot for the success of my research. My daughters Sumaya and Shakiya always encouraged and pushed me to step forward to the door of success.

# Table of Contents

# LIST OF TABLES

# LIST OF MAPS

# LIST OF FIGURES AND PHOTOGRAPHS

# LIST OF ANNEXES

# List of Acronyms and Abbreviations

| | |
|---|---|
| AC | Alternating current |
| ACRE | Unit of land (1 acre=100 decimals) |
| ADB | Asian Development Bank |
| ADP | Annual Development Programme |
| BBS | Bangladesh Bureau of Statistics |
| BCIC | Bangladesh Chemical Industries Corporation |
| BCSIR | Bangladesh Council for Scientific and Industrial Research |
| BFIDC | Bangladesh Forest Industries Development Corporation |
| BIDS | Bangladesh Institute of Development |
| BPC | Bangladesh Petroleum Corporation |
| BPDB | Bangladesh Power development Board |
| BRAC | Bangladesh Rural Advancement Committee (NGO) |
| BRDB | Bangladesh Rural Development Board |
| BREB | Bangladesh Rural Electrification Board |
| BSCIC | Bangladesh Small and Cottage Industries Corporation |
| BTC | British Tobacco Company |
| btc/year | Billion tons per year |
| BTV | Bangladesh Television |
| BUET | Bangladesh University of Engineering and Technology |
| BUP | Bangladesh Unnayan Parishad |
| BWDB | Bangladesh Water Development Board |
| CMI | Census of Manufacturing Industries |
| $CO_2$ | Carbon dioxide |
| DC | Direct current |
| DE | Department of Environment |
| DESA | Dhaka Electric Supply Authority |
| DESCO | Dhaka Electric Supply Company |
| FCCC | Framework Convention for Climate Change |
| FFYP | Fourth Five-Year Plan |
| FFYP | Fifth Five-Year Plan |
| SFYP | Sixth Five-Year Plan |

| | |
|---|---|
| GHG | Greenhouse gas |
| GIIP | Gas Initially In Place |
| GJ | Gigajoule, Energy unit of 10*10 |
| GOB | Government of Bangladesh |
| GTCL | Gas Transmission Company Limited |
| Ha | Unit of land measurement |
| IFAD | International Fund for Agricultural Development |
| IOC | International Oil Company |
| IPCC | Inter-Governmental Panel on Climate Change |
| Kg | Kilogram |
| LGED | Local Government Engineering Department |
| LPG | Liquid Petroleum Gas |
| ME&F | Ministry of Environment and Forestry |
| MEMR | Ministry of Energy and Mineral Resources |
| MLR | Multiple Linear Regression |
| NEP | National Energy Policy |
| NGO | Non-Government Organisation |
| OECD | Overseas Economic Cooperation and Development |
| PC | Planning Commission of the Government of Bangladesh |
| PJ | Peta Joule, energy unit of 10*15 joules |
| PRA | Participatory Rural Appraisal |
| PSC | Production Sharing Contract |
| PSMP | Power Sector Master Plan |
| PV | Photovoltaic |
| REDB | Rural Electrification Development Board |
| RES | Rio Earth Summit |
| RISP | Rural Industries Study Project |
| SET | Sustainable Energy Technology |
| SFYP | Second Five-Year Plan |
| SPSS | Statistical Package for Social Science |
| sq.km. | Square kilometre |
| tcf | Trillion cubic foot |
| TFYP | Third Five-Year Plan |
| TGL | Titas Gas Limited |

| | |
|---|---|
| TOE | Ton of Oil Equivalent |
| UNDP | United Nations Development Programmes |
| WAPDA | Water and Power Development Authority |
| WB | World Bank |

## Energy Conversion Factors

| | | |
|---|---|---|
| 1000 cft of gas | = | 6.4 gallon of crude oil |
| 1000 cft of gas | = | 6.5 gallon of furnace oil |
| 1000 cft of gas | = | 6.1 gallon of kerosene |
| 1000 cft of gas | = | 6.1 gallon of diesel oil |
| 1000 cft of gas | = | 6.1 gallon of gasoline oil |
| 1 ton crude oil | = | 40 MCF of gas |
| 1 gallon of kerosene oil | = | 164 cft of gas |
| 1 gallon of diesel oil | = | 164 cft gas |
| 1 mound firewood | = | 572 cft gas |
| 1 ton firewood | = | 15.5 MCF gas |
| 1 ton coal | = | 28.00 MCF gas |
| 1 hectare | = | 2.471 acres |
| 1 acre | = | 4,046 sq.m |
| 1 acre | = | 100 decimals |
| 1 bigha (l0cal unit) | = | 33 decimals |
| 1 BTU | = | 1055 J |
| 1 calorie | = | 4.184 J |
| 1 foot | = | 0.3048 m |
| 1 sft. | = | 0.092903 sq.m |
| 1 yard | = | 0.9144 m |
| 1 toe | = | 42.7 GJ |
| 1 PJ | = | 10 E15 J |