Economics of Greenhouse Gas Limitations

COUNTRY STUDY SERIES

Vietnam

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Hanoi

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
AGRICULT-SS	Agricultural System
AIJ	Activities Implemented Jointly
ALGAS	Asia Least Cost Greenhouse Gas Abatement Strategy
BAU	Business as Usual
BCF	Billion Cubic Feet
C	Carbon
CENELEC-SS	Central Electricity System
CERI	Cost Emission Reduction Initiatives
CFC	Chloro fluorocarbon
CFL	Compact Fluorescent Lamp
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COAL -SS	Coal system
COMAP	Comprehensive Mitigation Assessment Process.
CNG	Compressed Natural Gas
DSM	Demand Side Management
EC	Electric Cooperative
EERs	Energy Efficiency Ratios
EEDB	Energy Environment Data Base.
EFOM	Energy Flow Optimization Model
ENR	Enhanced Natural Regeneration
EU	European Union
EVN	Electricity of Viet Nam
FAO	Food and Agriculture Organization
FIPI	Forest Inventory and Planning Institute
FORPROT	Forest Protect
FP	Forest Protection
FSI	Forest Science Institute
GAS-SS	Gas system
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Giga Grams
GHG	Greenhouse Gas
Gj	Giga Joules
GWh	Giga watt-hour
GWP	Global Warming Potential
GSO	General Statistical Office
H	Hydrogen
ha	Hectare

HH-SS	Household System
HMS	Hydrometeorological Service
ILB	Incandescent Light Bulb
IMH	Institute of Hydrology and Meteorology
INDUS-SS	Industrial System
IPCC	Intergovernmental Panel on Climate Change
ITE	International Technical Expert
Kgoe	Kilogram oil equivalent
KgC	Kilogram Carbon
Kha	Kilo hectares (1000 ha)
Km	Kilometer
Km^2	Square Kilometer
$KTCO_2$	Kilo Tonnes CO_2
Kt	Kilo tonnes
KtC	Kilo Tonnes Carbon
Kt dm	Kilo Tonnes dry matter
Ktoe	Kilo Tonnes oil equivalent
KV	Kilo Volt
Kwh	Kilowatt hour
LANDSAT	US Satellite
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LRR	Long Rotation Reforestation
MARKAL	Market Allocation Model
MOARD	Ministry of Agriculture and Rural Development
MEDEE-S	Model for Energy Demand Evaluation
Mha	Mega hectare
MOF	Ministry of Forestry
MOI	Ministry of Industry
MPI	Ministry of Planning and Investment
Mt	Million tonnes
MtC	Million tonnes of Carbon
MUS$	Million United States Dollar
MW	Megawatt
NEP	National Energy Plan
NPV	Net Present Value
NGO	Non-Governmental Organization
NIAPP	National Institute for Agricultural Planning and Projection
NMVOCs	Non-Methane Volatile Organic Component
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxides
NTE	National Technical Expert
O	Oxygen
OECD	Organization for Economic Cooperation and Development
OIL-SS	Oil system
PJ	Peta joules

PV	Photovoltaic
SRV	Socialist Republic of Viet Nam
S	Sulfur
SRR	Short Rotation Reforestation
ST	Scattered Trees
TF-SS	Traditional Natural System
TC/ha	Tonnes of Carbon per hectare
tdm	Tonnes dry matter
TgC	Teragram of Carbon
TOE/year	Tonne Oil Equivalent/year
TRANSPOR-SS	Transportation System
TWh	Terawatt hour
UK	United of Kingdom
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	United Nations Institute for training and Research
US$ (USD)	United States Dollar
VNCCCT	Viet Nam Climate Change Country Team
VND	Viet Nam Dong (Viet Nam Currency)
W	Watt
WB	World Bank
WWF	World Widelife Fund
MUS$	Million United States Dollar

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FOREWORD

Vietnam signed the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and ratified it on 16 November 1994. The Convention entered into force on 14 February 1995.

In June 1994 the Government of Vietnam assigned the Hydrometeorological Service (H.M.S.) as the responsible agency coordinating activities on the implementation of UNFCCC in Viet Nam. Since then H.M.S. has been leading and coordinating experts from various ministries and institutions involved in climate change issues.

Following the activities in the Regional project " Asia Least cost Greenhouse gas Abatement Strategy" (ALGAS) " the H.M.S. began work on a GEF Project "The economics of GHG limitation" in 1996. UNEP Collaborating Centre on Energy and Environment at Riso Denmark is managing and organizing technical support for the project.

Most of the assessment presented here is based on methodologies given in the Technical Guidelines of Riso National Laboratory. This study draws from significant amounts of information from the work done under the ALGAS project.

The Report has been completed with the supports of several government institutions and the important contributions of several experts from above agencies.

The authors would like to express their gratitude to the UNEP Collaborating Centre on Energy and Environment, Denmark and Lawrence Berkeley National Laboratory, USA - who assisted and supported the Study.

PREFACE

The implementation of the UNEP/GEF project Economics of GHG Limitation - Phase 1: Establishment of a Methodological Framework for Climate Change Mitigation Assessment was started in Viet Nam in July, 1996.

The principal objective of the project is to conduct a Climate Change Mitigation Study for Viet Nam, adopting and applying a common methodological framework for calculating the cost of climate change mitigation activities at country level. The main tasks of the project to be implemented for the Viet Nam country study was described in the Common Country Study Element 01408.02/01 dated 12 June 1996.

Institutional arrangements:

Viet Nam's Government nominated the Hydrometeorological Service of Viet Nam (H.M.S.) is an Executing Agency for this study. A large number of organizations and institutions are involved in Climate Change activities in the country including representatives from Ministries of Planning and Investment, Science, Technology and Environment, Industry, Transportation, Agriculture and Rural Development, Training and Education, Foreign Affairs, Finance, Public Health, Trade, as well as Viet Nam Union of Scientific and Technical Associations (NGOs) and Hydrometeorological Service. Their activities are principally coordinated by the H.M.S. under an officially appointed group called the "Viet Nam Climate Change Country team" (VNCCCT). The IMH has also been made responsible to lead the National Technical Expert (NTE) responsible undertaking the work programme under the project. The NTEs involving in the preparation of this Final Report are:

Prof. Dr. NGUYEN DUC NGU	Leader of Executing Agency
Prof. Dr. NGUYEN TRONG HIEU	Coordinator
Dr. NGUYEN QUANG THAI	Macro-economy
Dr. NGUYEN DUC MINH	Macro-economy
Mr. LE NGUYEN TUONG	Energy
Msc. DUONG QUANG THANH	Energy
Dr. TRAN VAN BINH	Energy
Dr. NGO DUC LAM	Energy
Dr. NGUYEN PHU GIA	Energy
Mr. NGUYEN KHAC HIEU	Forestry
Dr. HOANG XUAN TY	Forestry
Prof. Dr. HA CHU CHU	Forestry
Mr. NGUYEN MONG CUONG	Agriculture
Prof. Dr. NGUYEN TRUNG QUE	Agriculture
Prof. Dr. VU NANG DUNG	Agriculture

It is believed that results of this study will contribute significantly in the evaluation and review of policy options as well as for implementation of the UNFCCC in Viet Nam.

Executive Summary

(1) Introduction:

(1.1) Background information about Vietnam:

Viet Nam is located in Southeast Asia, sharing a land border with China, Laos and Cambodia. It has a land area of 330,990 Km^2, and stretches 1,650 km from North to South, 600 km at its widest and a 50 km at its narrowest. It consists of more than 1 million Km^2 of water surface, with 3,260 km of Coastline, and thousands of small islands, especially in Tokin Gulf. Viet Nam is the 12^{th} most populous country in the world with a population estimated at 80 million (1996), growing at a rate of 2.5%. About 20% of the population lives in the urban areas, while 80% in rural area.

There are about 2,860 small and big rivers in Viet Nam, among all the rivers, the Red River and the Mekong River are the largest and most important.

Viet Nam is located in the inter - tropical zone, but because of its long north - south span, climate conditions vary from sub - zero temperatures in the northern mountains to the year round heat of the Mekong Delta.

(1.2) Macro-economy:

Viet Nam's recent macro-economics performance has been impressive. The following major targets of the 1991 - 1995 five years plan were formulated :

- Average annual GDP growth rate of 5.5 - 6%.
- Average annual gross industrial output value growth rate of 7.5 - 8.5%.
- Average annual gross agricultural output value growth rate of 3.7 - 4.5%.
- Export earnings in five years : USD 12 - 15 billion.
- Import expenses in five years: USD 16 billion

The economic has gradually overcome stagnation and to data it has basically got out of the crisis. The following features has been characterized in the economy:

- Relating high economic growth rate in almost sectors and industries.
- Production can already cover consumption and the economy proceeds to generate an internal capital formation by itself.
- Living conditions of different strata of population have recorded a certain improvement.
- Hyper inflation was liquidated and the inflation rate is controllable.

In the two years 1996 and 1997 the GDP was 258 609 and 295 700 VND billion whereas the GDP per capita was 3 430 and 3 800 thousand VND in 1996 and 1997 respectively. Following quantum expressed the sectoral structure of Viet Nam's economy in 1996 - 1997.

Table (1): Sectoral structure of Viet Nam's economy in 1996 - 1997.

Sector	1996	1997
Industry and construction	30.7	31.7
Agriculture, Forestry and fishing	27.2	25.7
Service	42.1	42.6

Source: Development Strategy Institute, 1998.

The GDP structure projected for the period 1994 - 2030 by the Development Strategy Institute shown in Table (2). According to the structure the following baseline scenarios have been developed.

Table(2): Economic structure projected for the period 1994 - 2030

Sector	1994	2000	2010	2020	2030
Industry	30.0	33.5	37.3	38.1	38.8
Agriculture	27.5	19.5	11.0	6.3	4.0
Service	42.4	47.1	51.7	55.6	57.2

Source: Ministry of Planning and Investment, 1996.

(1.3) Status of Climate Change activities in Viet Nam:

Viet Nam ratified the UNFCCC on 16 November 1994. The Hydrometeorological Service (HMS) has been assigned by the Government to take full responsibility for Climate Change issues and for implementing programs related to the objectives of the UNFCCC.

Other studies in the Viet Nam related to climate change are described below:

- "Regional studies on Global Environment issues":

The study is sponsored by ADB for eight Asian Countries, including Viet Nam. It studied the socioeconomic impacts of climate change and policy options to cope with climate change.

- "Vulnerability Assessment in Viet Nam" funded by Netherlands. Started in 1994 and its objective was to undertake the vulnerability and impacts assessment on coastal zone.
- "Socio - economic and physical approaches to analyzing climate change impacts in Viet Nam" funded by UK. This 24 months research project started in April 1996. It is an interdisclop - linearly study of socio - economic vulnerability to climate change impacts in the coastal zone of the Red River Delta of Viet Nam.
- ADB/GEF-UNDP project " Asia Least Cost Greenhouse Gas Abatement Strategy-ALGAS" assisting 12 Asian countries in assessment GHG abatement options and development of the least cost abatement strategy.

- UNDP/UNITAR/GEF "CC: TRAIN" (phase 1) - Its objective was to assist the countries in formulating climate change policy for the implementation of the UNFCCC.
- UNEP/GEF Project on "Economics of GHG Limitation - Phase 1 : Establishment of a Methodological Framework for Climate Change Mitigation Assessment " . This Project is implemented by the IMH in co-operation with relevant ministries and Government agencies .

(1.4) National Development Objectives:

During 1996-2000 Vietnam's economy targeted to achieve an average annual growth rate of 9-10%, of which agriculture (including forestry and fishery) represents an annual increase of 4-5%, industry (including construction) an annual growth rate of 14-15% and service sector 12 - 13% yearly. With such a tendency , GDP at current price will reach 35 billion US$ by the year 2000.

From now up to the year 2000 the area of rice field will increase to 7.0 million ha. By the year 2000 the forest cover will increase to 11 million ha and the forest coverage will be more than 30%.

By the year 2020 with a population of 105 million persons the total GDP will reach 185 billion US$. The share of industry, service and agriculture will be respectively 41.0, 49.0 and 10.0 per cent of the total GDP.

In order to gain the above principal objective the growth rate of the total GDP will be 9% in the period 2001 - 2010 and 7% in the period 2011 - 2020.

(2) Description of approaches and model used for mitigation options:

(2.1) Energy:

In order to identify the optimization strategies which satisfy energy demand the optimal strategy could be determined based on EFOM-ENV model. EFOM is a supply-technico-economic energy model that simulates or optimizes the primary energy requirements and the related investments in energy production and consumption.

In EFOM-ENV model the energy flow begins with primary energy through energy transportation to the final energy demand. The energy supply and demand are represented by systems as follows :

- Energy Supply Systems

- Coal system (COAL-SS)
- Oil System (OIL-SS)
- Gas System (GAS-SS)

- Central Electricity System (CENTELEC-SS)
    (i) northern system and
    (ii) southern system.
- Traditional Fuel System (TF-SS)

- Energy Consumption Systems

- Industrial system (INDUSTRY-SS) :
    * Metallurgy and Machinery sub-sector
    * Construction material sub-sector
    * Others
- Household system (HH-SS)
    * Rural households
    * Urban households
- Transportation system (TRANSPOR-SS)
- Agricultural system (AGRICULT-SS)

(2.2) Forestry:

COMAP (Comprehensive Mitigation Analysis Process) model was used for developing and assessing forestry mitigation options in this study. COMAP is intended to guide an analyst in undertaking a comprehensive assessment of the role of forest sector in a country's climate change mitigation efforts (Sathaye and Stephen Meyers, 1995). This approach includes several specific steps such as screening to identify mitigation options signified to the country, developing the mitigation options which could be implemented on the various available lands, estimating of the emission reduction or carbon sequestration per unit area for each mitigation option and, evaluating the cost-effectiveness of identified mitigation options.

In the study, two sub-models: FORPROT and REFOREST of COMAP model are used for assessing 4 forestry mitigation options.

(2.3) Agriculture:

The following approach have been used to assess the mitigation options in agricultural sector:

1) Noting that the global environmental objective is to reduce GHG emissions.

2) Identify that the goal is to increase agricultural productivity which supported by the program:" Making intensive cultivation higher to the food crops and bio-diversification of agricultural system".

3) Incorporate global environment objectives in national development objectives.

4) Aware that the global environment objectives of reducing GHG emission can be met without compromising the goal of increasing productivity in the agriculture sector.

(3) National Inventory and Projection of GHG emissions:

(3.1) GHG emission factors:

The IPCC default emission factors were used in the Viet Nam GHG inventory.

(3.2) Global Warming Potential (GWP's):

CO_2 equivalents are based on GWP's of 21 for CH_4 and 310 for N_2O

(3.3) National inventory of GHG emissions:

The 1993 GHG emissions in Viet Nam were 111.7 million tonnes CO_2 equivalent, of which carbon dioxide contributed about 52% and methane 44%. Balance was contributed by nitrous oxide.

The Agriculture sector contributed to 47 million tonnes of CO_2 equivalent, while the Energy sector emitted 27.5 million tonnes of CO_2 equivalent, the Forestry sector emitted 30 million tonnes CO_2 equivalent .

(3.4) GHG inventory projection to 2030:

Emission in the future will be increased mainly causing by the fossil fuel consumption.

Emission from the energy sector in 2030 is projected to 396 million tonnes CO_2, it is more than 10 time higher than 1993.

The GHG emissions from agriculture are projected from 47 M tonnes CO_2 equivalent in 1993 to 68 M tonnes CO_2 equivalent in 2030.

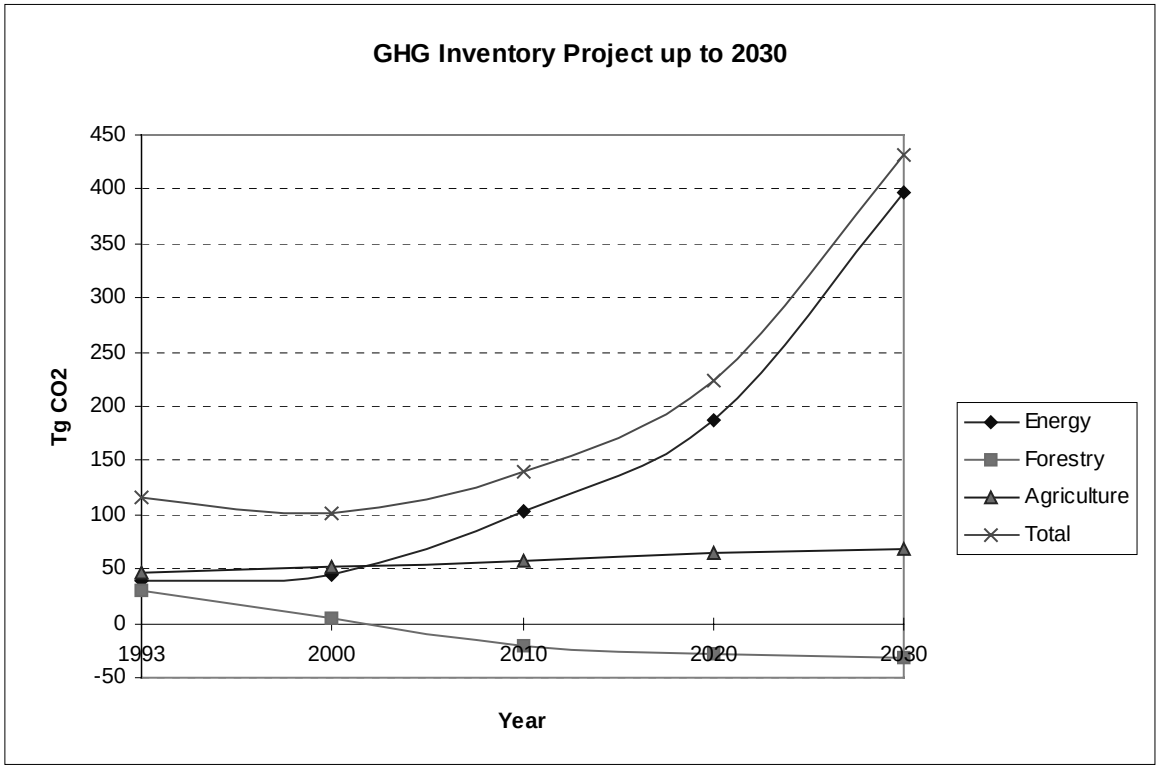
In the forestry sector, the amount of CO_2 is projected to decline from 29.9 million tonnes in 1993 to 4.2 million tonnes in the year 2000 and the net sequestration of 32.1 million tonnes in 2030. Table (3) and Figure (1)

The Table (3) shows the GHG inventory projection to 2030.

Table (3): Projection GHG emission in Sectors (Tg) of CO_2 equivalent to 2030.

Tg	1993	2000	2010	2020	2030
Energy	27.5	44.48	103.40	187.82	396.35
Forestry	29.88	4.20	-21.70	-28.40	-32.10
Agriculture	46.60	52.50	57.20	64.70	68.29
Total	111.69	101.18	138.90	224.12	432.54

Figure (1): Total National GHG emission (CO_2 equivalent)



(4) Baseline and Abatement Scenario in energy sector:

(4.1) Baseline Scenarios:

Table (4): Energy demand forecast for period 1994 - 2030.

Unit: ktoe

	1994	2000	2005	2010	2020	2030
Household sector	5472.27	6535.59	7071.76	7841.57	9889.36	17710.34
Urban	1037.976	1938.651	2299.195	3153.235	5419.075	9704.738
Rural	4434.294	4596.939	4772.565	4688.335	4470.285	8005.6
Service sector	274.5	476.67	674.59	996.62	1487.72	2664.28
Transport sector	2082.67	4046.69	6164.13	8525.77	14252.59	25524.22
Industry sector	2610.66	5676.95	10752.51	16158.6	32300.92	57846.03
Agricultural sector	354.11	479.39	621.74	694.42	620.93	1111.991
Total	10794.21	17215.29	25284.73	34216.98	58551.52	104856.9

Source: Calculated by MEDEE-S Model from this report

(4.2) Abatement Scenario:

a. Energy consumption scenarios:

- Efficiency Improvement in Cooking
- Compact Fluorescent Lamp (CFL)
- High Efficiency Refrigerators
- Air Conditioning efficiency improvement
- More Efficient Industrial Motors.

b. Energy supply scenario

- Fuel Switching in Power Generation
- Wind power plants

Table (5): Differences in CO_2 Emissions and Costs by Various Mitigation Scenarios Compared to Base Scenario,(energy sector).

	Base line	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7
CO_2 emissions (Mt)	7520	7299	7470	7254	7362	7308	7506	7416
Cost (Mil. .US$)	43800	43414	43631	42842	43101	43159	44096	43598
ΔCO_2 emissions (Mt)		221	50	266	158	212	14	104
ΔCosts (Mil. US$)		-386	-169	-958	-699	-641	296	-202
Cost per t ΔCO_2 reduction		-1.75	-3.38	-3.60	-4.42	-3.02	21.14	-1.94

Source: Calculated from this study.

ENV-1: Efficiency improvement in coal cooking

ENV-2: Compact fluorescent lamps

ENV-3: Energy efficient refrigerators

ENV-4: Energy efficient air conditioners

ENV-5: High efficient electric motors

ENV-6: Fuel Switching in existing thermal power plant

ENV-7: Wind power plant.

(5) Baseline and Abatement Scenario in Forestry Sector:

(5.1) Baseline Scenario:

Recently, a plan for reforestation and natural regeneration of 5 million additional hectares by 2010 was adopted by the Government. However, for the forestry sector the likely trends scenario is developed. Based on current trend, it is assumed that the deforestation rate will continue to be on the average of 100,000 hectares per year. Likewise, the level of reforestation effort is not enough to offset the deforestation. The reforestation rate is about 70,000 hectares per year and the survival rate is assumed 100%, same as in the COMAP analysis. In addition, 3 billion scattered trees will be planted up to the year 2030 and 2.4 million hectares of protection forests will be conserved over the period 1994-2030.

(5.2) Abatement Scenario:

The following options are developed for the abatement scenario :

- 1.85 million hectares of degraded forests will be promoted for natural regeneration in combination with reforestation at a rate of 50.000 ha per year.

- 1.95 million hectares of degraded land will be converted into forest plantations at a reforestation rate of 130,000 ha per year.

- 6.5 million hectares of natural forest will be protected. Logging and timber harvesting will not be allowed in the protected areas.

- 4 billion scattered trees, equivalent of about 1.65 million hectares, will be planted up to 2030.

The above options will lead to a reduction of emissions 4539 Tg CO_2 equivalent compared to 2144 Tg in the baseline.

Comparison of the four forestry mitigation options is presented in Figure (3) and Table (6).

Table (6): COMAP output for the forestry mitigation options

Option No	Option Category	Mitigation Potential	Present Value of Benefit		Present Value of Cost		NPV	
		(tC/ha)	($/tC)	($/ha)	($/tC)	($/ha)	($/tC)	($/ha)
F1	Enhanced natural regeneration	47.2	1.27	55.55	1.04	45.42	0.23	10
F2	Reforestation	107.3	5.51	577.10	3.35	351.19	2.16	226
F3	Natural forest protection	132.7	0.69	91.04	0.33	43.45	0.36	48
F4	Scattered trees	47.7	9.25	404.25	1.35	59.17	7.90	345

(6) Baseline and abatement scenario in Agricultural sector:

(6.1) Baseline scenario:

Viet Nam is an agricultural country, 80% of it's population involved in agriculture on about more than 7 million hectares : The urban population is projected to increase from 19.9% in 1994 to 55% in 2020 and 65% in 2030, therefore the rural population will decrease to about 45% and 35% in 2020, 2030 respectively. Because of urbanization, GDP contribution of agriculture will drop from 29.9% in 1993 to 6.3% in 2020 and 4.0% in 2030.

The area under rice cultivation is projected to increase from 6.5 Mha in 1993 to 8.0 Mha in 2030.

The livestock population is projected to increase from 6.2 M head (dairy and buffalo) in 1993 to 13.6 M head in 2030.

(6.2) Abatement scenario:

1) By the year 2030, 5.5 M ha of rice paddy land will have intermittent drainage under controllable irrigation, resulting in a reduction of methane emissions from rice field of about 50 kg/ha/year. This will result in a total of mitigation of 5,005 Gg CH_4.

2) Providing a higher quality of improved (processed) animal feed (4.2 Mt/year) will result in a reduction of 5 kg CH_4/head/year on a total of 4.4 M animals. This will result in the reduction of 385 Gg CH_4/year from animal husbandary.

Table (7): Mitigation options in Agricultural Sector.

Scenario	Description	Total Methane abated (Gg)	Life cycle cost	Aggregate incremental investment required (US$ mill.)
Baseline	- 6.5 Million ha of rice cultivation in 1993, growing up to 7.1 in 2000, 7.3 in 2010 and 8.0 in 2030. - 1.7 Tg CH_4 emitted in 1993, 1.9 Tg CH_4 in 2000, 2.0 Tg CH_4 in 2010 and 2.2 Tg CH_4 in 2030. - The population of livestock is 6.6 M of cattle and buffaloes in 1993 growing up to 13.6 M in 2030. - 425 Gg CH_4 emitted in 1993, 560 Gg CH4 in 2010 and 1026 Gg in 2030			
Water management in rice field	Projection to 5.5 million ha of rice paddy with water management and under intermittent draining on the rice growing season in 2030	5005	US$/tC 13.12	5620
Improving nutrition through mechanical and chemical feed processing	Projection to 4.4 million head of buffaloes and cattle providing with mechanical and chemical feed processing.	385	US$/tC 5.19	92

(7) National Perspective on GHG emissions and Mitigation Options:

(7.1) Cost of Emission Reduction Initiatives (CERI) Curves for each sector:

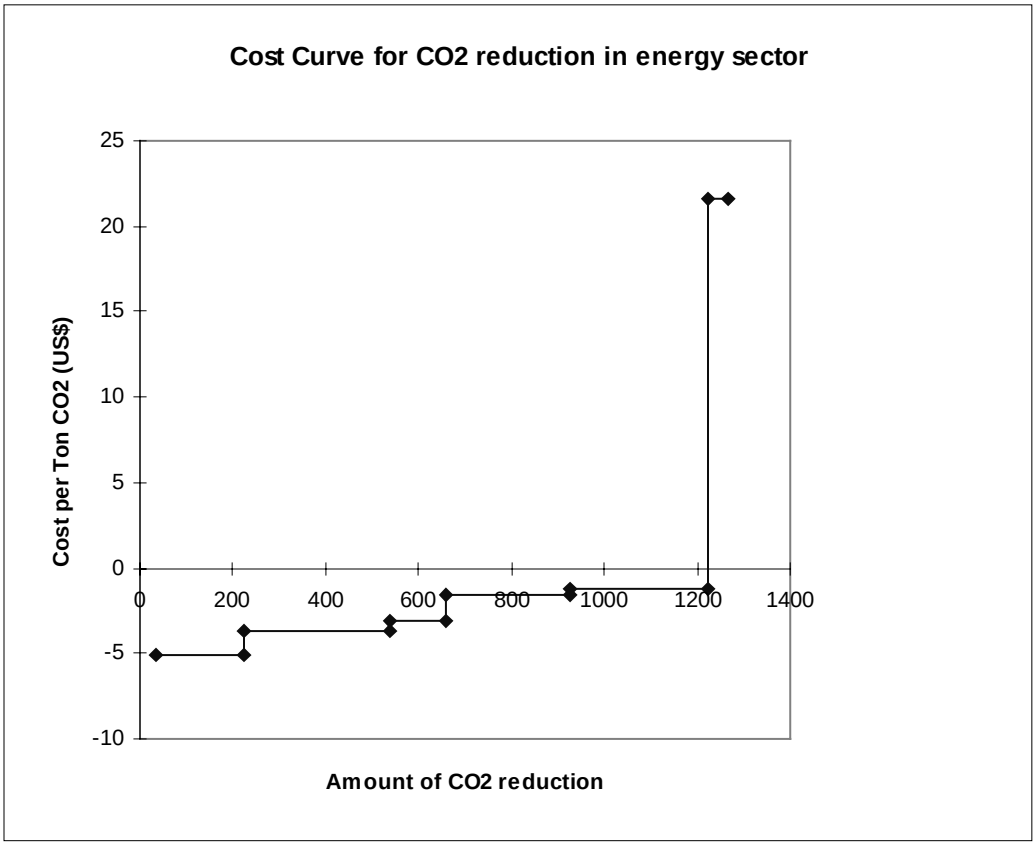
(7.1.1) Energy Sector:

Cost curves in Energy sector under this study were developed. Seven GHG abatement scenarios were estimated using EFOM-ENV model. These abatement scenarios are shown in Table (8)

Table (8): Cost of CO2 reduction

	Option	Amount of CO_2 reduced (Tg)	Cost of CO_2 reduction (US$)
1	Energy efficient Air conditioners	158	-4.42
2	Energy efficient refrigerator	266	-3.60
3	Compact fluorescent lamps	50	-3.38
4	High efficient electric motors	212	-3.02
5	Wind power plant	104	-1.94
6	Efficiency improvement in coal cooking	221	-1.75
7	Fuel Switching in existing thermal power plants	14	21.14

Figure (2): Cost curve for Energy Sector

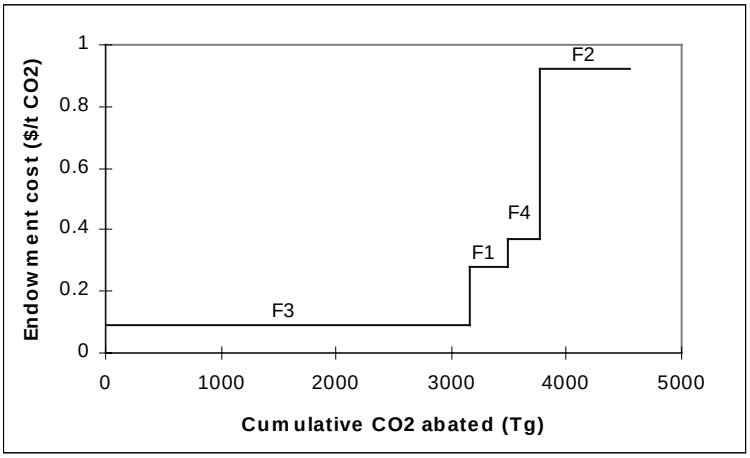


(7.1.2) Forestry Sector:

COMAP (Comprehensive Mitigation Analysis Process) model was used for assessing several identified forestry mitigation options. In addition, based on the modeling results such as carbon sequestration / storage potential, benefits and endowment cost of the mitigation options, forestry cost curves were developed for abatement scenario. The forestry mitigation scenarios consisted of four options, namely Enhanced natural regeneration (F1), Reforestation (F2), Forest protection (F3), and Scattered trees (F4). The calculation of average incremental cost of each option is based on present value of endowment cost in COMAP output. It is estimated that the total potential carbon abatement equal 585 and 1,238 million tonnes, approximating 2,144 and 4,539 million tonnes carbon dioxide equivalent under the baseline and mitigation scenarios respectively. COMAP output for forestry mitigation options is presented in Appendix 3-6

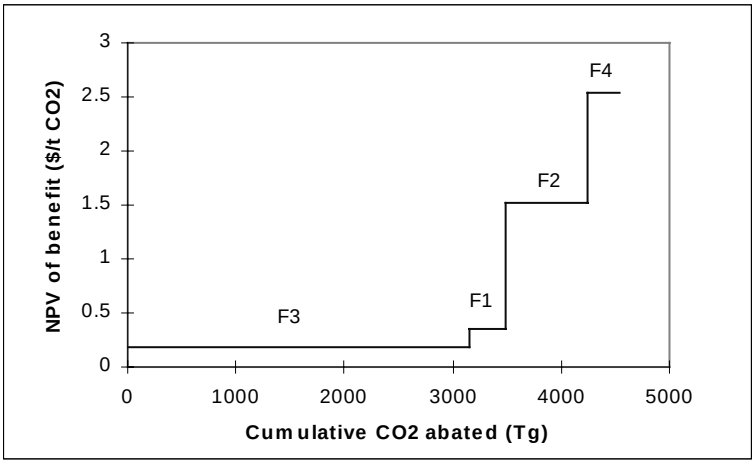
Figure 3A expresses the relationship between the potential carbon reduction (or carbon stored) and endowment cost per unit carbon reduction of the four forestry mitigation options under the abatement scenario, whereas Fig. 3B shows the NPV curve of a range of abatement levels. It is noteworthy, that using the latter criteria, the ranking of the four options change. For example, based on endowment criteria forest protection is the most attractive, but based on NPV of benefits, planting scattered trees is the most attractive.

Figure 3A: Cost curve for Forestry Sector



F1 : Enhanced natural regeneration
F2 : Reforestation
F3 : Forest protection
F4 : Planting scattered trees

Figure 3B: Cost curve for Forestry Sector

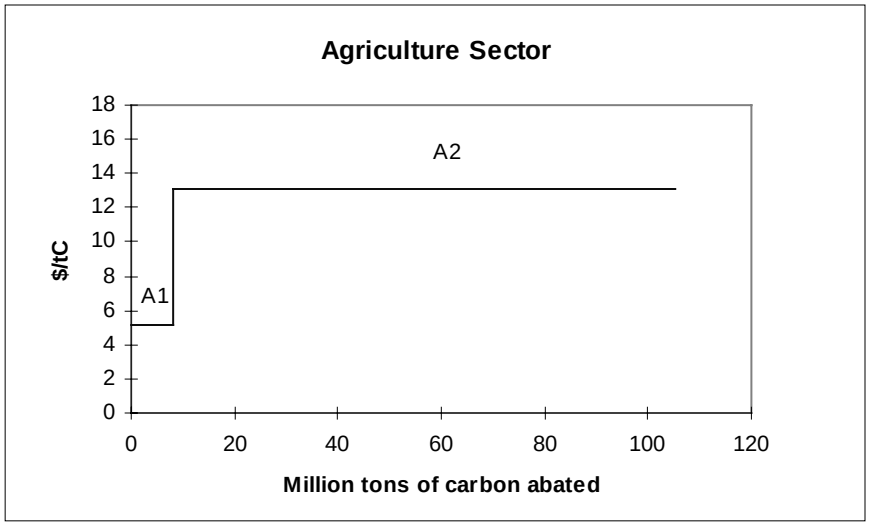


F1 : Enhanced natural regeneration
F2 : Reforestation
F3 : Forest protection
F4 : Planting scattered trees

(7.1.3) Agriculture Sector:

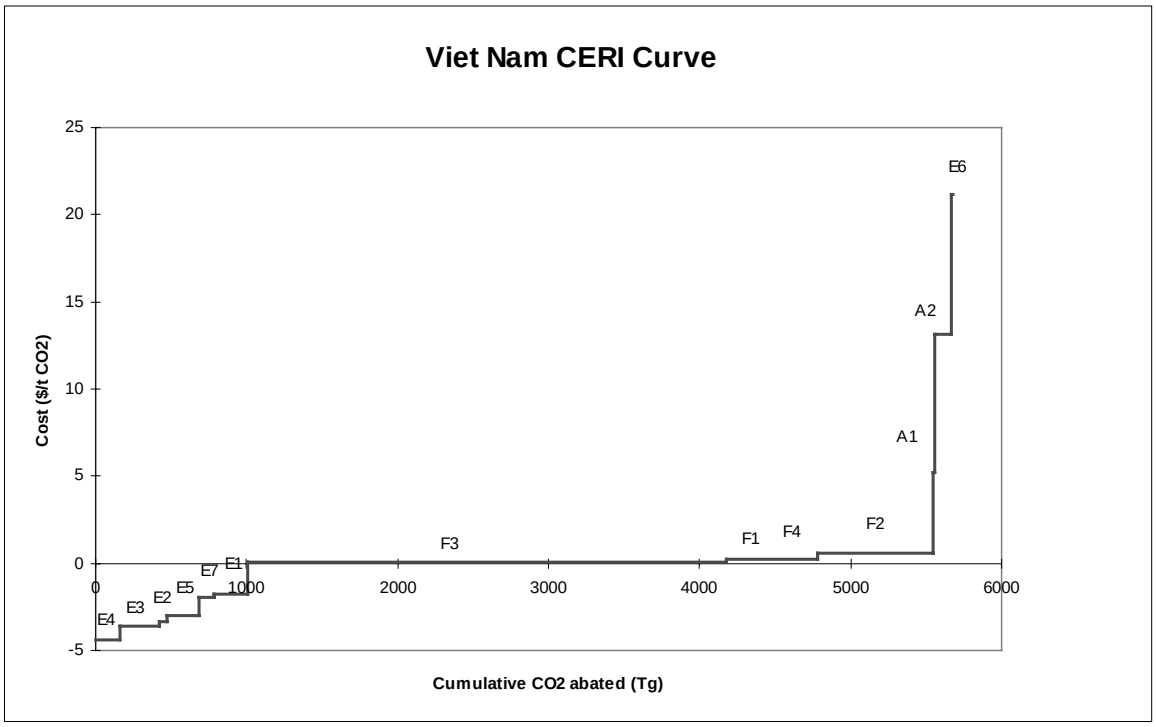
The principal approach for reducing methane emission from agricultural sector is water management with intermittent draining of rice fields during the growing season and improving nutrition through mechanical and chemical feed processing in livestock. Figure (4) shows the relationship between the potential carbon reduction and cost per unit carbon reduction of two agricultural mitigation options: improving nutrition (A1) and water management (A2).

Figure (4) : Cost Curve for Agriculture Sector



Generally for the three main sectors: Energy, Forestry and Agriculture, national cost curve is presented in Figure (5) whereas the total CO_2 abated in both short and long terms is shown in Table (9).

Figure (5) National cost curve for GHG mitigation in Viet Nam



E1:	Efficiency improvement in coal cooking	F1:	Enhanced natural regeneration
E2:	Compact flourescent lamps	F2:	Reforestation
E3:	Energy efficient refrigerators	F3:	Natural forest protection
E4:	Energy efficient air conditioners	F4:	Planting scattered trees
E5:	High efficient electric motors		
E6:	Fuel switching in existing thermal power plant	A1:	Improving nutrition
E7:	Wind power plant	A2:	Water Management

The options are not comparable across the sectors since benefits in the forest sector are are not included in the above curves. If NPV/t CO2 was used, all the forestry and agriculture options will be below X axis.

Table (9): Total CO_2 Abated in Short Term and Long Term.

Sector	Mitigation Options	Total CO_2 abated (1,000 tonnes)	
		Short Term	**Long Term**
Energy	Energy efficient air conditioners	70,000	158,000
	Energy efficient refrigerators	118,000	266,000
	Compact flourescent lamps	22,000	50,000
	High efficient electric motors	94,000	212,000
	Wind power plant	46,000	104,000
	Efficiency improvement in coal cooking	98,000	212,000
	Fuel switching in existing thermal power plant	14,000	-
Forestry	Natural forest protection	1,746,100	3,162,500
	Enhanced natural regeneration	131,600	320,100
	Planting scattered trees	116,600	288,566
	Reforestation	349,100	768,533
Agriculture	Improving nutrition	1,575	8,085
	Water Management	19,530	105,100
	Total abatement	***2,826,505***	***5,654,884***

(7.2) GHG Abatement Action Plan:

(7.2.1) Energy:

The general objectives in the GHG abatement strategy of Vietnam on energy sector is to use energy efficiently in order to reduce energy use for service in the demand side and reduce losses in the supply side, while minimizing the cost and reducing the polluting emissions, especially GHG emissions. The major contents and action plans of the GHG abatement strategy are presented in Table (10).

Table (10). Summary of National Least-cost Abatement Strategy Initiatives in Energy

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million tonne of CO2)	Cost of initiative (US$/ tonne of CO2)
(1998-2005)	-Fuel switching	14	21.14
	-Wind power construction	27.6	-1.94
	-Improvement of efficiency in cooking	78.8	-1.75
	-CFL	12.5	-3.38
	- High efficiency air conditioning	39.5	-4.42
	-High efficiency refrigerator	88.6	-3.60
	-High efficiency electric motors	35.2	-3.02
	Integrated scenarios	**296.2**	**-1.81**
(2005-2015)	-Wind power construction	27.6	-1.94
	-Improvement of efficiency in cooking	63.2	-1.75
	-CFL	14.5	-3.38
	- High efficiency air conditioning	59.2	-4.42
	-High efficiency refrigerator	77.7	-3.60
	-High efficiency electric motors	70.6	-3.02
	Integrated scenarios	**312.8**	**-3.09**
(beyond 2015)	-Wind power construction	48.6	-1.94
	-Improvement of efficiency in cooking	78.8	-1.75
	-CFL	22.0	-3.38
	- High efficiency air conditioning	59.3	-4.42
	-High efficiency refrigerator	99.8	-3.60
	-High efficiency electric motors	106.0	-3.02
	Integrated scenarios	**414.7**	**-3.00**

(7.2.2) Forestry:

For GHG abatement action plan, the following short term and long term actions are proposed.

Short - term (upto 2015):

In the period, an area of 1.85 million hectares of degraded forests will be conserved for natural regeneration in combination with reforestation at a rate of 50,000 ha/year. Conversion of more than 1,000,000 hectares of degraded forest land into forest plantation with 10-year rotation. To allocate forest lands to local households to reforestation and forest protection. To spread the movement of planting scattered trees at a rate of 400 million trees / year.

In addition, 6.5 million hectares of existing natural forest will be conserved. In the period, natural forest exploitation will be halted gradually. Annual exploitation rate of wood from the natural forest would decline from 3 million cubic meters in previous years to 0.5 million cubic meters. Wood processing industry would be improved. Develop plans and projects for establishing firewood plantations in order to meet firewood demand. Until 2005, nearly all woody biomass needs of the country would come from established forest plantations.

Long term: Continuing to carry out natural forest protection in order to maintain and improve the important carbon sinks in the country.

It is assumed that the same activities would be undertaken beyond 2015. The rate of reforestation at 120,000-150,000 hectares per year while a rate of planting scattered trees will be about 40,000-50,000 ha equivalent/year. For biomass demand, a number of forest products such as fire wood, industrial wood, round wood, timber, etc. from the areas which were under enhanced natural regeneration, reforestation and natural forest could be harvested to meet the in-country demand as well as woody export. The period is the full implementation of the selected forestry options. However, at that time there will be a need to assess the current land use in the country to consider which options should be continued, improved as well as developed to correspond with the nation's situation.

The potential GHG emissions reduction and cost of each initiative in the Forestry sector are presented in Table (11).

Table (11): Potential GHG emissions reduction and Present value of costs for Forestry Mitigation Options:

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million tonne of C)	Present Value of Costs (US$ tonne of C)
Short-term	- Forest protection	476.2	0.6
	- Enhanced natural reforestation	35.9	1.6
	- Reforestation	95.2	4.1
	- Planting scattered trees	31.8	2.0
Long-term	- Forest protection	862.5	0.3
	- Enhanced natural reforestation	87.3	1.0
	- Reforestation	209.6	3.4
	- Planting scattered trees	78.7	1.4

(7.2.3) Agriculture:

The GHG abatement action plan shall focus on water management in rice fields and improving nutrition through mechanical and chemical feed processing.

In the Short-term: (2005 - 2010)

Within the short-term, GHG abatement shall be a component of the environmental impact assessment for agriculture related projects and activities.

Water management in the rice field with the intermittent draining during growing season will be researched and developed in the pilot area such as Red River Delta then extend to Mekong River Delta with the benefit areas of about 3.0 million ha.

At the same time, nearly 2 million buffaloes and cattle will be fed by improved method of animal nutrition through the use of mechanical and chemical feed processing.

In the Long -term: (2020 - 2030)

The same activities are assumed to be undertaken beyond 2015 with the adjustment in terms of target setting per option. The question will be raised for what new options and strategies have to be formulated.

It is continued with 5.5 million ha of rice field under water management, this total area is comprised of 1.102 million ha in the Red River Delta, 0.59 million ha of the North Central Coast, 0.497 million ha of the South Central Coast and 3.269 million ha of the Mekong River Delta.

In this period, a total of 4.4 million buffaloes and cattle would be provided with the improved nutrition through mechanical and chemical feed processing.

1. Introduction

1.1. Background information about Viet Nam:

1.1.1. Geography:

Viet Nam has a land area of 330,990 km^2 consisting of thousands of islands and more than 1 million km^2 of water surface. The entire length of coastline is 3260 km.

Viet Nam climate is under the influence of tropical monsoon. However the rainfall is not evenly distributed over the country and it is seasonal.

In 1993 Viet Nam's population was estimated to be 71.02 million with a density of 214 persons per km^2. The estimated population in 1994 and 1995 was 72.5 and 73.96 million respectively.

Viet Nam is one of the nations with high rate of population growth. In 1930 its population was only 17.852 million persons and it become nearly 74 million by 1995, i.e. the population has multiplied by 4.2 times in 65 years. However in recent years the growth rate has been decreasing. The estimated population in 2010, 2020 and 2030 is 94, 106 and 116 million respectively.

1.1.2. Land use:

Land use in Viet Nam has changed over the last few decades. Prior to 1970 more than 35% of the country was covered with forest, about 21% was agricultural land and 39% was waste land.

In 1993 forest area decreased to 30% while agricultural land increased to 22.2%. In agricultural area industrial crops and fruit crops occupied 1.247 million ha. In forestry area natural forest occupied 8.8 million ha and plantation forest covered 0.8 million ha.

Viet Nam is currently implementing a national plan to expand the forest cover. The percentage of forest land is proposal to be 45.0 and 48.9 in the periods 2005-2010 and 2020 - 2030 respectively, while that of the agricultural land is projected at 26.0 and 28.9 in the same periods.

1.2. Economic information:

1.2.1. Macro-economy:

Viet Nam's recent macro-economic performance has been impressive. The following major targets of the 1991 - 1995 five years plan were formulated :

- Average annual GDP growth rate of 5.5 - 6%.
- Average annual gross industrial output value growth rate of 7.5 - 8.5%.
- Average annual gross agricultural output value growth rate of 3.7 - 4.5%.
- Export earnings in five years : USD 12 - 15 billion.
- Import expenses in five years: USD 16 billion

The economy now almost out of the stagnation crisis, and the following features are evident

- Economic growth rate is high in almost all sectors and industries.
- Production covers consumption and the economy generates significant amount of internal capital.
- Living conditions of different strata of population have recorded some improvement.
- Hyper inflation is no longer a problem and the inflation rate is now under control.

In the two years 1996 and 1997 the GDP was 258,609 and 295,700 VND billion whereas the GDP per capita was 3,430 and 3,800 thousand VND in 1996 and 1997 respectively. Table 1.1 indicates the sectoral structure of Viet Nam's economy in 1996 - 1997.

Table 1.1: Sectoral structure of Viet Nam's economy in 1996 - 1997.

Sector	**1996**	**1997**
Industry and construction	30.7	31.7
Agriculture, Forestry and Fishery	27.2	25.7
Service	42.1	42.6

Source: Development Strategy Institute, 1998

It is very complicated to evaluate development perspective of the Viet Nam's economy up to the years 2010, 2020 and 2030. However based on requirements of the economic assessment in the project, the following indicators have been considered for analysis purposes (Table 1.2).

The most important figures indicate that the economy of Viet Nam will continue the sustainable trends in the future with the GDP in the year 2030 at approximately 11 times that in the year 2000.

Table 1.2: Main macro-economic indicators in the period 2000 - 2030

Items	Unit	2000	2010	2020	2030
Population	Mill. pers	80.863	93.844	105.734	116.796
Population growth rate	%	1.8	1.5	1.2	1.0
GDP current price	VND billion	492,335	1,733,285	5,169,735	12,790,735
GDP current price	USD billion	35.165	83.634	185.613	376.734
GDP average growth rate during 5 years	%	8.5	7.5	7.0	6.5
GDP per capita (in current price)	USD	435	891	1 755	3 226

Table 1.3: The economic structure projected for the period 1994 - 2030

Sector	1994	2000	2010	2020	2030
Industry	30.0	33.5	37.3	38.1	38.8
Agriculture	27.5	19.5	11.0	6.3	4.0
Service	42.4	47.1	51.7	55.6	57.2

Source: Ministry of Planning and Investment, 1996.

1.2.2. Energy:

Viet Nam has a broad range of mineral resources. There is considerable energy potential in form of coal, oil and gas, hydropower and fuel wood.

Viet Nam has a total electricity capacity of about 4000 MW of which hydroelectric, thermoelectric and other accounting for 66%, 21% and 13% respectively.

The total coal reserves are estimated at more than 6 billion tonnes. Most of them is anthracite. In recent years coal production has fluctuated between 4 - 8 million tonnes per year.

The total oil and gas potential reserves is estimated at about 2 billion tonnes of oil equivalent. Consumption of oil products rose from 1.5 million tonnes in 1989 to 7.7 million tonnes in 1995.

The total hydroelectric power capacity which can be developed is 17,100 MW with an average annual output of 82 billion kWh.

The power consumption of socioeconomic activities is distributed to following 4 main sectors: Industrial, agricultural, residential and non-industrial. In the period 1989-1994 the share of industrial sector in the power consumption was more than 40%, while the residential sector consumed more than 30% of total power.

Based on the projection in the long-term energy plan the predicted energy demand up to 2020 is shown in Table 1.4. It is noteworthy that during the period, the total commercial energy demand will increase more than five-fold, while the consumption of biomass energy will decline by about a third.

Table 1.4: Viet Nam's Energy demand forecast by fuel for 2000 - 2020 (KTOE/yr).

Fuel	2000	2010	2020
Coal	3933	8514	15908
Gasoline	2311	4984	8437
Diesel oil	4434	12775	27130
Fuel oil	684	1799	3775
Jet fuel	314	682	1425
Electricity	1926	6585	14211
Total commercial energy	13628	35592	71615
Biomass	4021	3259	2624

1.2.3. Industry:

The main industries in Viet Nam consist of metal, mining, chemical, construction material, textile, paper, and food processing. Generally the size is small, the technology is old, the investment is incomplete and the level of pollution has reached an alarming level. Table 1.5 shows the main industrial production figures between 1992 and 1995.

Table 1.5: Main industrial products in 1992 - 1995

Product	1992	1993	1994	1995
Steel (000 tonnes)	196	243	279	386
Chemical fertilizes (000 tonnes)	530	714	845	895
Phosphaticores (000 tonnes)	290	362	470	-
Cement (000 tonnes)	3926	4849	5371	5854
Lime (000 tonnes)	693	787	825	-
Paper cover (000 tonnes)	118	128	154	204
Building glass (000 m^2)	2890	1790	3504	-

Source: General Statistical Office, 1995

In the period 1991 - 1995 the share of industrial sector in GDP ranged from 20% to 23%. In the years 2000, 2010, 2020, 2030 the figure will be 33.5, 37.3, 38.1, 38.8 percent respectively.

1.2.4. Forestry:

About 19 million hectares of the territory's 33 million hectares are classified as forest land. However only about half of the area i.e. 9.3 million hectares has dense forests.

Forest land is divided into three categories: special use forest, protection forest and production forest with different areas (Table 1.6).

Table 1.6: Area of forest types and forest use classes in 1989 (million ha).

Forest types	***Forest use classes***			**Total**
	Production	Protection	Special use	
Natural forest				
• Woody forests	4.593	2.154	0.475	7.222
• Bamboo forests	0.881	0.207	0.033	1.121
• Woody/Bamboo	0.260	0.064	0.030	0.354
• Others	0.027	0.001	0.001	0.029
Plantations	0.540	0.034	0.009	0.583
Total	6.301	2.460	0.548	9.309

Source: Ministry of Forestry, 1990

The area under different forest categories in 1993 includes 8657 Kha natural forest, 799 Kha plantation and 11419 Kha savanna.

The forestry sector in Viet Nam contributes about 3% to the GDP. In the first years of this decade the annual planting of forests was about 125,000 ha and annual deforestation was 150,000 ha. However according to the national reforestation programme in the next 20 years the annual planting of forests will be 150,000 ha while deforestation will decline to 100,000 ha.

1.2.5. Agriculture:

Viet Nam is an agricultural country with 80% population involved in agriculture. The sector contributes nearly one third of the total Gross Domestic Product (GDP). Agricultural land is about 7.3 million hectares i.e. 22 percent of the territory.

Viet Nam agricultural economy is based on food crops, industrial crops and livestock husbandry. Food crops including paddy, maize, sweet potato, cassava and potato are of predominant importance (Table 1.7). This sub-sector as a whole made up 47% of the agricultural GDP. Gross output of food crops in paddy equivalent increased from 21.5 million tonnes in 1990 to 27 million tonnes in 1995. Paddy output increased from 19.2 million tonnes in 1990 to 25 million tonnes in 1995.

Industrial crops include perennial crops such as rubber, coffee, coconut and tea, some of which have been important export commodities in recent years.

The livestock sub-sector has also grown fast in recent years, supported mostly by domestic demand.

Table 1.7: Gross value of crops during 1991 - 1994 (%)

Crop	1991	1992	1993	1994
Food crop	79.1	79.4	78.4	78.2
Vegetable	4.5	4.3	4.6	4.7
Perennial industrial crop	7.1	6.9	7.2	7.4
Other	9.3	9.4	9.8	9.7

According to the national programme the agricultural sector is targeted to achieve the following growth in the next two decades (Table 1.8)

Table 1.8: Some projected indicators of agricultural sector performance

Activities level	2000	2010	2020
Agriculture land (%)	24.4	26.6	26.6
Rice cultivation area (M ha)	7.0	7.3	7.7
Cattle and buffaloes (M head)	7.4	9.4	11.9
Agriculture GDP (%)	19.4	12.7	10.0

1.3 Status of climate change Activities in Viet Nam:

Viet Nam ratified the UNFCCC on 16 November 1994. The Hydrometeorological Service (HMS) was assigned by the Prime Minister's Office to take full responsibility for climate change issues and for implementing programme related to the objectives of the UNFCCC.

A Viet Nam Climate Change Country Team (VNCCCT) was established in 1994 with a mandate to improve knowledge on climate change and its social, economic and environmental impacts. The VNCCCT is chaired by the Director General of HMS, and represented by all relevant Ministries and Government agencies including representatives from Ministries of Planning and Investment, Science, Technology and Environment, Industry, Transportation, Agriculture and Rural Development, Training and Education, Foreign Affairs, Finance, Public Health, Trade, as well as Viet Nam Union of Scientific and Technical Associations (NGOs) and Hydrometeorological Service. The VNCCCT has

remained the main policy advisory in the area of climate change and will play a key role in the implementation of the present project as it is charged with both overseeing and advising on the implementation of the project.

Viet Nam has been implementing the following climate change activities related programmes:

1. UNDP/UNITAR/GEF "*CC:TRAIN (Phase 1)*" -- Viet Nam is one of the three participating countries in this project. It started in June 1994 and was completed in June 1996. The project was implemented by the HMS in co-operation with relevant ministries and government agencies. Its objective was to assist the countries in formulating climate change policy for the implementation of the UNFCCC. A number of national programmes for implementing the UNFCCC has been identified, while actions needed and implementation measures have been outlined.

2. "*Viet Nam Coastal Zone Vulnerability Assessment*" -- This project, funded by the Government of the Netherlands and executed by a Vietnamese project team from Hydrometeorological Service working closely together with a European team comprised of Dutch and Polish experts in coastal zone management. It started in November 1994 and ended in April 1996, and the final report was published in December 1996. The objective was to assess the vulnerability of the entire coastal zone of Viet Nam to the impacts of accelerated sea level due to climate change and outlined the first steps towards integrated Coastal Zone Management in Viet Nam.

3. "*Asia Least-Cost Greenhouse Gas Abatement Strategy*" (ALGAS) Project -- Viet Nam is one of the 12 participating countries in this UNDP/GEF/ADB project, which started in 1995 and ended in 1998. This project is implemented by the IMH of HMS. It aims to enhance and improve the national capacity of the participating countries in conducting GHG Inventory, assessing mitigation options, and developing the least-cost GHG abatement strategy and action plan.

4. "*Climate Change in Asia: Viet Nam" --* A *Regional Study on Global Environment Issues* funded by ADB and implemented by the Ministry of Water Resources and Hydrometeorological Service of Viet Nam. The project started in 1992, and a report was published by ADB in July 1994. Its scope includes GHG emission inventory based on the 1990 data and provided mitigation options for energy and industrial, building, transportation, agriculture, forestry and land use sectors

5. "*The potential socio-economic effects of climate change on Viet Nam*" - This UNEP-funded project aimed to consider the effects of present-day climate variability on the natural environment and economy of Viet Nam, and to evaluate the implications of possible future climate changes that might result from the GHG emission. It consisted of a number of research activities focusing on the assessment of potential impacts of climate variability in Viet Nam on agriculture human health, energy production and use, mangrove forests and coastal fisheries. A report was completed in May 1994.

6. "*Socio-economic and physical approaches to analyzing climate change impacts in Viet Nam*" funded by the UK Economic and Social Research Council and implemented by the Centre of Environment Research, Education and Development (CERED), the University of Hanoi and the Centre for Social and Economic Research on the Global Environment and the Climatic Research Unit, University of East Anglia. UK. This 24 month research project started in April 1996. It is an interdisciplinary study of socio-economic vulnerability to climate change impacts in the coastal zone of the Red River delta of Viet Nam. The ultimate goal is to develop

an effective approach in support of policy development regarding the adaptation at relevant policies to both the case study site and more generally, to vulnerable social groups and regions.

7. UNEP/GEF project on "*Economics of GHG limitation - Phase 1: Establishment of a Methodological Framework for Climate Change Mitigation Assessment*". This project is implemented by the IMH in co-operation with relevant ministries and government agencies. It has now been completed.

Several other research efforts on climate change issues were conducted in co-ordination between Ministries, Institutions and NGOs, including:

-The grade and features of climate variation in recent decades and its tendency in coming decades.

- The scenarios of climate change in the short and long term.

- The features of potential and current climate change and its impacts on socio-economic activities.

1.4 National Development Objectives:

During 1991-1995 the Viet Nam' economy had an average annual growth rate of 8,2%, including 8.8% in 1994 and 9.5% in 1995

Gross agricultural output value continuously increased and food output reached more than 27 million tonnes in 1995. Industrial production grew at a rate of 10.0% in 1991, 17.1% in 1992, 12.7% in 1993, 13.7% in 1994 and 14% in 1995. Growth rates were from sector to sector: Crude oil : 23.3%, power: 20.8%, cement: 18.3%, rolling steel: 30.3%, tool machinery 14.8%, chemical fertilizer: 20.4%

Viet Nam has launched a campaign to gradually shift the economy to a new development stage, with an objective of achieving a new industrial country statusb (NIC) by 2020, with more than 40% of GDP from the industrial sector.

During 1996-2000 the economy is expected to grow at an average annual rate of 9-10%, of which agriculture (including forestry and fishery) will represent an annual increase of 4-5%, industry (including construction) will increase by 14-15% per annum and service sector will grow at a rate of 12 - 13% yearly. The country's GDP at current prices is expected to reach 35 billion US$ by the year 2000.

By the year 2000 the area of rice field will increase to 7.0 million ha, with a projected output exceeding 20 million tonnes. By the year 2000 the forest cover will increase to 11 million ha covering about 30% of the country's land area.

By the year 2020 with a population of 105 million persons the total GDP will reach 185 billion US$. The share of industry, service and agriculture will be respectively 41.0, 49.0 and 10.0 per cent of the total GDP.

The GDP per capita is expected to reach 1755 US$/person and the urban population will exceed 50 percent of the total population.

In order to gain the above principal objective the growth rate of the total GDP will be 7.5 in the period 2001 - 2010 and 7.0 in the period 2011 - 2020.

According to Government plan by the year 2020 the area of rice fields will be 7.7 million ha and the rice production will reach 44 million tonnes and there will be an animal population of 7 million cattles, 4.5 million buffaloes and 38 million swines.

The area under forests and population will include 7500 Kha of plantation, 9500 Kha of natural forest and 2000 Kha of savannas and waste land.

The gross energy consumption will be more than 74 million tonnes of oil equivalent and the energy intensity per GDP will be more than 300 KOE/US$

Local data and national statistics are used where available. The base year used for assessment is 1994.

2. Data and models used

2.1 Description of approaches and models used for mitigation options:

2.1.1 Energy Sector:

In order to identify the strategies which satisfy energy demand the optimal strategy could be determined based on EFOM-ENV model. For the analysis of pollution emission control options, the model was supplemented with additional energy conservation options. Based on the assumptions optimum strategies are derived over time together with supply costs and emissions.

EFOM is a supply-technico-economic energy model that simulates or optimize the primary energy requirements and the related investments in energy production and consumption. Two operation models are provided-simulation and optimization-which can be used alternatively on any earlier particular structure.

The main functions of the EFOM-ENV package are :

a) To create and maintain an energy data base.

b) To support simulation studies.

c) To support optimization studies.

The EFOM-ENV package consists of the corresponding components as follows :

- The data base management software (DBMS) which manages the energy data base containing the structural and numerical description of the energy network model (DAMOCLES/DAMINT).

- A simulation model used to perform data validation and to explore energy system configurations and alternative policies. It is designed to perform single-country/single-period calculations of energy/material flows and associated costs (SIMUL).

- An optimization model based on linear programming formulation. It defines optimal policy with respect to some criteria with a multi-country/multi-period scope of calculations (ORESTE/ORACLE).

In EFOM-ENV model the energy flow begins with primary energy through energy transportation to the final energy demand. Some primary energy forms are converted to intermediate energy forms then to final energy demand such as hydropower, fossil fuels converted to electricity etc. Model generally distinguishes different systems and each system comprises a set of technologies with similar function. It provides a function decomposition of all

energy related activities in the economy. In line with the desegregation used for the Vietnam 2020 program, the energy supply and demand are represented by systems as follows :

- Energy Supply Systems

- Coal system (COAL-SS)
- Oil System (OIL-SS)
- Gas System (GAS-SS)
- Central Electricity System (CENTELEC-SS)

  (i) northern system and

  (ii) southern system.
- Traditional Fuel System (TF-SS)

- Energy Consumption Systems

The energy consumption systems consist of systems : Industrial system, Agricultural system, Transportation system and Household system. The structures of these systems are as follows

- Industrial system (INDUSTRY-SS) :

  * Metallurgy and Machinery sub-sector

  * Construction material sub-sector

  * Others
- Household system (HH-SS)

  * Rural households

  * Urban households
- Transportation system (TRANSPOR-SS)
- Agricultural system (AGRICULT-SS)

2.1.2 Forestry Sector:

Forestry sector plays a crucial role in local as well as national economy of developing countries of Asia by providing various products and services to local communities, industry as well as exports.

In the environment area, forestry sector offers a number of options for reducing GHGs. Forestry mitigation options could lead to meeting the biomass requirements, conservation of biodiversity, watershed protection and significant contribution to sustainable development. These goals could be achieved through slowing down and eventually stopping deforestation, raising plantations in degraded forest and non-forest lands, promoting natural regeneration and planting scattered trees in urban areas and on farms, etc.

Linkages between forests, communities and economy are very complex, as such, it is difficult to estimate the fluxes of C and measurable C emission reduction or sequestration. There is a need to analyze forestry options at country level along with the relevant environmental, social and economic aspects.

COMAP (Comprehensive Mitigation Analysis Process) model was used for developing and assessing forestry mitigation options in this study. COMAP is intended to guide an analyst in undertaking a comprehensive assessment of the role of forest sector in a country's climate change mitigation efforts (Sathaye et al. 1995). This approach includes several specific steps such as screening to identify mitigation options specific to the country, developing the mitigation options which could be implemented on the various available lands, estimating of the emission reduction or carbon sequestration per unit area for each mitigation option and, evaluating the cost-effectiveness of identified mitigation options.

In the study, two sub-models: FORPROT and REFOREST of COMAP model are used for assessing 4 forestry mitigation options:

- Option F1: Enhanced natural regeneration of 1.85 million ha of degraded forest areas.
- Option F2: Reforestation of 1.95 million ha of degraded forest lands under 10-year-rotation.
- Option F3: Protection of 6.5 million ha of exiting natural forests.
- Option F4: Planting 4 billion of scattered trees.

Assessment of potential and cost effectiveness of the above options are given in Section 5.2.2

2.1.3 Agriculture:

The following approach was used to assess the mitigation options in the agricultural sector:

1) Noting that the global environmental objective is to reduce GHG emissions.

2) Identify that the national goal is to increase agricultural productivity , supported by the program:" Making intensive cultivation of food crops and bio-diversification of the agricultural system".

3) Incorporate global environment objectives in national development objectives.

4) Aware that the global environment objectives of reducing GHG emission can be met without compromising the goal of increasing productivity in the agricultural sector.

The following measures have been carried out:

A . Identify the potential GHG abatement options in the agricultural sector and select the most valuable options.

In 1993, 2.2 million tons of CH_4 were emitted from the agricultural sector accounting for 87% of total CH_4 emission of the country. The most significant sources are rice cultivation (78% of total CH_4) and livestock (20% of total CH_4). Any important mitigation measures should be focused in the sub- sector .

Several potential GHG abatement options in the agricultural sector for mitigating GHG emissions are presented in Table 2.1

Table 2. 1 : Potential GHG abatement options in agricultural sector.

Options		Potential emission abatement	
		CH_4	N_2O
1	Water management in irrigated rice paddy fields	High	-
2	Changing the cropping pattern from two-rice-crop to three crops system (Rice-upland crop-rice)	Medium	Low
3	Directly sowing of rice paddy	Low	Low
4	Using biofertilizers on the field crops	-	Low
5	Rational feeding of livestock	High	-
6	Using biogas as manure management option in rural areas	Low	-

However, the following two options have been identified as the most valuable:

i) Water management in irrigated rice paddy fields.

ii) Rational feeding of livestock

B . Define baseline rice cultivation area and livestock population.

The area under rice cultivation is projected to increase by 19% (Institute of Agricultural Planning and Projection, 1996), from 6.3 M ha in 1993 to 7.3 Mha, 7.7 Mha and 8.0 Mha in the year 2010, 2020 and 2030 respectively.

The livestock population (Million heads of cattle and buffaloes) is projected to increase from 6.4 in 1993 to 9.4, 11.9 and 13.6 the year 2010, 2020 and 2030 respectively.

C . Develop mitigation scenarios for rice cultivation area and livestock population.

The mitigation scenarios up to 2030 in agricultural sector have been developed on the main assumption that towards the year 2030 rice paddy under controllable irrigation will be 5.5 M ha, and heads of animal provided with feed through mechanical and chemical processing will be 4.4M.

D . Estimate cost and benefit of the GHG emission reduction.

Cost and benefit analysis of the baseline scenario were carried out by Institute of Agricultural Economies (IAE). By the survey conducted by IAE and the Institute of Agricultural Planning and Projection: the following conclusions have been presented:

- The experiments on irrigated rice field with periodically draining showed that at: the end of tillering and 15-20 days after flowering, the water requirement of rice is minimum. Draining of rice field during these two stages may lead to achieving the higher yield of rice (3-7%). At the same time, it can decrease methane emissions by 25-50%.

- The practice of improving nutrition through increased feed digestibility by mechanical and chemical processing of the feed was found to be a feasible mitigation option in the livestock sector. This option will lead to a higher productivity in livestock (about 10%) and it also reduces methane emissions by about 10-25%.

2.2. Input data:

2.2.1 Energy:

Data source which was used for this study was collected from government and energy sector's institutions, they are:

(i) Economic data:

- Viet Nam's Economic development forecast up to the year 2030, Development Strategy Institute, Ministry of Planning and Investment.
- 1994 Statistical Year Book, GSO.
- Viet Nam's economy; The period 1945 - 1995 and its perspective by the year 2020
- Power Development Plan Stage 4, Institute of Energy 1995
- Orientation for National Energy Strategy, Ministry of Planning and Investment, 1996.
- Projection of economic development to 2030, Development Strategy Institute, 1998.
- Energy Balance of Viet Nam, Institute of Energy, 1994.
- Coal Investigation and Design. VINA Coal, 1996.

(2) Energy cost assumption used for calculation is given in Table 2.2

Table 2.2: Energy cost assumption

Activities	Unit	Value
1. Investment cost of Coal Extraction	$U95/TOY	
+ Deep mine	$U95/TOY	2.72
+ Open pit	$U95/TOY	2.36
2. Gas Extraction cost		
+ Offshore	$U95/MBTU	0.017
+ Onshore	$U95/TOY	17
3. Gas Transportation cost	$U95/MBTU	0.008
4. Oil Extraction cost	$U95/TOE	25
5. Oil Refining	$U95/TOY	160
6. Hydropower plants Investment cost	$U95/kW	
+ North	$U95/kW	1500
+ South	$U95/kW	1800
7. Coal fired thermal plants Investment cost	$U95/kW	970
8. Oil-gas fired Power Plants Investment cost	$U95/kW	900
9. Combine Cycle Investment cost	$U95/kW	580
10. Nuclear Power Plants	$U95/kW	2200
11. 500 kv network	$U95/kW	195
12. Transmission network	$U95/kW	150

(3) Energy processing efficiencies:

Table 2.3: Energy processing efficiencies

Item	Value (%)
1. Existing Coal-fired thermal Plants	18
2. new Coal-fired thermal Plants	35
3. Existing Oil-fired thermal Plants	30
4. New Oil-fired thermal Plants	38
5. Natural gas thermal Plants	38
6. Gas Combined Cycle	44
7. Electricity Transmission	94
8. Electricity Subtransmission	86

(4) Capable Capacity of Energy production:

Table 2.4: Capable Capacity of Energy production in period 1994 - 2030

	Unit	2000	2005	2010	2020	2030
Crude oil production	Mtoe/year	20	25	30	35	35
Gas production	Mtoe/year	2.5	2.5	5.2	8.59	8.59
Hydropower	MW	NA*	NA	NA	NA	NA
- Northern system	MW	2088	2400	6000	7500	7500
- Southern system	MW	1350	2250	3050	4050	4050
Nuclear power	MW	NA	NA	1600	4000	4000
Wind power	MW	10	20	50	100	100
Geothermal Power	MW	NA	50	100	100	100

* NA: Not Applicable

2.2.2 Forestry:

Data source used for estimation of GHGs emission and sequestration to 2030 was collected mainly from General Statistical Office (GSO), Forest Science Institute (FSI) and Forest Inventory and Planning Institute (FIPI).

For developing and assessing forestry mitigation options, input data was gathered from the following sources:

(i) Economic data:

- Viet Nam's economic development forecast up to the year 2030, Development Strategy Institute, Ministry of Planning and Investment.

- 1994 Statistical Year Book, GSO.

- Viet Nam's economy; the period 1945 - 1995 and its perspective by the year 2020.

(ii) Current land use and forest categories:

- Forestry in Viet Nam, Ha Noi, 1992, Ministry of Forestry (MOF).

- Forestry Sector Review, Land use issues, Ha Noi, 1994, MOF.

- Forestry Sector Review, Management of natural forests, Ha Noi, 1994, MOF.

(iii) Baseline / mitigation project area:

- Sector Reports and Publications of Forest Science Institute.

- Current state and development direction of Viet Nam's Forestry Sector in the period 1996 - 2010.

- Forestry Sector Review, Ha Noi, 1990, MOF.

- Reforestation program of 5 million hectares in the period 1996 - 2010, Ha Noi, 3 - 1997, Ministry of Agriculture and Rural Development (MARD).

(iv) Bio-physiological data:

- Results of national forest inventory in 1993, MOF

- Statistical data of Agriculture, Forestry and Fishery 1985 - 1995, Ha Noi, 1996.

- Forestry Sector Review: Management of natural forests, Ha Noi, 1990, MOF.

- Sector reports and Publications of FSI and FIPI, MOF.

2.2.3 Agriculture:

- The agricultural economic data such as rice yield, area, livestock population and productivity, investment cost, production cost, value of benefit etc. come from the Institute of Agricultural Economies (IAE). The data inputs are grouped into 4 main economic regions: Red River Delta, North Central Coast, South Central Coast and Mekong River Delta.

- The Social economic data come from Viet Nam's Economic development forecast up to the year 2030 published by Development Strategy Institute, Ministry of Planning and Investment. The following are the main assumptions and data need for the analysis :

+ Discount rate : 10%.

+ The price of rice : US$ 170/ton

+ Increase in yield from rice field draining : 3-7 %.

+ Associated CH4 emission reduction : 25 - 50 % .

+ The average productivity of rice field is 7,340 kg/ha/year.

+ The inputs taken into account for rice field consist of labour, material, land rent, irrigation, and miscellaneous .

+ Increased productivity due to improved livestock nutrition : 10 %.

+ Associated methane emission reduction : 10-25 % .

+ The average livestock productivity : 84 kg/head/year.

+ The calculation of unit cost is based on economic valuation (social opportunity cost) and the input taken into account consist of labor, material, and the primary investment cost.

3. Inventory and Projection of GHG emissions

3.1 GHG emission factors and Global Warming Potential:

3.1.1 GHG emission factors:

The following IPCC default emission factors were used in the Viet Nam GHG inventory (Tables 3.1 ,3.2 and 3.3).

Table 3.1 : CO_2 emission factors in energy sector

Fuel type	Emission factor (Kg CO_2 /GJ)
Coal anthracite	98.3
Coke	108.2
Gasoline	69.3
Diesel oil	74.1
Residual fuel oil	77.4
Lubricant	73.3
Petroleum Coke	100.8
Anthracite	98.3
Other oil	73.3
Wood	97.9
Natural Gas	56.1

Table 3.2: CO2 emission factors in industrial sector

Productivity	Emission factor (tonne CO_2/tonne product)
Cement	0.4985
Lime	0.752
Soda ash use	0.415
Soda ash production	0.097
Aluminum	1.850

Table 3.3: CH_4 emission factors

	Emission factor
CH_4 from combustion biomass (C-CH4 Ratio)	0.012
CH_4 from Coal mining underground surface mining	18 m^3/t 1.15 m^3/t
CH_4 from enteric fermentation (kg/head/year)	
- Dairy cattle	56
- Non-dairy cattle	44
- Buffaloes	55
- Goat	5
- Horse	18
CH_4 from rice cultivation (g/m^2)	
- Irrigated	20
- Deep water	16
- Rain feed	16
Waste water (Gg CH_4 /Gg BOD_5)	0.22

3.1.2 Global Warming Potential (GWP's):

CO_2 equivalents are based on GWP's of 21 for CH_4 and 310 for N_2O (Table 3.4)

Table 3.4 : Global Warming Potential

Gas	Global Warming Potential
CO_2	1
CH_4	21
N_2O	310

3.2 Energy sector GHG emissions:

3.2.1 Background:

In Vietnam the first energy sector greenhouse gas inventory was undertaken in 1990. In this inventory, emission covered only combustion activities and the methodology used was proposed by the Organization for Economic Cooperation and Development (OECD) .

In the current Inventory the emissions from energy sector includes both fuel combustion and fugitive emissions.

Emissions from fuel combustion include emissions from fossil fuels (coal, oil) and biomass fuel (wood fuel, agricultural residues)

The main sources from energy sector are Energy transformation, industry, transportation, residential combustion and traditional biomass burned for energy.

This inventory was carried out in 1995. The Institute of Meteorology and Hydrology conducted the Inventory in cooperation with the Institute of Energy, the Institute of Transport Science and Technology, Vietnam Electricity Company, the Hanoi Technical University, and the Ministry of Planning and Investment. The data submitted by experts from these institutions and Ministries have been used to set up the sectoral inventory. At the same time, this GHG inventory was prepared by fuel type using a "top down" approach. The result of the inventory for the energy sector is presented for the base year 1993 and projection of GHG emissions are made up to the year 2030.

3.2.2. Methodology:

The inventory was carried out using the 1992 IPCC Guideline for National GHG Inventory.

The following assumptions were made in the calculation of GHG emissions :

- Emissions of almost all greenhouse gases from the energy sector come from burning fossil and traditional biomass fuels.
- Fossil fuels are defined as conventional fuels such as coal, oil and gas. Data was provided by the Institute of Energy (IOE).
- Coal used for Energy is domestic anthracite.
- Traditional biomass fuels consist of wood and rice residues. The estimated consumption of these fuels are based on an average consumption per capita in rural and urban areas.
- The consumption of fossil fuels are based on the balance of imported and stored quantities forded by the oil import and export company.

CO_2 emissions have been estimated on the basis of IPCC assumption, that the emission mostly depends on fuel characteristics rather than on technological processes. CO_2 emissions are calculated from the carbon contents of the fuels consumed by the various sectors.

Almost all emission factors and calorific value and other coefficients used for the GHG estimation provided by IPCC. Some of the coefficients such as emission factors for road transport are adopted from an Indian study results. The use of Indian studies based on the understanding that road transportation vehicles in both countries are at the same technological level. Local country specific coefficients for this sector are not available at present in Vietnam.

3.2.3 GHG emissions from energy sector in 1993:

The results of estimation of GHG emission from the energy sector sources in Vietnam in 1993 are presented in Table 3.5. Carbon dioxide emission from biomass was more about double that of fossil fuel. Coal production emitted methane less than carbon dioxide: 0.078 Gg compared to 7,351.92 Gg, respectively. Total emission from fossil fuel reached 22,938.85 Gg CO_2 equivalent in 1993. Industry sector had the highest GHG emission (6,931.54 Gg CO2 equivalent) in 1993 (table 3.5).

Table 3.5 : GHG Emissions from fuel combustion by fuel type and sector in 1993

Unit: Gg

Fuel type	CO_2	CH_4	N_2O	NO_X	CO	CO_2 equivalent (CO_2+CH_4+N_2O)
Fossil	***19,833.47***	***1.924***	***7.801***	***52.222***	***126.5***	***22,309.59***
Coal	7,351.92	0.778	4.587	18.348	15.161	8790.23
FO	2,384.88	0.046	1.313	0.423	0.485	2792.88
DO	6,285.89	0.136	0.539	21.362	6.962	6455.84
Gasoline	2,732.08	0.951	0.985	10.818	103.753	3057.40
Kerosene	571.77	0.013	0.377	1.271	0.139	688.91
Other oil products	506.93					506.93
Gas	17.40					17.40
Biomass	***37,211.80***	***162.38***	***1.12***	***38.59***	***1420.84***	***3,757.18***
Total	**57,045.27**	**164.30**	**8.921**	**90.812**	**1547.34**	***26,066.77***
Sector						
Fossil	***19,833.47***	***1.88***	***9.89***	***102.66***	***216.54***	***22,938.85***
Power generation	3,585.76	0.77	7.54	27.77	13.79	5,939.33
Industry	6,931.54					6,931.54
Transportation	2,663.90	0.92	0.16	66.99	199.55	2732.82
Com. & service	3,818.00	0.12	1.46	5.30	2.20	4,273.26
Others	2,834.27	0.07	0.73	2.60	1.00	3,106.90
Fugitive		***38.09***				***799.89***
Solid fuel		38.09				799.89
Oil and Natural gas						
Biomass	***37,211.80***	***162.38***	***1.12***	***38.59***	***1420.84***	***3,757.18***
Total	**57,045.27**	**202.35**	**11.01**	**141.25**	**1637.38**	**27,495.78**

Source: Report of GHG inventory under ALGAS project with the correction.
CO_2 emission from biomass is needed to be used for calculation other gases
The total CO_2 equivalent presented in the table is not included CO_2 from biomass

1. End-use:

The industry sector emitted 7 million tonnes of carbon dioxide equivalent, which is about 40% of the total emission of the energy sector.

The commercial and service sector emitted 4 million tonnes of carbon dioxide equivalent or 18% of the total emission from the energy sector. Emission contained 3.8 million tonnes of carbon dioxide, small amounts of nitrous oxide with negligible amounts from methane.

The transport sector emitted 2.7 million tonnes of carbon dioxide equivalent or 11% of total emissions from energy sector. Emissions of carbon monoxide were about 200 thousand tonnes with small amount of oxides of nitrogen and negligible amount of methane.

The other sectors like agriculture emitted 3 million tonnes of carbon dioxide equivalent or 13% of the total emission from energy sector. The emission consisted of mostly carbon dioxide with the GHG being negligible other.

2. Conversion:

Power sector emitted 6 million tonnes of carbon dioxide equivalent or 25% of the total emission from the energy sector. Emissions were mainly carbon dioxide (3.5 million tonnes) with negligible amounts of methane and nitrous oxide as well as carbon monoxide.

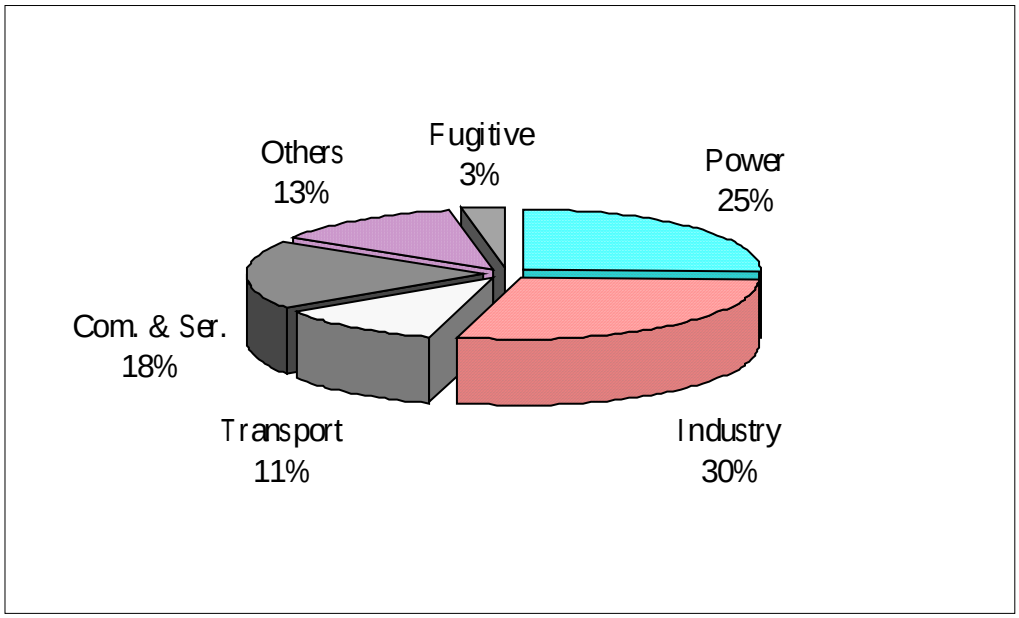
3. Fugitive:

In Vietnam there are coal, oil and gas exploitation and production. However the data used for the estimation of fugitive emissions from oil - gas production in 1993 are not available. So the fugitive emissions are estimated for coal mining only, including underground and surface mining activities. As there is no local specific emission factors in Vietnam so fugitive methane emission from coal mining is estimated based on CH_4 emission coefficients used in India for different types of mine. Fugitive emission from fossil fuel emitted about 0.8 million tonnes of carbon dioxide equivalent or 3% of the total emission from the energy sector. Emission of methane was about 0.076 million tonnes.

In conclusion, overall emission of carbon dioxide contribute major share in the total GHGs emission (about 90%). Methane and nitrous oxide were insignificant, contributing less than 1% of the total emission. In CO_2 equivalent, the industrial sector has highest emission (30%), the power generation followed with 25%, then commercial and service - 18%, others 13% and transport 11% and fugitive only 3% of the total emission form energy combustion and fugitive.

In 1993, the estimated GHG emissions from energy sector were at 27,495.78 million tonnes CO_2 equivalent, not including traditional biomass burned for energy. The CO_2 emissions from fossil fuel combustion were 19.83 million tonnes. The total GHG emissions by fossil fuel from combustion were 27.5 million tonnes. They represented 24.6 % of the total warming effect and the second highest source of the country.

Figure 3.1: GHG emissions from energy sector, fuel combustion and fugitive emissions, expressed as CO_2 equivalent:



Source: Calculated from the study, 1998

3.2.4. GHG emission Projection to 2030 (Baseline Scenario) in Energy sector:

Macro-economic assumptions

The baseline case is an extension of present trends and assumes no major change in energy policy. In this case, the market would be the crucial driving force in determining energy demand and supply. The economic development was undertaken by the Development Strategy Institute, Ministry of Planning and Investment are shown in the table 1.2 with the following main assumptions:

- It is estimated that Vietnam's population will reach 80.9, 93.8, 105.7 and 116.8 million people in 2000, 2005, 2010, 2020 and 2030, respectively.

- With regard to labour, the average annual growth rate is 2,7 % for the period 1996 -2000. This growth rate will drop to 2.5 % for the period after 2000.

- The growth rate of investment for the period 1996 - 2000 has been projected to be 15%. In the period 2001-2010 and 2020, this figure will increase according to economic target, better quality of life and more effective use of capital.

- The growing of income in the non-agricultural sector will increase from 5.5% /year during the period 1996-2000 to 9%-10% /year in the period after 2000.

- The GDP average growth rate will be 8.5 percent upto year 2000 and decline to 7.5 and 7.0 percent in year 2010 and 2020. In years 2030 this growth rate will be around 6.5 percent.

The Baseline Scenario up to 2030 of the GHG from the Energy sector is based on the projection of the Energy demand final energy use.

The MEDEE-S model was used for forecasting the energy demand, organized into homogeneous categories of consumers.

Final Energy Demand

The final energy demand projections of the BAU case for the study period come from the result of MEDEE-S model. The energy consumption system of Vietnam is separated into 5 sectors: Industry, Agriculture, Transportation, Household and Commercial-Service. The forecast process is applied to 5 periods 1990-1995, 1995-2000, 2000-2005, 2010-2020 and 2020-2030. The table 3.6 summarize the demand forecast results by sector for the study period.

The industrial sector include 6 subsectors: Food industry, Textile-Garment, Chemicals, Metallurgy & Engineering, Building materials and others. Data of energy consumption had been collected from Energy Institute and Ministry of Industry (MOI), and data of GDP of each sector from statistical yearbook. On the basis of those data (year 1994), the values of electric intensity, fossil fuel intensity of each subdivision at base year (values of basic variables) can be calculated. Viewing from the structure of overall energy balance, the proportion of kinds of energy fuel used for heating in each industrial subdivision can also be evaluated.

The result of calculation showed that the industrial sector will be the largest consumer of energy in the future. From now up to year 2005 growth rate in energy demand of the industry sector is 11-12 percent. In the period from 2020 to 2030 this growth rate will be at 6-7 percent.

Total energy demand in year 2030 was estimated at a level 104,856 Ktoe. The growth rate for the period is about 5-7 percent (Table 3.6)

The CO2 emission in 2030 will be 396 Tg. By 2030 the most important sources will be industry power generation and transport. The highest emission at present by the fuel is coal. Situation will be the same, after 2020, when coal consumption will increase rapidly. (about 200 Tg CO_2 Tables 3.7 and 3.8).

Table 3.6: Energy Demand Forecast of Viet Nam by sectors for 1994-2030 period (Baseline case). (KTOE)

Unit: ktoe

	1994	2000	2005	2010	2020	2030
Household sector	5472.27	6535.59	7071.76	7841.57	9889.36	17710.34
Urban	1037.976	1938.651	2299.195	3153.235	5419.075	9704.738
Rural	4434.294	4596.939	4772.565	4688.335	4470.285	8005.6
Service sector	274.5	476.67	674.59	996.62	1487.72	2664.28
Transport sector	2082.67	4046.69	6164.13	8525.77	14252.59	25524.22
Industry sector	2610.66	5676.95	10752.51	16158.6	32300.92	57846.03
Growth rate (%)		12.0	11.4	7.9	6.6	5.6
Agricultural sector	354.11	479.39	621.74	694.42	620.93	1111.991
Total	10794.21	17215.29	25284.73	34216.98	58551.52	104856.9
Growth rate(%)		7.7	7.3	6.5	5.2	5.3

Source: Calculated by MEDEE-S Model from this report

Table 3.7 : CO_2 emission by fuel Unit: Kt CO_2

	1994	2000	2005	2010	2020	2030
Coal	8414.12	16609.68	31925.49	37437.72	68149.78	196100.64
Oil	1.3320.03	22975.45	37267.53	53989.86	99508.38	180091.03
Gas	0.0	4900.54	5867.50	11969.70	20160.73	20160.73
Total	21734.16	44485.67	75060.52	103397.88	187818.88	396352.97

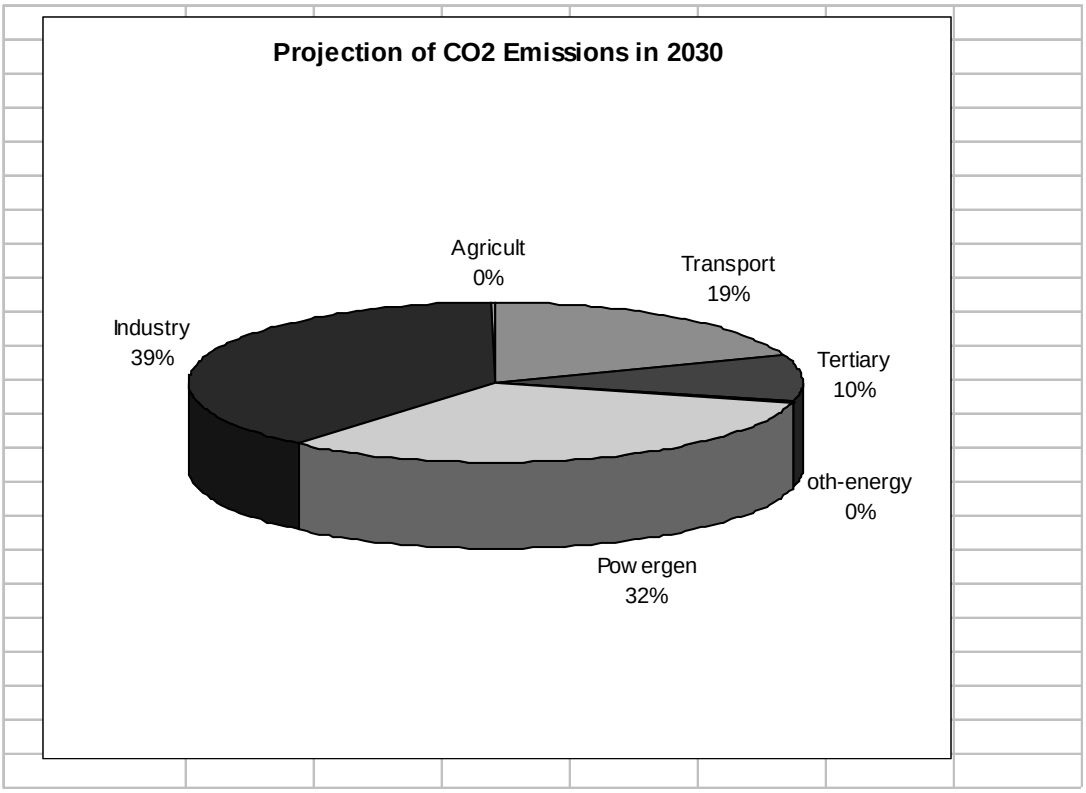
Table 3.8: CO2 emission by sector

(KT CO_2)

	1994	2000	2005	2010	2020	2030
Transport	6207.60	12065.39	13431.47	25523.11	42758.60	76566.27
Tertiary	4430.01	8156.07	9731.13	13272.59	19180.07	38126.88
Other-energy	0	454.54	562.82	840.16	1391.00	1177.00
Powergen.	3192.32	6487.36	15378.56	19613.91	38306.98	126579.30
Industry	7655.42	16987.13	30527.68	43675.79	85566.78	152801.38
Agriculture	248.80	335.19	428.86	472.31	615.45	1102.20
Total	21734.16	44485.67	75060.52	103397.88	187818.88	396352.97

These figures do not include other Greenhouse Gases.

Figure 3.2 : Projection of GHG emissions from energy sector



The future projections of energy demand , Vietnam as many other developing countries needs to develop it's economy; this economic growth will lead to the use of more energy and then to the production of more GHG emissions. The total projection of the energy sector GHG emissions, in CO_2 equivalent, up to year 2020 are about 188 million and 396 million tonnes in 2030, Table 3.8.

3.3 Industry sector GHG emissions:

3.3.1 GHG emissions form industry sector in 1993:

GHGs are emitted as by-products of various production processes which involve the chemical or physical transformation of raw materials, and which are not related to energy combustion activities. Cement production is the most notable example of industrial process that emits a significant amount of CO_2.

GHG emissions from the Industrial Processes sector in Viet Nam in 1993 were estimated using IPCC methodology . The data used for this inventory was obtained from the 1994 Statistical Year Book, General Statistical Office and Viet Nam Cement Corporation. The result show that total CO_2 emission in 1993 from the sector is about 3,086.8 Gg, contributing 2.8% of the total amount of CO_2 emission in the country . In the sector, the most important emission source is cement manufacturing, holding a share of more than 78% of the total CO_2 emission while only 22% of which comes from lime and soda ash production, soda ash use and aluminum production activities. 1993 National GHG inventory result in the sector is presented in Table 3.9

Table 3.9 : Total CO_2 emissions in Industry Sector in 1993.

Activities	Total emission (Gg CO_2)
Cement production	2,417.2
Lime	591.8
Soda Ash production	0.6
Soda Ash Use	36.5
Aluminum	40.7
Total	**3,086.8**

3.3.2 GHG emission projection to 2030 in industry sector:

Since cement manufacture is the most important emission source in the sector so the amount of cement production projected for the period 1997 - 2030 is used for estimation of total CO_2 emission in the sector. The Master plan and Development Strategy of Coal Branch in Viet Nam was used to obtain the figure up to the year 2010 and forecast to 2030, amount of CO_2 emission from cement manufacture in Viet Nam. Under baseline scenario cement production would increase from 4,998 Gg in 2000 to 13,008 Gg in 2010 , to 15,419 Gg in 2020 and to 20,559 Gg

by 2030.

3.4. Forestry sector GHG emissions:

3.4.1. Introduction:

In Viet Nam land is classified into forestry, agriculture, special uses, residential and other. According to Forest Inventory (FIPI-1988), 18.9 million hectares were under management of forestry sector, of which 9.3 million hectares were under forest cover. Forestry is the major source of fuelwood and timber. The total standing volume (stemwood) in the forests is around 525 million cubic meters.

Forests are both a source and sink of carbon dioxide (CO_2). Activities such as forest land conversion and exploitation of forests lead to emission of CO_2 into the atmosphere, whereas the planting of forests sequester CO_2 in vegetation, soils and long term products.

In Viet Nam the previous National GHG Inventory based on OECD methodology was carried out under ADB's Regional Study on Global Environment Issues. Under ALGAS project, the last National GHG Inventory was conducted by Institute of Meteorology and Hydrology, Hydrometeorological Service of Viet Nam in cooperation with Forest Science Institute, Ministry of Agriculture and Rural Development. The IPCC method was adopted for making emission inventory for the land use change and forestry sector.

3.4.2. GHG emissions from forestry sector in 1993:

In order to calculate emission or uptake of carbon from Land use change and Forestry sector, data were collected mainly from General Statistical Office, Forest Science Institute (FSI) and Forest Inventory and Planning Institute (FIPI). In addition, the data and results from Forestry Sector Review, Forestry and Land use reports, Government reports and Publications of Food and Agriculture Organization of the United Nations (FAO) are also referred for this GHG inventory. Type of data used for the inventory is discussed in Section 2.2.2

The standard IPCC methodology for emissions inventory in the land use change and forestry sector was used. The major spreadsheets of the IPCC methodology included the following submodules :

i) 5.1 Changes in forest and other woody biomass stock.

ii) 5.2 Forest and Grass land conversion.

iii) 5.3 On site burning of forests (for trace gases such as CH_4, CO, N_2O and NO_x).

iv) 5.4 Abandonment of managed lands.

The IPCC worksheets used for calculation of GHG emissions in the sector are given in Appendix 3. Area under different forest categories used for estimating total carbon content in annual growth of forests is shown in Table 3.10. However, due to lack of detailed data the average value of annual growth rate under main groups of natural forest and savanna was used for this study.

Table 3.10 : Forest types and amount of carbon uptake increment in 1993

Forest Types		Area of Forest/Biomass Stocks (kha)	Annual Growth Rate (t dm/ha)	Annual Biomass Increment (kt dm)	Total Carbon Uptake Increment (kt C)
Plantations	Acacia spp	120	8.45	1,014	507
	Eucalyptus spp	479	6.75	3,233	1,617
	Pinus spp	40	4.50	180	90
	Other species	160	6.30	1,008	504
Natural Forest	Evergreen	1,335	0.6	801	401
	Secondary	4,825	4.0	19,300	9,650
	Mixed	392	4.0	1,568	784
	Young	1,453	4.0	5,812	2,906
	Bamboo	580	4.5	2,610	1,305
	Other	45	2.0	90	45
Savannas	Woody	3,334	2.5	8,335	4,167
	Shrub	3,323	2.0	6,646	3,323
	Grass	4,134	2.5	10,335	5,168
	Rocky	628	1.0	628	314

It is estimated that about 30,785 ktC was uptaken by forest/biomass. On the contrary, because 30,943 kt of dry matter of biomass from stocks was harvested in 1993, annual carbon released from total biomass consumption from the stocks was 15,472 ktC. As a result, net carbon uptake could be given by subtracting the annual carbon release from the total annual carbon uptake increment. Total carbon uptake due to changes in forest and other woody biomass stock was 15,313 ktC, equivalent of 56,147 kt CO_2.

GHG emission from conversion of exiting forests and natural grasslands to other land uses such as agriculture was estimated. Three sets of calculations are as follows:

i) Carbon emitted by burning above-ground biomass (immediate emission, occurring in the year of conversion).

ii) Carbon released by decay of aboveground biomass (delayed emission, occurring over a ten-year period).

iii) Carbon released from soil (delayed emission, occurring over a 25 year period).

Total of carbon release from forest and grassland conversion arrived by adding the above three indicates that:

- Quantity "C" released from on site burning of biomass: 3,678 ktC
- Quantity "C" released from off site burning of biomass: 617 ktC
- C released from decay of above ground biomass: 2,401 ktC
- C release form soil: 17,052 ktC
- Total annual C release: 23,748 ktC

In addition based on quantity released from on site burning of biomass, trace gas emission from burning of cleared forests can be estimated. The quantity of three non-CO2 trace gases as follows:

CH_4: 58.9 Gg

N_2O: 0.4 Gg

NO_x: 14.6 Gg

For Abandonment of management lands, carbon uptake occurred in vegetation and soil is estimated. Four sets of calculations have been used to produce estimates of CO2 removals.

i) Annual carbon uptake in aboveground biomass (land abandoned in the last 20 years).

ii) Annual carbon uptake in soils (land abandoned in the last 20 years).

iii) Annual carbon uptake in aboveground biomass (land abandoned for between 20 years and a hundred years).

iv) Annual carbon uptake in soil (land abandoned for between 20 years and a hundred years).

It is estimated that about 100,000 ha were abandoned over the last 20 years, which is regenerating. However, due to lack of data on abandoned land prior to 20 years ago, carbon uptake was not estimated for this area. Besides, the estimated emissions did not include below-ground biomass carbon uptake. These gaps need to be overcome in the next inventory. Total carbon uptake from abandoned managed lands is about 285 Gg (equivalent of 1,045 Gg CO_2) including 185 GgC from annual C uptake aboveground biomass in abandoned land (20 years) and 100 GgC from annual C uptake in soil (< 20 years).

In general, total CO_2 emission (excluding non-CO_2 GHG emission) from the sector in 1993 is about 29.9 million tonnes from changes in woody biomass stocks, forest and grassland conversion, and abandoned lands.

Although 57.2 million tonnes of carbon dioxide were sequestered in the forest sector, 29.9 million tonnes of carbon dioxide (excluding non- CO_2 GHG) were emitted in 1993. Table 3.11 shows the total carbon dioxide uptake/emission from the sector in 1993.

Table 3.11: Total Forestry Sector Carbon Dioxide emissions 1993.

	Module	Total emission (kt CO2)
1	CO_2 uptake in forests	-56,147
2	CO_2 emission from forest and grassland conversion	87,077
3	Non-CO_2 GHG emissions (CO_2 equivalence)	1,361
4	CO_2 uptake in abandoned managed lands	- 1,045
	Net CO_2 emissions including non-CO_2 GHG in CO_2 equivalent	31,246

3.4.3. GHG emission projection to 2030 (baseline scenario) in forestry sector:

Land-use change and forestry sector has a large potential for reducing GHG emissions through enhancing carbon sink in the country while at the same time protecting the environment. Thus the Government's plan in coming decades aims at several targets in the attempt to protect the existing natural forest areas as well as develop watershed protection forest and plantation in order to increase rapidly forest coverage to over 40 percent in the next decade. It is also proposed to accomplish the promotion of sedentary farming and settlement throughout the country by the year 2000.

A plan in which 5 million ha of forest and 6 billion scattered trees will be planted in period 1996 - 2010 was developed by Vietnamese Government. However, it is noted that to meet the Government's targets in which 5 additional million hectares of new forest will be established by 2010 and most existing natural forests will be protected over 2020, is very difficult to achieve. Therefore under this study, the Likely trends scenario is used for GHG emission projection to 2030. Estimated forest land area used for the projection is presented in Table 3.12

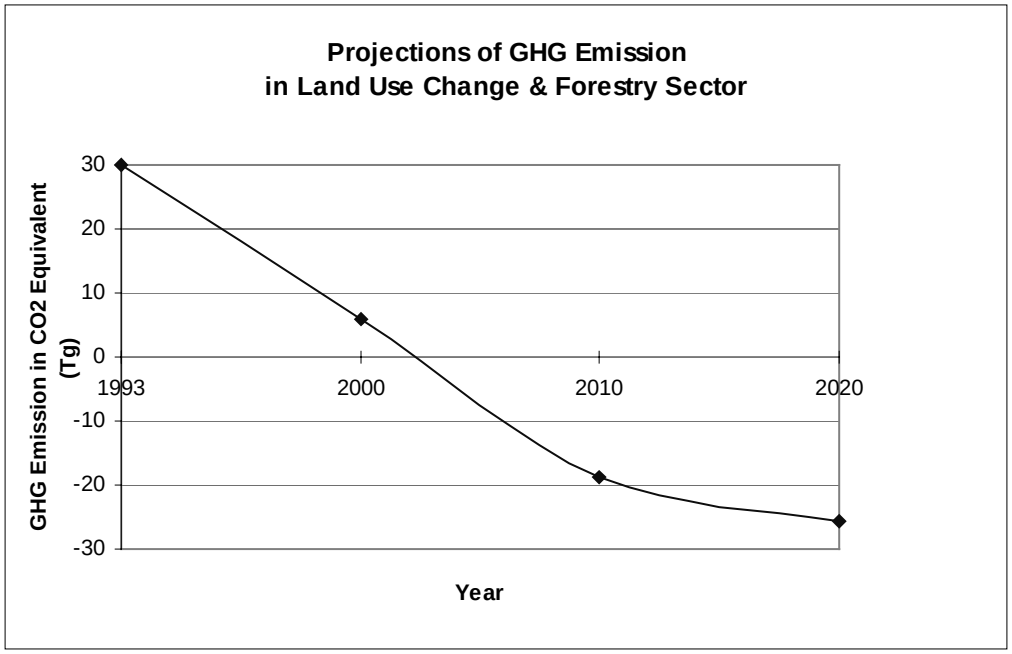
Table 3.12 : Viet Nam forest areas, 1994 - 2030.

Unit: kha

Categories	1994	2000	2010	2020	2030
Plantation	900	2,000	4,200	6,000	8,000
Natural forest	8,630	8,500	9,000	9,500	9,800
Savanna and waste land	10,123	8,600	5,800	3,500	1,200
Total	19,653	19,100	19,000	19,000	19,000

It is estimated that the amount of CO_2 emission projection excluding non- CO_2 GHG is to decline from 29.9 million tonnes in 1993 to 5.8 million tonnes in the year 2000. However, no net emissions are projected for the year 2010, 2020 and 2030. Instead a net sequestration of 18.7 million tonnes by 2010, 25.6 by 2020 and 32.1 by 2030 are projected. This projected reduction in CO_2 emissions (or in fact net sequestration) is mainly due to the large projected increases in plantation area as well as conservation of natural forests (Figure 3. 3)

Figure 3.3: Projection of GHG emissions from Forestry Sector



3.5 Agricultural sector GHG emissions:

3.5.1 Introduction:

Emission of GHGs in the Agricultural sector is primarily of methane from paddy field and livestock (including enteric fermentation and manure management). Nitrogen fertilizer used to increase crop productivity is a source of nitrous oxide emission, while field burning of agricultural residues and prescribed burning of savannas are sources of methane, nitrous oxide, oxides of nitrogen, and carbon dioxide emissions

Based on the methodologies provided by the Intergovernmental Panel on Climate Change (IPCC) this inventory is carried out for the base year of 1993. This year is representative of the transition time in Viet Nam' economy.

3.5.2. GHG emissions from agriculture sector in 1993:

The summary of GHG emission from agricultural sector (CH_4, CO, N_2O and NO_x) in 1993 are presented in table 3.13 and figure 3.4.

The major emissions in agricultural sector consist of CH_4(2247 Gg/year), CO (975 Gg/year), NO_x (24 Gg/year) and N_2O (3Gg/year).

Methane:

The agricultural sector is the major source of methane emission of which rice cultivation contributes 78% of the total (1.755 Tg/year).

Livestock sub-sector contributes 20% (452 Gg/year) to the total emission of. which enteric fermentation occupies 73% and manure management 27%. Biomass burning from savanna and agricultural residues emit only 1% of methane (24 and 16 Gg/year). The major regions of savanna burning (shrub and grass) occurs in the Central and the North of Vietnam while the burning of agricultural residues is practiced mainly in the South of Vietnam.

Carbon Monoxide:

The sources of CO emission includes biomass burning from savanna and agricultural residue with the total emission of 975 Gg/year. Prescribed burning of savannas is the most important source (65%) while the remaining (35%) comes from the burning of agricultural residues.

Nitrogen Oxide (NO_x):

Emission of NO_x from burning of savanna is 11 Gg/year and from agricultural residues is 14Gg/year.

Nitrous Oxide (N_2O):

The total emission of N_2O is 3 Gg/year and was estimated based on the medium default values of emission coefficient from the IPCC methodology - 1995. Agricultural soils is the most important source of N_2O emission which contributed 79% of the total N_2O

emission. The remaining is from biomass 21% prescribed burning of savanna (9%) and agricultural residues (12%) .

Figure 3.4: The emissions in theAgricultural sector (CO2 equivalent)

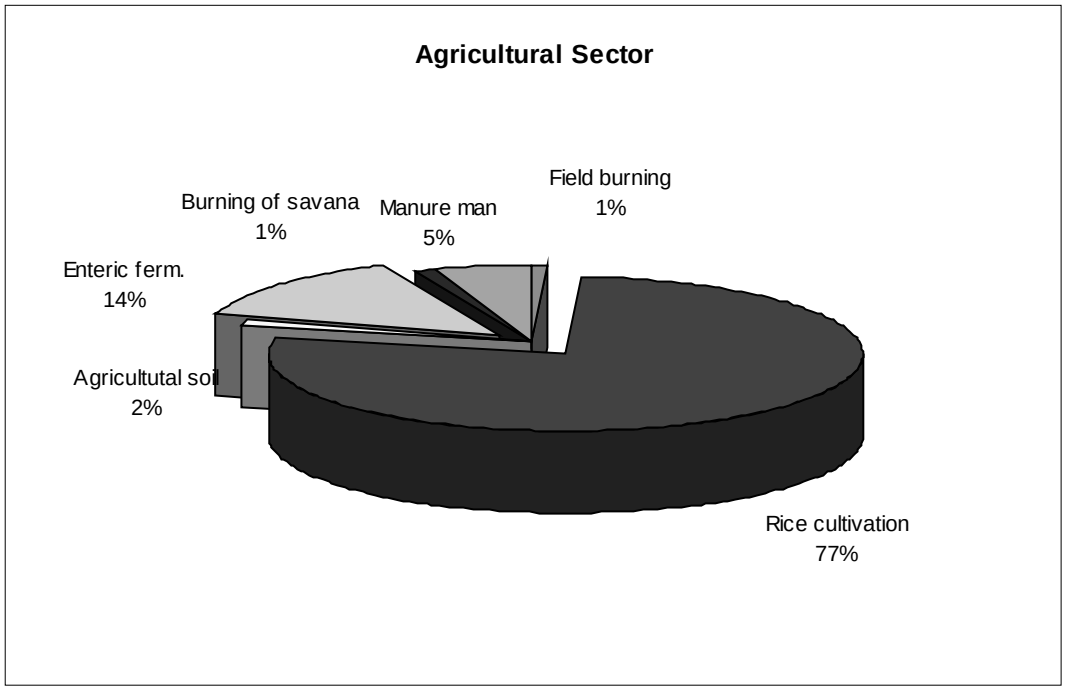


Table 3.13: Summary of the 1993 emissions of green-house gases from agricultural sector.

Unit : Gg

No	Sub-sectors	CH4 (Gg/yr)				CH_4	CO	N_2O	NO_x
1	**Livestock**	**Enteric Fermentation**	**Manure Mngt**						
	a. Dairy Cattle	0.896	0.432						
	b. Non-dairy Cattle	145.948	6.634						
	c. Buffalo	162.800	8.880						
	d. Swine	14.865	104.118						
	e. Goats	1.765	0.078						
	f. Horse	2.394	0.293						
	g. Poultry		3.068						
	Sub Total	328.668	123.503			452			
2	**Rice Field**	**CH_4**							
	a. Completely flooded	1.511							
	b. Intermittently flooded								
	c. deep water rice	0.102							
	d. Rainfed	0.142							
	Sub Total					1755			
3	**Agricultural Soils**		**N2O**						
	Total for sector		2.542					2.542	
4	**Prescribed Burning of Savanna**	**CH_4**	**CO**	**N_2O**	**NOx**				
	Shrub								
	Grassland								
	Shifting Cultivation								
	Sub Total	23.959	628.908	0.297	10.715	24	628.908	0.297	10.715
5	**Burning of Agricultural Residue**	**CH_4**	**CO**	**N_2O**	**NOx**				
		16.495	346.388	0.380	13.770	16	346.388	0.380	13.770
		Total Emissions				2247	975.3	3.22	24.48

3.5.3 GHG emission Projection to 2030 (baseline scenario) in agriculture sector:

GHG emission Inventory Projection for 2000, 2010, 2020 and 2030 are presented in Table 3.14 based on the GHG inventory for 1993 and those of 2030.

Table 3.14 : CH_4, NO_2 emissions inventory projection to 2030.

Unit: Gg

		1993		2000		2010		2020		2030	
		CH_4	N_2O	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
1	Livestock	452		560		692		927		1026	
2	Rice cultivation	1755		1894		1998		2111		2223	
3	Burning of savanna	24	0.30	27	0.39	12	0.15	12	0.15		
4	Field burning of Agricultural residue	16	0.38	20	0.47	24	0.56	31	0.73		
5	Agricultural soil		2.54		3.31		3.72		4.95		5.76
	Total	2247	3.22	2501	4.17	2726	4.43	3081	5.83	3249	5.76

The total 2,247 Gg CH4 emission from agricultural sector in 1993 will grow to 2501 Gg in 2000, 2726 Gg in 2010, 3081 Gg in 2020 and 3249 Gg in 2030 while N_2O emission will increase from about 3 Gg in 1993 to about 6 Gg in 2030.

Rice cultivation emitted the highest amount of CH_4, it contributes 76% of total CH_4 emission in 2000 and 68% in 2030 (Table 3.14)

3.6 Summary of GHG emissions in Vietnam 1993 and projection to 2030:

3.6.1. Summary of GHG emissions in 1993:

The three most important GHGs are carbon dioxide (CO_2) methane (CH_4) and nitrous oxide (N_2O). Total emissions of Vietnam in 1993 were 111.7 million tonnes of CO_2 equivalent. Table 3.15 presents the emissions of GHG by sector.

Table 3.15 : GHG emissions by sector in Vietnam, 1993

Unit : Million tones

Sector	Emission in CO_2 equivalent	Percentage of total emission
Energy	27.50	24.62
Industrial processes	3.09	2.77
Agriculture	48.19	43.14
Land use change and forestry	31.25	27.98
Waste	1.67	1.49
Total	111.70	100

The most important emission source in Viet Nam was agriculture sector with the total CH_4 emission of 2.3 million tonnes (about 48 Tg CO2 equivalent) contributing 43% of the total GHG national emissions in the country in 1993. GHG emission from forestry sector came in second with 31 Tg CO2 holding a share of 28% of the GHG emission, while energy sector emitted 27.5 Tg CO_2 contributing 25% to the GHG emissions(Table 3.15) .

The industrial processes and waste sectors contributed small amounts to total emission in comparison with the three sectors mentioned above. 3.09 million tonnes CO_2 equivalent was emitted from industrial process sector and 1.67 million tonnes CO_2 equivalent from waste sector which contributed 2.8 % and 1.5 % respectively to total national emissions .

3.6.2 GHG inventory projection up to 2030:

Emission in the future will increase mainly from increased fossil fuel consumption.

Emission from the energy sector in 2030 is projected to 396 million tonnes CO_2, which is 15 time higher than 1993.

GHG emission from agriculture sector will also increase but with lower growth rate compared with energy sector. The GHG emissions from agriculture is projected from 48 million tonnes CO_2 equivalent in 1993 to 68 million tonnes CO_2 equivalent in 2030.

In the forestry sector, the amount of CO_2 emissions is projected to decline from 29.9 million tonnes in 1993 to 5.8 million tonnes in the year 2000 and lead to net sequestration of 18.7, 25.6 and 32.1 million tonnes in 2010, 2020 and 2030 respectively. Table 3.16 shows the GHG inventory projection in Viet Nam to 2030.

Table 3.16: Projection of GHG emissions in Sectors; (Tg) of CO_2 equivalent in 2030.

Unit: Tg CO_2

Sector	***1993***	***2000***	***2010***	***2020***	***2030***
Energy	27.5	44.48	103.40	187.82	396.35
Forestry	29.88	5.80	-18.70	-25.60	-32.10
Agriculture	48.19	52.50	57.20	64.70	68.29
Total	105.57	102.78	141.90	226.92	432.54

4. Energy sector baseline and abatement scenarios

Introduction:

Viet Nam has a broad range of mineral resources. There is considerable energy potential in form of coal, oil and gas, hydropower and fuel wood.

Viet Nam has a total electricity production capacity of about 4000 MW of which hydroelectric, thermoelectric and other account for 66%, 21% and 13% respectively.

The total coal reserves are estimated at more than 6 billion tonnes. Most of it is anthracite. In recent years coal production has fluctuated between of 4 - 8 million tonnes per year.

The total oil and gas potential reserves is estimated at about 2 billion tonnes of oil equivalent. Consumption of oil products are from 1.5 million tonnes in 1989 to 7.7 million tonnes in 1995.

The total hydroelectric power capacity which can be developed is 17,100 MW with an average annual output of 82 billion kwh.

The power consumption of socioeconomic activities is distributed to following 4 main sectors: Industrial, agricultural, residential and non-industrial. In the period 1989-1994 the share of industrial sector in the power consumption was about 40%, while the residential sector consumed about 30% of total power.

4.1 Baseline scenarios

4.1.1.Baseline assumptions

For the baseline scenario (BASE) levels of energy efficiency used in calculation is provided in the table 2.3. The model calculates a cost-optimal energy supply strategy for the given energy demand.

Definition of the Structure of Vietnam Energy System

In EFOM-ENV model , some primary energy forms are converted to intermediate energy forms then to final energy demand. Model generally distinguishes different subsystems. Each subsystem comprises a set of technologies with similar function. It provides a function decomposition of all energy related activities in the economy. The energy supply and demand are represented by subsystems as follows:

- Coal subsystem (COAL-SS)

The coal subsystem comprises all conventional activities from the coal extraction with two types of mines such as open pits and deep mines to coal washing for the production of clean coal, then transport to users. The coal export and import are included.

At present, Vietnam exports coal but the demand for coal will increase rapidly, especially in power generation so that domestic coal production might not satisfy demand .

- Oil Subsystem (OIL-SS)

This subsystem includes all activities from extraction of crude oil to refining and distribution oil products to end users. Vietnam's crude oil is a low sulfur light oil and there is only offshore extraction . At present, there is no refining, but according to Vietnam Petroleum and Gas Corporation, Vietnam will build oil refining plants between 2000-2020.

Until oil refining plants are in operation, Vietnam will have to import all oil products to cover its demands. After year 2000, part of oil products from indigenous refining might be exported.

- Gas Subsystem (GAS-SS)

This subsystem covers all gas related activities from natural gas extraction onshore and offshore to end-use, including intermediate processing such as production of liquefied natural gas (LNG), compressed natural gas (CNG) and liquefied petroleum gas (LPG). There is potential for Vietnam to export natural gas, in its gaseous form by undersea pipeline to Thailand. This project is under discussion by the two governments. The associated gas from oil extraction is included in this subsystem.

- Central Electricity Subsystem (CENTELEC-SS)

The electricity corporation of Vietnam (EVN) manages the chain from power generation to distribution of the electricity to end-users. On the network side, two electricity systems are considered: (i) northern system and (ii) southern system.

In the northern system, hard coal is the fuel for all thermal plants. However, in the future use of lignite will also be considered .

Fuel supply will be a key determinant in the future for choosing the thermal generating plants in the southern system. Possible energy sources include offshore natural gas and coal from the north or from other Asian countries. Coal-fired plant, oil-fired plant, oil-gas fired plant and gas combined cycle are considered in the future in the southern sub-system.

There are also reservoir hydropower plants in both systems. The two systems are connected by a super high voltage 500 kV transmission line. The export of electricity is considered in both northern and south sub-systems.

- Traditional Fuel Subsystem (TF-SS)

The two main types of traditional fuel are fuelwood and agricultural residues. This subsystem considers the fuel chain from extraction of biomass to transport to end-users. The traditional fuel is mainly used in household sector for cooking.

- Final Subsystems (FINAL-SS)

The final subsystems consist of the following subsystems:

* *Industrial subsystem (INDUSTRY-SS)*

Industrial sector is the largest energy consumer now and also in the future. At present, in the industrial production, almost of all equipment are outdated. They consume more energy than the those in developed countries, especially in thermal processes.

* *Agricultural subsystem (AGRICULT-SS)*

* *Transportation subsystem (TRANSPOR-SS)*

The energy forms in transport subsystem are coal, diesel oil, gasoline and jet fuel. In Vietnam up to now, the railway uses coal like fuel for steam engines, but it will be replaced by diesel engines by year 2005.

* *Household subsystem (HH-SS)*

In order to account properly for option substitution and conservation inside the household subsystem, the demand is split according to end-use application, mainly into three categories: cooking, lighting and other electrical uses. The fuel types in consideration for cooking are electricity, kerosene, LPG, coal and traditional fuels. The fuel types for lighting are kerosene and electricity.

* *Commercial and service subsystem (COMM-SS)*

4.1.2. The economic development assumption

The GDP structure for the period 1994 - 2030 projected by the Development Strategy Institute is shown in the table 1.2. According to the structure the following baseline scenario has been developed.

In this case, the economic development forecast was undertaken by the Development Strategy Institute, Ministry of Planning and Investment are shown in the table 1.2 and 1.3 with the main following assumptions:

- It is estimated that Vietnam's population will reach 80.9, 93.8, 105.7 and 116.8 million people in 2000, 2005, 2010, 2020 and 2030 respectively.

- With the regard to labour, the average annual growth rate is 2,7 % for the period 1996 -2000. This growth rate will decline to 2.5 % for the period after 2000.

- The growth rate of investment for the period 1996 - 2000 has been projected to be 15%. In the period 2001-2010 and 2020-2030, this figure will increase according to economic target, better quality of life and more effective use of capital.

- The growing of income in the non-agricultural sector will increase from 5.5% /year during the period 1996-2000 to 9%-10% /year in the period after 2000.

- The GDP average growth rate will be 8.5 percent during year 2000 and decreases to 7.5 and 7.0 percent in year 2010-2020. In year 2030 this growth rate will be around 6.5 percent.

Energy cost assumption used for calculation is given in Table 2.2

4.1.3. Energy demand projection

Base on the combination of MEDEE-S model and EFOM-ENV the energy demand forecast have been produced (Table 4.1).

Table 4.1 : Energy demand forecast by sectors for period 1994 - 2030.

Unit: ktoe

	1994	2000	2005	2010	2020	2030
Household sector	5472.27	6535.59	7071.76	7841.57	9889.36	17710.34
Urban	1037.976	1938.651	2299.195	3153.235	5419.075	9704.738
Rural	4434.294	4596.939	4772.565	4688.335	4470.285	8005.6
Service sector	274.5	476.67	674.59	996.62	1487.72	2664.28
Transport sector	2082.67	4046.69	6164.13	8525.77	14252.59	25524.22
Industry sector	2610.66	5676.95	10752.51	16158.6	32300.92	57846.03
Agricultural sector	354.11	479.39	621.74	694.42	620.93	1111.991
Total	10794.21	17215.29	25284.73	34216.98	58551.52	104856.9

Source: Calculated by MEDEE-S Model from this report

Table 4.2 : Energy Demand Forecast of Viet Nam by fuels for 1994-2030 period (Baseline case). (KTOE)

Unit: ktoe

	1994	2000	2005	2010	2020	2030
Household sector	5472.27	6535.59	7071.76	7841.57	9889.36	17710.34
Urban	1037.976	1938.651	2299.195	3153.235	5419.075	9704.738
Rural	4434.294	4596.939	4772.565	4688.335	4470.285	8005.6
Service sector	274.5	476.67	674.59	996.62	1487.72	2664.28
Transport sector	2082.67	4046.69	6164.13	8525.77	14252.59	25524.22
Industry sector	2610.66	5676.95	10752.51	16158.6	32300.92	57846.03
Growth rate (%)		12.0	11.4	7.9	6.6	5.6
Agricultural sector	354.11	479.39	621.74	694.42	620.93	1111.991
Total	10794.21	17215.29	25284.73	34216.98	58551.52	104856.9
Growth rate(%)		7.7	7.3	6.5	5.2	5.3

Source: Calculated by MEDEE-S Model from this report

Models for forecasting energy demand in the future are mostly based on proposed economic growth rate. Normally, there are three economic development scenarios appropriated to high, medium and low growth rate scenarios (Appendix 1.5, 1.6, 1.7, 1.8). Therefore, energy demand forecast is carried out based on economic development scenario with medium growth rate.

The energy system structure was designed to comply with results calculated by MEDEE-S model.

It is one of the existing techno-economic model organized into homogeneous categories of consumers or modules-which unable a detailed modeling of the energy demand dynamics at sectoral and sub-sectoral level.

The basic model is automatically implemented for the 5 economic sectors, and series of annex sub-models are used are used for detailed calculations.

4.1.4 Primary energy projection

At present Viet Nam imports oil refinery products for domestic use . However by 2000 the country will domestically produce refinery oil products. Furthermore by 2015 Viet Nam will start importing coal for domestic use.

The potential of new renewable energy sources in Viet Nam will meet around 12-13% of the demand. Towards 2030 the demand of all primary will increase and the consumption of traditional biomass energy will decrease.

The demand of primary energy for baseline case is presented in Table 4.3

Table 4.3: Primary energy demand baseline scenario

VIETNAM	1994	2000	2005	2010	2020	2030
SOLID FUELS						
PROD.	3519.00	5824.00	9130.00	10426.00	12000.00	8200.00
IMPORT	0.00	0.00	0.00		4364.00	39440.00
EXPORT	-1428.00	-1824.00	-1428.00	-1428.00	0.00	0.00
TOTAL	2091.00	4000.00	7702.00	8998.00	16364.00	47640.00
PETROLEUM						
PROD.CRU	7024.00	10420.00	15420.00	24420.00	19740.00	0.00
IMP-CRUD	0.00	0.00	0.00	0.00	16510.00	36250.00
IMP.DIS.	4567.30	1664.20	6317.53	11795.70	20659.90	47023.00
EXP.CRU.	-7024.00	-3500.00	-8500.00	-17500.00	-22500.00	-22500.00
EXP.DIS.	0.00	-354.25	-222.10	-115.20	-398.23	-310.00
TOTAL	4567.30	8229.95	13015.43	18600.50	34011.67	60463.00
GAS						
PROD.	0.00	2088.00	2500.00	5100.00	8590.00	9417.00
TOTAL	0.00	2088.00	2500.00	5100.00	8590.00	9417.00
NEW & RENEWABLE						
HYDRAUL.	1863.71	2844.86	5494.86	8116.00	11937.14	13648.57
NUCLEAR	0.00	0.00	0.00	404.00	1805.00	3008.00
GEOTHERM	0.00	0.00	37.60	37.60	75.20	75.20
WIND	0.00	0.00	37.60	37.60	75.20	75.20
TOTAL	1863.71	2844.86	5570.06	8595.20	13892.54	16806.97
TRATIONAL BIOMASS	4186.00	4023.00	3790.00	3135.00	2649.00	3401.00
TOTAL	12708.01	21185.81	32577.49	44428.70	75507.21	137727.97

Primary energy projection was set up as follows:

- Based on potential energy sources such as coal, oil, gas, hydropower and other energy resources.
- Based on energy development policy.
- Apply new and modern technology for energy transportation and production.

There is also a large potential for energy efficiency improvement on the supply. transmission and distribution of energy.

4.1.5- Power Generation

Due to the high growth rates of electricity demand, power generations is expected to rise drastically. The electricity production in 2020 would be more than 18 times that in 1994. The electricity production reaches 11,390 GWh in 1994 and up to 152,502 GWh in 2020.

Hydropower is the most favorable primary energy for power generation until 2020. However, the share of hydropower in total energy input for production of electricity reached a maximum at 69.8% in 1994, and is projected to decline to 31.9% by 2020. Natural gas for power generation increases with an annual average growth rate at 8.5% in period 2000 - 2020. The share of coal increases drastically from approximately 9% in 1994 to 25.3% in 2020. By contrast, oil products are not consumed for electricity production in year 2000. The substitution of oil in year 2000 would be mainly due to an increased use of natural gas and hydropower for electricity generation (see Tables 4.4 and 4.5).

Table 4.4 Power Generation by Fuel Types in the BASE case (GWh)

	1994	2000	2005	2010	2020
Coal-fir	957.91	673.26	3,805.00	3,270.00	18,445.00
Gas-tur	232.56	3,779.07	2,616.28	1,162.79	581.40
Oil-fir	1,644.19	0.00	1,762.79	1,762.79	713.49
Diesel	208.14	0.00	0.00	0.00	0.00
Gas-CC	0.00	7,258.37	17,755.81	27,860.46	54,720.93
Nuclear	0.00	0.00	0.00	0.00	0.00
Hydro	8,663.29	11,577.45	21,551.92	43,529.78	55,548.46
Biomass	0.00	41.98	83.95	104.93	104.93
Geothermal	0.00	0.00	0.00	349.78	699.56
Wind	0.00	0.00	0.00	218.63	437.26
Total	11,706.09	23,330.13	47,575.75	78,259.16	131,251.03

Source: Calculated from this study by EFOM-ENV Model

Table 4.5 Energy input for Power Generation in the BASE case

Unit: ktoe

	1994	2000	2005	2010	2020
Coal	305,1	409,7	1744	1995	5713
Gas	0	1700	3500	5150	9590
Oil	602,8	800	551,6	151,6	61,36
Hydro	2128,57	2844,86	5414,86	10694,29	13648,57
Nuclear power	0	0	0	0	564,22
Wind power	0	0	0	18,8	37,6
Geothermal power	0	0	0	30,08	60,16

Source: Calculated from this study by EFOM-ENV Model

4.2. Abatement scenarios

4.2.1. Abatement scenario assumption

The development of economy and improvement of people's living condition should lead to increase in energy consumption, usually resulting in generation of more CO_2, CH_4, NO_2, NO_x and CO emissions. The main principle of the energy development strategy for reducing pollution emissions on the supply side is to reduce fossil fuel usage by improving energy efficiency, substitution of fossil fuels by non-fossil sources, and replacing fuels with high carbon content by fuels with low carbon content.

The present situation in Vietnam in the energy sector is characterized by:

- An inefficient transportation and conversion of primary energies;
- High losses in energy distribution networks; and
- An inefficient end-use due to outdated industrial processes, and a lack of metering system, regulations and standards.

In this study both ways of reducing primary energy requirements will be considered: improvement of energy efficiency and fuel switching.

Identification of Energy Strategies on the Supply Side

There is a large potential for energy efficiency gains on the supply side. In the construction of thermal power plants in the future, the priority should be the development of larger units consuming less energy for electricity production.

In the future, transmission and distribution networks will need to be of rehabilitated and regarded to the selection of a standard medium voltage level at 20 kV for reducing power losses during transmission and distribution processes.

Identification of Energy Strategies on the Demand Side: Energy Conservation

The improvement of efficiency in the end-use sector would play a major role in reducing final energy demand. Several audits conducted recently in industrial sector show that there is a scope for saving up to 5% if average efficiency of fossil fuels for heating increase at an annual rate of 1%.

The substitution of coal-fired plants and oil-fired thermal plants by gas-fired plants or combined cycle would lead to a reduction of coal and oil consumption in power generation. The extra high voltage transmission line can be regarded as environmentally sound since it may eliminate the need for more oil-fired thermal plants in the south.

4.2.2. Abatement scenarios

Energy conservation and saving activities are major abatement scenarios

These scenarios were set up based on demand side management studies in order to improve efficiency of energy use equipment. They consist of following options:

- Use production technologies with less energy consumption such as replacing dry production technology for wet production technology in cement production.
- Improvement in energy efficiency in fuel combustion processes used in Industry replacement of old low efficiency boiler by energy - efficient industrial boilers ;
- Highly efficient household electric equipment;
- Improvement of efficiency of cooking stoves.
- Energy efficient lighting ;
- Replacement of existing electric motors by highly efficient electric motors; and
- Increased vehicle efficiency.

From possible scenarios, consumption scenarios have been specifically considered and estimated.

4.2.3. Energy consumption scenarios

- Efficiency Improvement in Cooking
- Compact Fluorescent Lamp (CFL)
- High Efficiency Refrigerators
- Air Conditioning Efficiency Improvement
- More Efficient Industrial Motors.

Scenario 1: Efficiency Improvement in Cooking

Energy for cooking in Vietnam is dominated by biomass fuels. In rural areas, fuelwood is used for cooking. Some kerosene is also used for cooking both with wick and pressure stoves. Coal, either in lump form or as briquettes, is widely used. The share of electricity for cooking is very small.

The change from burning lump coal in homemade stoves to burn briquettes in innovated stoves leads to an efficiency increment from 17% to 25%. Cost of efficiency improvement of a cooking stove is estimated to be 50$/ktoe saved. The penetration rates in milestone years are assumed as follows:

	2000	2005	2010	2020	2030
Rural households (%)	5	10	15	20	30
Urban households (%)	10	15	20	30	40

The least-cost results show the potential CO_2 mitigation would be 221 million tonnes in 36 years, at cost of US$ -1.75 per tonne avoided CO_2 emission.

Scenario 2: Compact Fluorescent Lamp (CFL)

Until now, electric lighting in Vietnam is based predominantly on mercury vapor lamps. Fluorescent lighting is rarely used. Incandescent lighting is still found in outlying areas. There is a large potential for application of CFLs in Vietnam.

This option entails the installation of CFL to substitute existing lamps. Characteristics of bulbs and compact fluorescent lamps can be described as follows:

	Bulb	CFL
Nominal power capacity	75 W	14 W
Lifetime (hours)	1000	8000
Initial cost (USD)	0.5	20
Annual consumption (kWh)	109.5	23

Based on these figures the substitution cost of bulbs by CFLs is estimated to be $0.0313/kWh saved.

The schedule for substitution is as follows:

	2005	2010	2020	2030
Rural households (%)	0	3	5	10
Urban households (%)	10	15	20	30

This option proposes to replace inefficient bulbs (ILB) by energy-efficient compact fluorescent lamps (CFL). Average power consumption of the existing bulb is about 75W and electricity consumption is about 110 kWh per annum. CFLs use roughly 80% less electricity but

CFLs are more expensive than ILBs. Lifetime of CFLs is estimated to be 8 times more than that of ILBs. However cost of CFLs is five times higher than that of IBLs for a comparable lifetime..

EFOM-ENV model results indicate a potential of 50 million tonnes of CO_2 mitigated with an incremental cost of -US$ -3.38 per tonne of avoided CO_2 emission.

Scenario 3: High Efficiency refrigerators

Estimated power consumption of refrigerator ranges between 100W to 135W. In this study the figures and characteristics were taken from the DSM analysis report. They are related to 150 liter refrigerator with a 120W capacity. Compressor operates on an average of 14 hours per day resulting in 614 kWh/yr. annual electricity consumption. This scenario assumed that the existing standard refrigerators should be replaced by efficient ones. The characteristics of the two kinds of refrigerators are indicated in the table below:

	Standard	Efficient
Nominal power capacity (W)	120	102
Lifetime (years)	8	8
Initial cost (USD)	350	385
Annual consumption (kWh)	614	521

Based on the above figures cost for substitution of standard refrigerator by efficient refrigerator is estimated to be $0.0628/kWh.

The schedule for substitution is as follows:

	2005	2010	2020	2030
Rural households (%)	5	10	15	20
Urban households (%)	15	20	30	40

This option requires to better marketing of energy-efficient refrigerators to replace existing refrigerators. The average efficiency assumed is equivalent to a unit consumption of 521 kWh/year about 85% compared to the old one.

Modeling results show a potential of 266 million tonnes of carbon with an incremental cost-US$3.6 per tonne of avoided CO_2.

Scenario 4: Air Conditioning

This study considers the replacement of existing air conditioners (from former Soviet Union) by more efficient ones. Average annual electricity consumption of existing air conditioner is estimated at 1987 kWh per year. By using efficient ones electricity consumption is expected to be reduced 22%. The characteristics of the two kinds of the air conditioners are given in the following table:

	Standard	Efficient
Nominal power capacity (W)		
Lifetime (years)	10	10
Incremental cost (USD)		25
Annual consumption (kWh)	1987	1548

Cost for substitution of standard air conditioner by efficient air conditioner is estimated to be $0.009/kWh.

The schedule for substitution is as follows:

	2005	2010	2020	2030
Rural households (%)	5	10	15	20
Urban households (%)	10	20	30	40

The window air conditioners are commonly used in the residential and commercial buildings in Vietnam. This option involves the replacement of in efficient air-conditioners with energy-efficient units.

The results show a potential of 158 million tonnes of CO_2 reduction with cost of US$ -4.42 per tonne avoided CO_2.

Scenario 5: More Efficient Industrial Motors

This option considers the saving impact based on a 15 kW motor representing the average motor size in the o.75 to 150 kW motor range. For this average size a 5% efficiency improvement based on 86% standard efficiency motor results in 6.4% energy savings. The energy consumption and incremental cost are shown in the table below:

	Standard	Efficient
Nominal power capacity (kW)	0.015	0.015
Motor efficiency (%)	86	91
Lifetime (years)	20	20
Incremental cost (USD)		225
Annual consumption (kWh)	61047	57692

Cost for substitution if existing electric motors by efficient ones is estimated to be US$0.0078/kWh.

The schedule for substitution is as follows:

	2005	2010	2020	2030
(%)	5	10	20	30

This option considers the replacement of existing motors with energy efficient motors. It is assumed that the average efficiency of standard-efficient electric motors can be improved by at least 5% from 86% to 91%.

The least-cost results showed that a potential CO_2 mitigation in the order of 212 million tonnes of CO_2 in 36 years. The cost of avoided CO_2 for this option was estimated to be US$ -3.02 per tonne of CO_2.

4.2.4. Energy supply scenarios

- Fuel Switching in Power Generation
- Wind power plants

Scenario 6: Fuel Switching in Power Generation

The abatement option involves fuel switching in the power generation sector. In the North, existing coal-fired power plants are substituted by oil-fired power plants and in the South, existing oil-fired power plants are substituted by gas fired thermal power plants.

Total capacity of the existing coal fired power plants to be converted to use oil is 640 MW in period 2000-2005. The investment requirement is estimated to be about US$150/kW. Total capacity of the existing oil fired power plants to be converted to use gas is 198 MW in period 2000-2005. The investment requirement is estimated to be about US$100/kW.

This scenario considers the substitution of coal by oil in existing thermal power plants in the north and oil by gas (increasing gas used in generation of existing thermal power plant) in the south. In this scenario primary energy supply is not much different compared with the Base scenario. Share of fuel oil in total fuel for generation is higher than that of Base scenario, while coal share is lower.

Environmental Impacts and costs

The switching from coal to oil in the north and oil to gas in the south for power generation reduces GHG emissions substantially. The total GHG (CO_2) emissions of this scenario will be 14 million tonnes CO_2 with an incremental cost of US$ 21.14 per tonne of avoided CO_2.

Scenario 7: Wind Turbine

The technical viability of operating wind energy system depends basically on the availability of wind in terms of velocity and duration. Vietnam especially the central part of the country is located in high wind velocity area. However the wind energy used is still very limited and is used mainly for remote areas. At present some foreign companies have proposed new wind farms for Vietnam. German Ventis Company conducted a feasibility study for the construction of a wind farm with a capacity of 10MW in the first period and 20MW at the end of the second period in Nha Trang city southern Viet Nam.

This study considers the penetration of wind power from year 2000 and installed capacity of wind power was projected as follows:

- 2000: 100 MW
- 2005: 200 MW
- 2010: 400 MW
- 2020: 750 MW.
- Investment cost: 1700 US$95/kW and fixed O&M cost: 34 US$/kW/yr.

Wind power is a new energy and also a new concept in Vietnam. In the past small-stand wind power stations for battery charging were used for low power such as lighting and telecommunication. They are most likely to be installed in remote islands as cheaper alternative for diesel generator sets.

The total GHG (CO_2) emissions of this scenario will be 104 million tonnes CO_2 with an incremental cost of US$ -1.94 per tonne of avoided CO_2.

4.3 Summary of mitigation opportunities:

Table 4.6 : Differences in CO_2 Emissions and Costs by Various Mitigation Scenarios Compared to Base Scenario

	Base line	ENV1	ENV2	ENV3	ENV4	ENV5	ENV6	ENV7
CO_2 emissions (Mt)	7520	7299	7470	7254	7362	7308	7506	7416
Cost (Mil. .US$)	43800	43414	43631	42842	43101	43159	44096	43598
ΔCO_2 emissions (Mt)		221	50	266	158	212	14	104
ΔCosts (Mil. US$)		-386	-169	-958	-699	-641	296	-202
Cost per t ΔCO_2 reduction		-1.75	-3.38	-3.60	-4.42	-3.02	21.14	-1.94

Source: Calculated from this study by EFOM-ENV Model.

ENV-1: Efficiency improvement in coal cooking
ENV-2: Compact fluorescent lamps
ENV-3: Energy efficient refrigerators
ENV-4: Energy efficient air conditioners
ENV-5: High efficient electric motors
ENV-6: Fuel Switching in existing thermal power plant
ENV-7: Wind power plant.

Table 4.6 shows the different options of CO2 reduction in energy sector in Viet Nam, which were calculated using the EFOM-ENV model. Most cost effective are the efficient air conditioning and energy efficient refrigerator options, followed by efficient lighting, motors and cooking. On the supply side, wind power is cost effective. In other words, all the CO2 abatement options from demand side (except fuel switching) in energy sector in Viet Nam are cost effective. This is due to the backwardness of the present technologies. A survey in 1995 by the

Institute of Energy showed that the energy consumption per unit of output in industry sector of Viet Nam is 50% and 30% higher than OECD countries for thermal energy and electricity respectively. So any measures and investment directed to these sectors will benefit not only environment but also the economy (win-win).

Table 4.7 Summary of CO_2 reduction in energy sector.

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million tonne of CO2)	Cost of initiative (US$ tonne of CO2)
(1998-2005)	-Fuel switching	14	21.14
	-Wind power construction	27.6	-1.94
	-Improvement of efficiency in cooking	78.8	-1.75
	-CFL	12.5	-3.38
	- High efficient air conditioning	39.5	-4.42
	-High efficient refrigerator	88.6	-3.60
	-High efficient electric motors	35.2	-3.02
	integrated scenarios	**296.2**	**-1.81**
(2005-2015)	-Wind power construction	27.6	-1.94
	-Improvement of efficiency in cooking	63.2	-1.75
	-CFL	14.5	-3.38
	- High efficient air conditioning	59.2	-4.42
	-High efficient refrigerator	77.7	-3.60
	-High efficient electric motors	70.6	-3.02
	Integrated scenarios	**312.8**	**-3.09**
(beyond 2015)	-Wind power construction	48.6	-1.94
	-Improvement of efficiency in cooking	78.8	-1.75
	-CFL	22.0	-3.38
	- High efficient air conditioning	59.3	-4.42
	-High efficient refrigerator	99.8	-3.60
	-High efficient electric motors	106.0	-3.02
	Integrated scenarios	**414.7**	**-3.00**

5. Baseline and Abatement Scenario in Forestry Sector

5.1. Baseline Scenario:

It is considered that during the past 5 decades, Viet Nam's forests have been degraded. The forest vegetation of Viet Nam was reduced from 14.3 million hectares with a forest cover of 44% in 1943 to 9.3 million hectares in 1994 with a forest cover of 28%.

Due to Viet Nam Government's strong efforts in both reducing deforestation rate and increasing reforestation areas in recent years, the deforestation rate now stands at about 100,000 hectares per year, down by 50% from previous levels. Particularly, reforestation rate is greater than deforestation. Several activities such as expanding plantations, planting scattered trees and promoting natural regeneration are being implemented in the country and will lead to significant reduction of net GHG emission in the sector.

Recently, a plan for reforestation and natural reforestation of 5 million additional hectares by 2010 was adopted by the Government. However, for GHG abatement in the forestry sector, the likely trends scenario is used. Based on current trend, it is assumed that the deforestation rate will continue to be on the average of 100,000 hectares per year. Likewise, the level of reforestation effort is not enough to offset the deforestation. The reforestation rate is about 75,000 hectares per year and the survival rate is assumed to be 100%. In addition, 3 billion scattered trees will be planted by the year 2030; 2.4 million hectares of additional natural forests will be also conserved and 1.1 million hectares of degraded forests will be rehabilitated through enhanced natural regeneration over the same period.

5.2. Description of forestry mitigation options:

5.2.1. Forestry mitigation options:

Development of forestry mitigation options needs to match with land categories in the country. At present, about 19 million hectares accounting for 58% of the land area in the country are classified as forest land. Description of potential areas under each land category actually available for the mitigation options is given in Table 5.1

Table 5.1: Potential areas for different forestry mitigation options

Unit: kha

Land categories	Total land area	Forestry mitigation options				Area converted to agriculture and others
		Reforestation	Enhanced natural forest generation	Forest Protection	Scattered tree planting	
Group A:						
Waste land/Savannas						
1. Woody	3,183	400	1,100	283	1,000	400
2. Shrub and grass	6,690	2,000	1,000	2,224	1,000	466
3. Rocky	628	0	0	628	0	0
Group B:						
Natural forests						
1. Evergreen	1,335	0	0	1,335	0	0
2. Secondary	4,625	0	0	4,625	0	0
3. Young	1,275	400	300	475	0	100
4. Mixed	1,017	553	300	64	0	100
Group C:						
Plantations	900	0	0	0	0	
Total	19,653	3,353	2,700	9,634	2,000	1,066

Source: Ministry of Agriculture and Rural Development, 1996

Due to several reasons such as socio-economic conditions, financial sources, feasibility, etc. only a part of the above available areas may be used for forestry mitigation options. For this study, four forestry mitigation options are developed:

- 1.85 million hectares of degraded forests will be promoted for natural regeneration in combination with reforestation at a rate of 50.000 ha per year (Option F1).

- 1.95 million hectares of degraded land will be converted into forest plantations at a rate of 130,000 ha per year. (Option F2).

- 6.5 million hectares of natural forest will be protected up to 2030. Logging and timber harvesting will not be allowed in the areas (Option F3).

- 4 billion scattered trees, equivalent of about 1.65 million hectares, will be planted up to 2030 (Option F4).

Mitigation option category and the size of area allocated for each option through the period are shown in Table 5.2

Table 5.2: Mitigation option category and the size of area allocated annually for each option.

Option No.	Land categories	Option category	Target area (ha)	Rate of planting (ha/yr)
F1	Waste land / Savannas and Natural forest land	Enhanced natural regeneration	1,850,000	50,000
F2	Waste land / Savannas and Degraded forest land	Reforestation and afforestation	1,950,000	130,000
F3	Natural forest land	Forest protection and conservation	6,500,000	-
F4	Waste land, Urban / Farm land	Scattered trees	1,640,000	44,000

In general, in all analysis a value of 10t/ha for the waste land was used to estimate dry weight of vegetation carbon with carbon density of 0.5, and a value of 50 tC/ha for amount of carbon stored in the soil. For the mitigation, values of 0.65 tC/ha/yr for reforestation; 0.5 tC/ha/yr (equivalent) for scattered trees; and 1.0 tC/ha/yr for enhanced natural regeneration were used to define amount of carbon stored in soil. A value of 5 years for decomposition period and a value of 10 tC/ha/yr for amount of decomposing carbon. For discount rate, a value of 10% was applied. The cost input used for the forestry mitigation options is presented in Table 5.3

Table 5.3: Estimated cost input used for each forestry mitigation option.

Cost component	Forestry mitigation options			
	Enhance natural regeneration	Reforestation	Natural forest protection	Scattered trees
Initial cost	$ 150 per ha	$340 per ha	$10 per ha	$ 160 per ha
Maintenance cost	$ 2 per ha per year	$ 5 per ha per year	$ 4 per ha per year	$ 2 per ha per year
Recurrent cost *	$ 300 per ha	$ 405 per ha	-	$ 646 per ha

* At the end-year of rotation

5.2.2. Assessment of Forestry mitigation options:

By using COMAP model, the 4 identified forestry mitigation options are developed and assessed. The COMAP outputs indicated that total carbon abatement would be 1,238 Tg. Planting scattered trees and enhanced natural regeneration options have lower mitigation potential while the two others have higher mitigation potential.

With 78.7 Tg C abated, the option to plant scattered trees option showed lowest mitigation potential whereas the natural forest protection has the highest mitigation potential with 862.5 Tg C sequestered, accounting for nearly 70% of the total carbon abated under mitigation scenario. As shown in Table 5.4, the natural forest protection is the option with the lowest endowment cost and highest mitigation potential. In terms of present value of benefits, natural forest protection and enhanced natural regeneration obtained lower benefits while reforestation and scattered trees showed higher benefits.

For investment cost, natural forest protection and enhanced natural regeneration required lower cost, whereas planting scattered trees and reforestation required higher cost. Main results given by COMAP model for the 4 forestry mitigation options are presented in Table 5.4

Table 5.4: Assessment of the forestry mitigation options by COMAP Models:

Option No	Option category	Mitigation Potential	Present Value of Benefit		Present Value of Cost	
		(tC/ha)	($/tC)	($/ha)	($/tC)	($/ha)
F1	Enhanced natural regeneration	47.2	1.27	55.55	1.04	45.42
F2	Reforestation	107.3	5.51	577.1	3.35	351.19
F3	Natural forest protection	132.7	0.69	91.04	0.33	43.45
F4	Scattered trees	47.7	9.25	404.25	1.35	59.17

5.3. Abatement Scenario:

The development of the abatement scenario in forestry sector are based on the sectoral strategy. According to the strategy carbon sinks would be enhanced through the protection of existing natural forests, promoting natural regeneration and reforestation.

The forestry sector in Viet Nam contributes about 3% to the GDP and it is expected to decline under 1.5% in the next decade. For GDP growth rate, it was assumed to be 8.5% per

annum until the year 2000, and then by 7.5%, 7.0% and 6.5% per annum to the years 2010, 2020 and 2030 respectively. As discussed in Section 5.2.1, four forestry mitigation options were developed for the abatement scenarios (Options F1-F4) including slowing deforestation, increasing reforested areas, natural regeneration as well as increasing forest coverage to 45% by 2010.

Under this scenario, the rate of reforestation would be about 130,000 hectares per year in the period of 1994 - 2030. 6.5 million hectares of exiting forests would be conserved to 2030 while about 1.8 million hectares of degraded forests would be promoted for enhanced natural regeneration over the same period. Moreover, 4 billion of scattered trees, equivalent of about 1.6 million hectares, would also be planted by 2030 with a rate of 44,000 hectares per year.

By carrying out the above options, total carbon abated was about 1,238 Tg equivalent of 4,539 Tg CO_2 while under baseline scenario, the amount of carbon abated was only 585 Tg equivalent of 2,144 Tg CO_2, which is less than half the amount under mitigation one. The lifecycle costs required would be about US$1149 and 680 millions in the Abatement and Baseline scenarios respectively. Mitigation potential and costs under the two scenarios are given in Table 5.5.

Table 5.5: Mitigation potential and cost under the two scenarios

Mitigation options	***Baseline scenario***			***Abatement scenario***		
	Total Area (kha)	**Cumulative Mitigation (TgC)**	**Cumulative Investment ($ mil.)**	**Total Area (kha)**	**Cumulative Mitigation (TgC)**	**Cumulative Investment ($ mil.)**
1. Enhanced Natural Regeneration	1,100	15.9	34.3	1,850	87.3	84.0
2. Reforestation	1,950	176.6	540.4	1,950	296.9	768.8
3. Forest Protection	2,400	545.8	621.6	6,500	1,159.4	1,051.2
4. Scattered Trees	1,200	584.9	680.3	1,640	1,238.1	1,148.8
Total	**6,650**	**584.9**	**680.3**	**11,940**	**1,238.1**	**1,148.8**

6. Baseline and abatement scenario in Agricultural sector

6.1 Baseline scenario:

Viet Nam is currently an agricultural country with 80% of it's population involved in agriculture on about 7 million hectares : The urban population is projected to increase from 19.9% in 1994 to 55% in 2020 and 65% in 2030 therefore the rural population will decrease to about 45%, 35% in 2020, 2030 respectively. Because of urbanization and growth of the manufacturing and service sectors, GDP contribution of agriculture will drop from 29.9% in 1993 to 6.3% by 2020 and 4.0% in 2030.

The area under rice cultivation is projected to increase from 6.5 Mh in 1993 to 8.0 Mh in 2030. Projected methane emissions from rice cultivation will reach 2223 Gg in 2030.

The livestock population is projected to increase from 6.2 M head (dairy and Buffalo) in 1993 to 13.6 M head in 2030. Projected methane emissions from livestock will reach 1026 Gg in 2030 including 702 Gg from enteric fermentation and 324 Gg from manure management.

+ Agricultural Development

In the next decades Vietnam agriculture will be developed according to the following strategy : "Continuing to firmly ensure that foods and foodstuffs matters for the full society and export reinforcement. Strongly developing all high valuable tree kinds via intensive cultivation in order to respond to the requirement of raw materials for processing industry. Forming the regions of concentrated breeding, the firms of processing foodstuffs with several shape/scale types. Strongly developing the processing industry, performing the investment in depth, closely attaching the process of renewed processing equipment to the rearrangement of system of agricultural-forest-products processing firms".

According to the above strategy, in the coming years the following main investment branches will take shape :

+ Production of foods in order to perform 3 objectives :

(a) To satisfy the food requirement for the people's consumption in any situation.

(b) To sufficiently assure the food source to make a strong development of breeding and enough raw materials for the industry.

(c) To further increase the export volume with high effectiveness.

These policies will increase the food productivity from 26 million tons at this time up to between 30 - 32 million tons in year 2000, and 45 - 60 million tons by 2030, every year there will be 2 million tons of exported rice with high effectiveness.

The animal husbandry program will produce 4.6 million buffaloes, 9 million cattle by the year 2030. It is expected to combine closely with the supply of nutrition to animal through mechanical and chemical feed processing.

6.2 Mitigation options in agricultural sector:

6.2.1 Mitigation option for methane emission from rice cultivation:

- In Viet Nam, rice production plays an important role. There is a need to achieve a production of 28 million tons in 2000, 33.8 million tons in 2010 and 45-50 million tons in 2030 to guarantee food security, and to provide for export (2.0 million tons/year). Intensive farming techniques have to be adopted achieve productivity level of more than 4 tons/ha/crop.

At present, there are 5 M ha of irrigated rice. However, the control of irrigation can be currently implemented in very small areas (15%). The Government is providing investments in order to improve the irrigation system.

The development needs to be focused on management of irrigation water with a system of draining rice fields during the growing season in the areas with secure irrigation supplies. These areas are: the Red River Delta, the North Central Coast, the South Central Coast and the Me Kong River Delta.

- The goals of this option are to control and to provide sufficient water requirement of rice crop aimed at improving food production as well as reducing methane emission from rice cultivation.

6.2.2 Mitigation option for methane emission from livestock:

- Animal population is expected to increase in the next few decades. There were 3.3 million cattle, 3 million buffaloes and 15 million swine in 1993. Their population is expected to increase up to 9 million cattle, 4.6 million buffaloes in 2030.

In Viet Nam, most of the feed supplied to ruminant animal (cattle and buffaloes) is of low quality and is not subjected to any form of processing. The greatest opportunity for reducing CH_4 emissions among ruminant animal is through increasing the feed digestibility through mechanical and chemical processing of the feed.

In other words, chemical and physical treatment of low quality crop residues that are fed to ruminants can enhance animal productivity and lower CH_4 emissions per unit product. The treatment methods include alkali/ammonia treatment, chopping, grinding, heating, steaming and wrapping and preserving by products of as rice, maize, sweet potatoes...straws.

- The goal of this option are to increase the quantity and quality of livestock feed in order to improve the meat and milk production and to reduce methane emission from livestock.

6.2.3 Cost - effectiveness of methane emission option:

1) The following cost effectiveness indicators used in assessing the methane emissions reduction options are incremental cost and NPV of net benefits.

- Methane emissions avoided were estimated for the two options: (i) water management (50 kg/ha/year), and (ii) improving nutrition (5kg/head/year).

- The incremental cost for the two options were all positive, with the water management giving the highest cost: US$ 1.01/kg methane reduction followed by improving nutrition at US$ 0.40/kg.

- The NPV of benefits is an indicator of the net direct benefit to be obtained from option with the water management of US$ 0.54/kg of methane avoided followed by improving nutrition at US$ 0.07/kg

2) The principal approach for reducing methane emission from agricultural sector is the water management with intermittent draining of rice fields during the growing season and improving nutrition through mechanical and chemical feed processing in livestock.

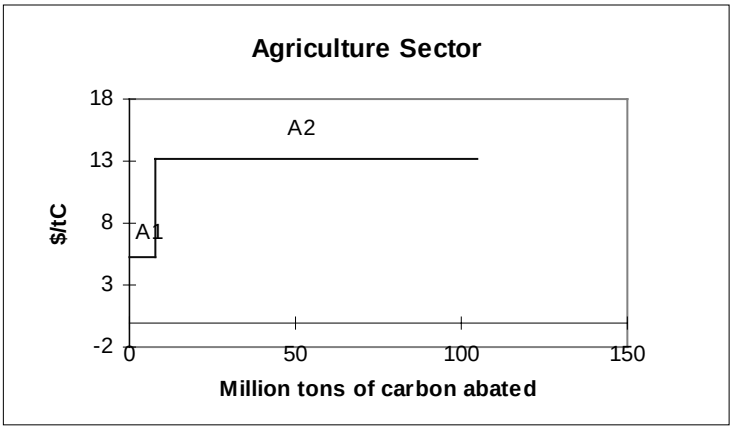
Baseline projection amount to 1755 Gg methane emission from the base year and to 3249 Gg methane emission in 2030.

The reduction of methane from rice paddy through the intermittent draining of field on the end of tillering and after flowing 15-20 days in projecting to decrease from 2223 Gg CH_4 to 1948 Gg CH_4 by the year 2030.

The reduction of methane emission from livestock subsector through nutrition improved is projected to decrease from 1026 Gg CH_4 to 1004 Gg CH_4 by the year 2030.

Figure 6.1 expresses the relationship between the potential carbon reduction and cost per unit carbon reduction by two agricultural mitigation options: improving nutrition (A1) and water management (A2).

FIGURE 6.1 : CERI Curve for Agriculture Sector



The description of GHG mitigation options on agricultural sector and their assessment results are summarized in Table 6.1

Table 6.1 : Mitigation options in Agricultural Sector.

Scenario	Description	Total Methane abated (Gg)	Life cycle cost	Aggregate incremental investment required (US$ mill.)
Baseline	- 6.5 Million ha of rice cultivation in 1993, growing up to 7.1 in 2000, 7.3 in 2010 and 8.0 in 2030. - 1.7 Tg CH_4 emitted in 1993, 1.9 Tg CH_4 in 2000, 2.0 Tg CH_4 in 2010 and 2.2 Tg CH_4 in 2030. - The population of livestock is 6.6 M of cattle and buffaloes in 1993 growing up to 13.6 M in 2030. - 425 Gg CH_4 emitted in 1993, 560 Gg CH4 in 2010 and 1026 Gg in 2030			
Water management in rice field	Projection to 5.5 million ha of rice paddy with water management and under intermittent draining on the rice growing season in 2030	5005	US$/tC* abated 13.12	5620
Improving nutrition through mechanical and chemical feed processing	Projection to 4.4 million head of buffaloes and cattle providing with mechanical and chemical feed processing.	385	US$/tC* abated 5.19	92

* CO_2 equivalence.

6.3 Abatement scenario:

A strategy will be generated to reduce methane emission up to 2030 to reach a level of 9% over the base year. This could be achieved by targeting the two mitigation options as follow :

1) By the year 2030, it carries out intermittent drainage of 5.5 M ha of rice paddy under controllable irrigation, a reduction of methane emission from rice field about 50 kg/ha/year will result in a total of mitigation of 5,005 Gg CH_4.

2) Providing an improved quality (processed) animal feed to 4.2 Mt/year will result in a reduction of 5 kg CH_4/head/year a total of 4.4 M head animal. This will result in a total reduction of 385 Gg CH_4/year.

7. National Perspective on GHG emissions and Mitigation Options

7.1. Cost of Emission Reduction Initiatives (CERI) Curves for each sector:

7.1.1. Introduction:

CERI curves are based on the principle of incremental cost analysis, where incremental costs are equal to the difference in costs over time between a reference (baseline) scenario and alternative GHG mitigation scenarios. CERI curves relate the quantity of GHG which can be reduced or sequestered by mitigation options to the cost per unit of GHG reduction. Cost curves for carbon reduction and for carbon storage can be combined to express the relationship between total amount GHG abated and the cost per unit of GHG abated over specified time period.

Based on CERI curves, policy makers, analysts and other interested groups can understand the economic impacts of choosing different sets of GHG mitigation options.

In order to develop cost curves in main sectors in Vietnam, several GHG mitigation assessment models have been used. In the energy sector, the MEDEE-S/ENV and EFOM-ENV models were used whereas in forestry sector, COMAP model was applied for developing and assessing forestry GHG mitigation options.

7.1.2 Energy Sector:

Cost curves in Energy sector under this study were developed. Seven GHG abatement scenarios were estimated using EFOM - ENV model. These abatement scenarios are shown in Table 7.1.

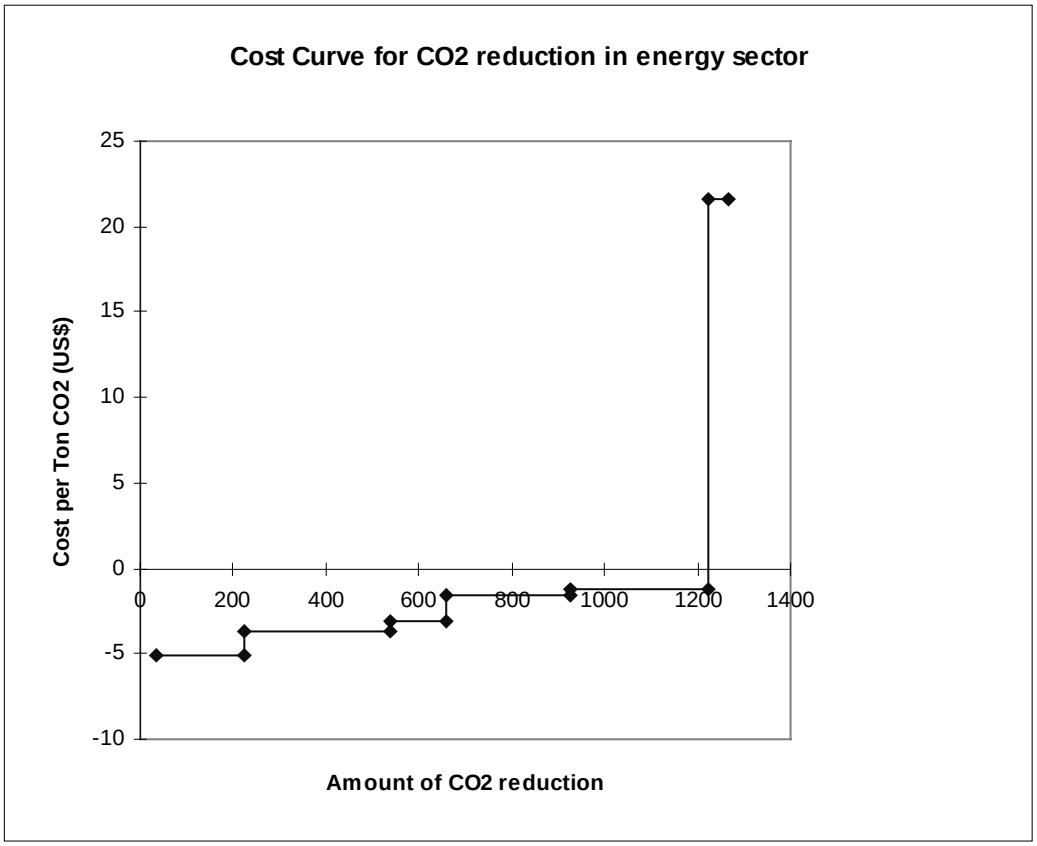
Table 7.1: Cost of CO2 reduction

	Option	Amount of CO_2 reduced (Tg)	Cost of CO_2 reduction (US$)
1	Energy efficient Air conditioners	158	-4.42
2	Energy efficient refrigerator	266	-3.60
3	Compact fluorescent lamps	50	-3.38
4	High efficient electric motors	212	-3.02
5	Wind power plant	104	-1.94
6	Efficiency improvement in coal cooking	221	-1.75
7	Fuel Switching in existing thermal power plants	14	21.14

Table 7.1 shows the different options of CO2 reduction in the energy sector and the associated CO2 reductions and costs. Most cost effective is replacement of incandescent lamps by the compact fluorescent lamps, but the amount of CO2 reduction is not so high. Both energy efficient air conditioning and energy efficient refrigerators options are cost effective and CO2 reduction. From supply side wind power plants option is cost effective. In other word, almost CO2 abatement options from demand side in energy sector in Viet Nam are costly effective. It is related the backwardness of the present technologies. The survey in 1995 of the Institute of Energy showed that the energy over consumption in industry sector of Viet Nam is 50% in thermal and 30% in electricity higher than OECD countries. So any measures any investment implementing to these sectors will be benefited not only environment but also economy (win-win).

Hydro power option has been taken into consideration. The assessment of the impacts hydro schemes in details has not been implemented. The environmental cost in the term of the land loss and resettlement are considerable and complex.

Figure 7.1: Cost curve for Energy Sector



7.1.3 Forestry Sector:

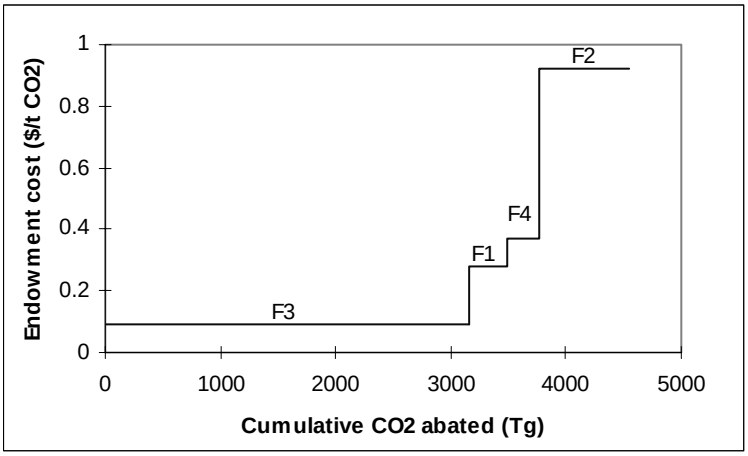
Forestry sector plays a crucial role in local as well as national economy of developing countries of Asia. Forests provide a number of products and services to local communities, industry and export.

Linkages between forests, communities and economy are very complex. Actually, it is difficult to estimate the fluxes of C and measurable C emission reduction or sequestration. There is a need to analyze forestry options at country level along with the relevant environmental, social and economic aspects.

COMAP (Comprehensive Mitigation Analysis Process) model was used for assessing several identified forestry mitigation options. In addition, based on the modeling results such as carbon sequestration / storage potential, benefits and endowment of the mitigation options, forestry cost curves were developed for abatement scenario. The forestry mitigation options under both baseline and abatement scenarios consist of four options, namely Enhanced natural regeneration (F1), Reforestation (F2), Forest protection (F3), and Scattered trees (F4). The calculation of average incremental cost of each option is based on present value of lifecycle cost (endowment cost) in COMAP output. It is estimated that the total potential carbon abatement equal 585 and 1,238 million tonnes, approximating 2,144 and 4,539 million tonnes carbon dioxide equivalent under the baseline and abatement scenarios respectively. COMAP output for forestry mitigation options is presented in Appendix 3-6

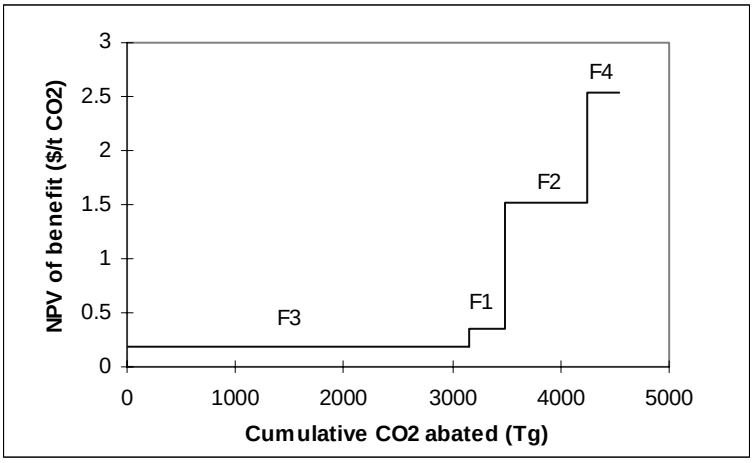
Figure 7.2 expresses the relationship between the potential carbon reduction (or carbon stored) and cost per unit carbon reduction of the four forestry mitigation options under the abatement scenario.

Figure 7.2: Cost curve for Forestry Sector



F1 : Enhanced natural regeneration
F2 : Reforestation
F3 : Forest protection
F4 : Planting scattered trees

Figure 7.2: Cost curve for Forestry Sector (cont.)



F1 : Enhanced natural regeneration
F2 : Reforestation
F3 : Forest protection
F4 : Planting scattered trees

As can be seen from Figure 7.2, forest protection option is the highest mitigation potential and the lowest cost options. For endowment cost, the ranked order of forestry options from low to high average cost under abatement scenario includes: Forest protection (F3), Enhanced natural regeneration (F1), Planting scattered trees (F4), and Reforestation (F2).

7.1.4 Agriculture Sector:

1. The following cost effectiveness indicators used in assessing the methane emissions reduction options are (i) incremental cost and (ii) NPV of net benefits.

- Methane emissions avoided were estimated for the two options: (i) water management (50 kg/ha/year), and (ii) improving nutrition (5 kg/head/year).

- The incremental cost for the two options were all positive, with the water management giving the highest cost: US$ 1.01/kg methane reduce followed by improving nutrition at US$ 0.40/kg.

- The NPV obtained from this option with the water management is US$ 0.54/kg of methane avoided followed by improving nutrition at US$ 0.07/kg

2. The principal approach for reducing methane emission from agricultural sector is the water management with the intermittent draining of rice fields during the growing season and improving nutrition through mechanical and chemical feed processing in livestock.

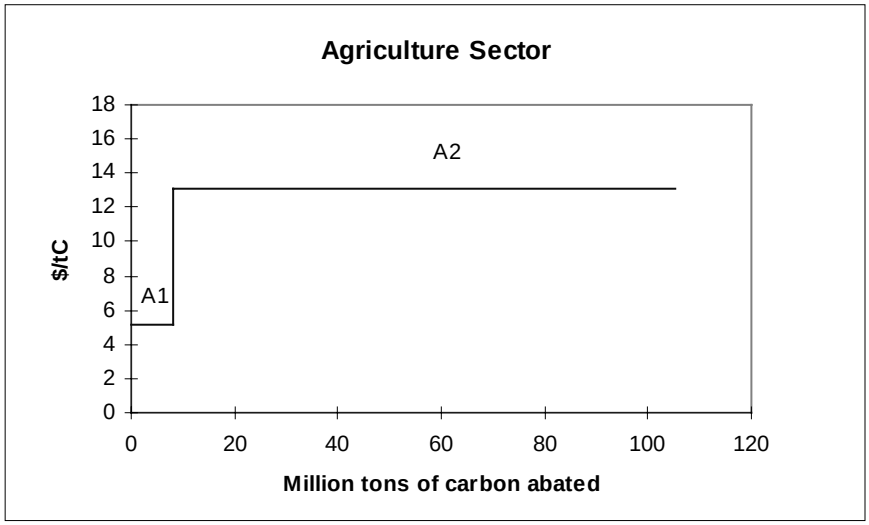
The analysis showed a base year emission of 1,755 Gg of CH4 rising to 3,249 Gg CH4 by 2030.

The reduction of methane from rice paddy through the intermittent draining of field on the end of tillering and after flowing 15-20 days is projected to decrease from 2223 Gg CH_4 to 1948 Gg CH_4 by the year 2030.

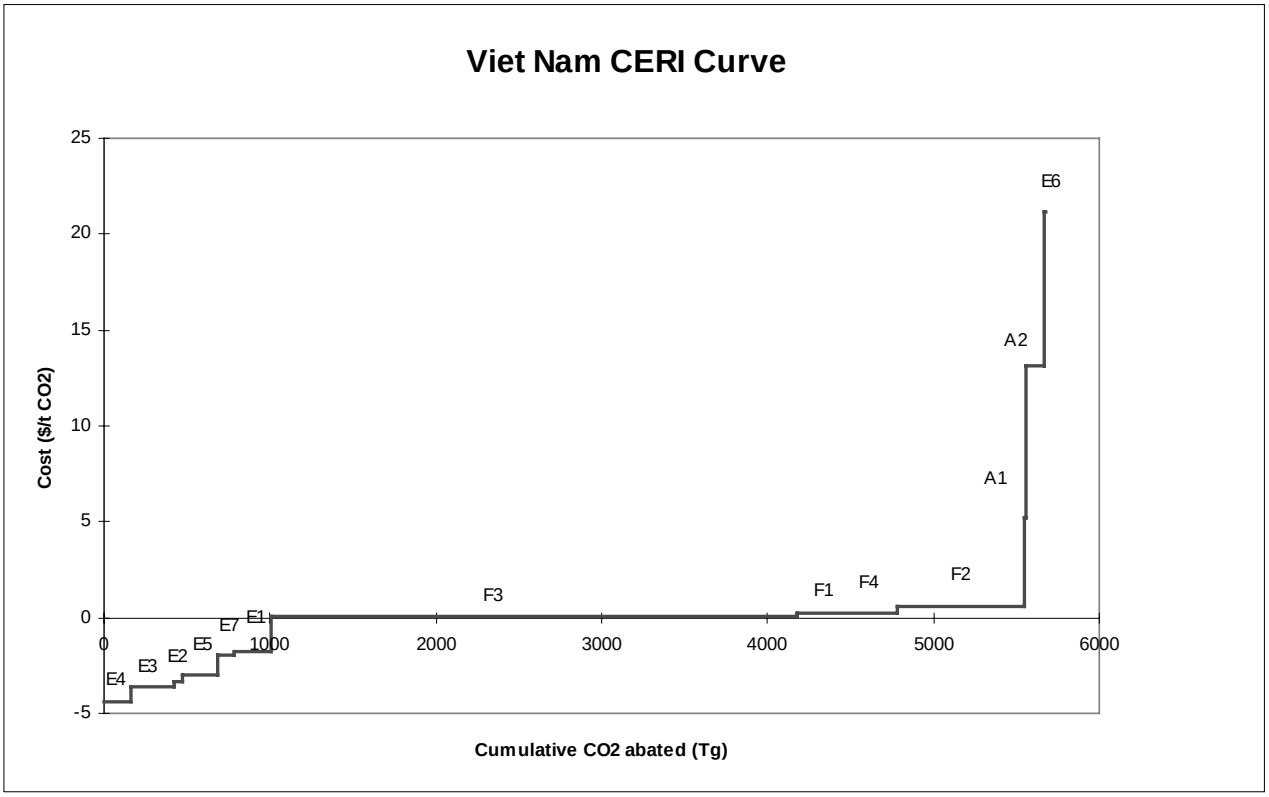
The reduction of methane emission from livestock subsector through nutrition improvement is projected to decrease from 1026 Gg CH_4 to 1004 Gg CH_4 by the year 2030.

Figure 7. 3 shows the relationship between the potential carbon reduction and cost per unit carbon reduction of two agricultural mitigation options: improving nutrition (A1) and water management (A2).

Figure 7. 3 : Cost Curve for Agriculture Sector



Generally, comparison of all mitigation options in energy, forestry and agriculture under abatement scenario is presented in Figure 7.4.



Note: If NPV is used for forestry, the ranking will change since forestry will show negative cost, except for protection.

Figure 7.4 : Comparison of mitigation in Energy , Forestry and Agriculture

E1: Efficiency improvement in coal cooking
E2: Compact flourescent lamps
E3: Energy efficient refrigerators
E4: Energy efficient air conditioners
E5: High efficient electric motors
E6: Fuel switching in existing thermal power plant
E7: Wind power plant

F1: Enhanced natural regeneration
F2: Reforestation
F3: Natural forest protection
F4: Planting scattered trees

A1: Improving nutrition
A2: Water Management

7.2. Total National Emissions in Baseline and Abatement Scenarios:

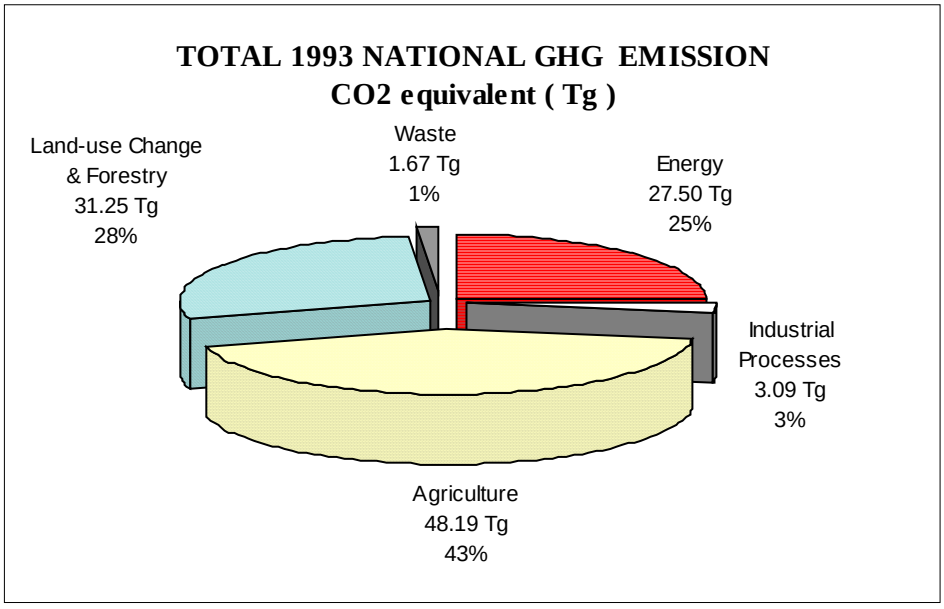
7.2.1 Total National Emissions in Baseline Scenarios:

Under ALGAS project, 1993 National GHG inventory has been carried out. Results of the inventory showed that total net emissions by gasses in Viet Nam in 1993 were: 64,062 Gg CO_2, 2,588 Gg CH_4, 14.63 Gg N_2O, 182.09 Gg NOx and 3,127.56 Gg CO. Using a GWP of 1 for CO_2, 21 for CH_4, and 310 for N_2O, the contribution of these three gases in terms of CO_2 equivalent or GWPs, is equivalent to total CO_2 of 111.7 million tonnes, which is contributed by:

- Carbon dioxide, 64 million tonnes.
- Methane, 54.4 million tonnes of CO_2 equivalent.
- Nitrous oxide, 4.5 million tonnes of CO_2 equivalent.

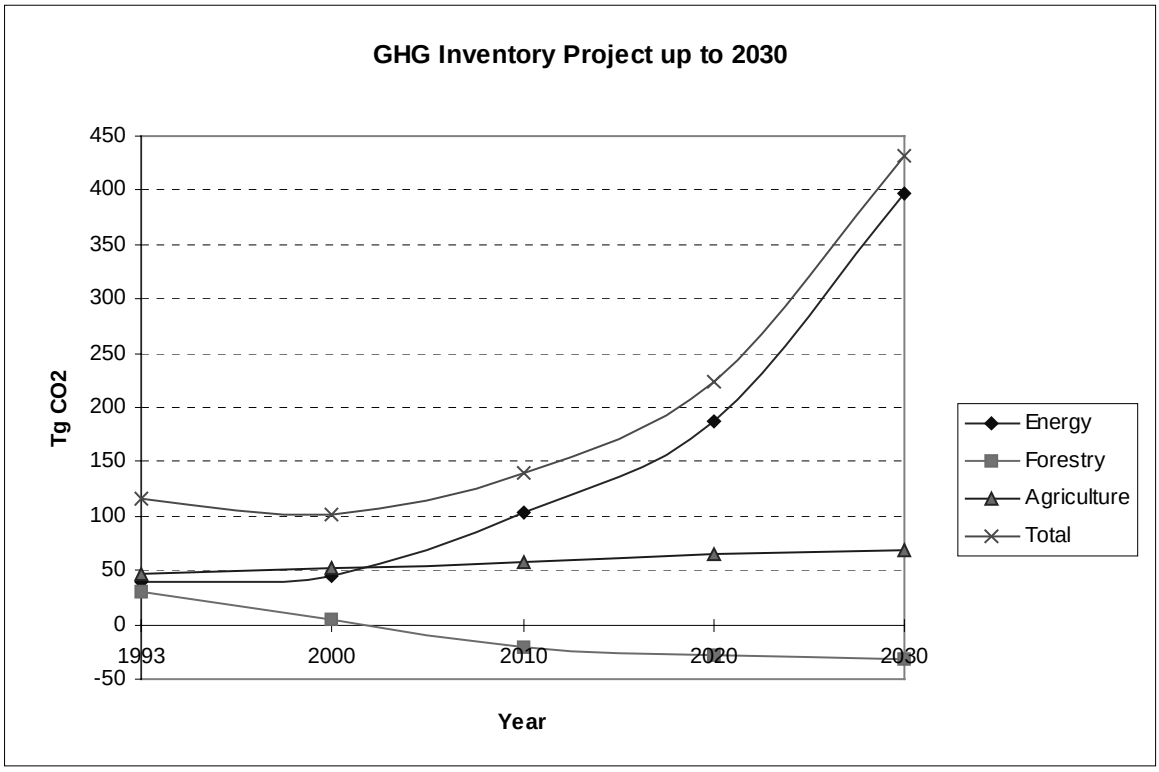
The three sectors with emitted largest quantities of GHG are Agriculture, Forestry and Energy. The Agriculture sector contributed to 48 million tonnes of CO_2 equivalent, while the Forestry sector emitted 31 million tonnes CO_2 equivalent, and the Energy sector emitted 27.5 million tonnes of CO_2 equivalent. Total GHG emission in CO_2 equivalent by sector in 1993 is presented in Figure 7.5

Figure 7.5: Total GHG emissions (in CO_2 equivalent) by sector in 1993



For GHG inventory projection up to 2030, relevant sectoral master plans and main documentation relating to orientations for a national energy strategy were referred. Due to the increase of fossil fuel consumption in the next decades, future GHG emission will be increased. Particularly, estimated GHG emission from the energy sector in 2030 will be about 396 million tonnes CO_2 equivalent which is higher 10 times against the amount of CO_2 emitted in the sector in 1993. In agriculture sector, total CO_2 equivalent emissions will be increase from 47 million tonnes in 1993 to 68 million tonnes in 2030 whereas in forestry sector, the amount of CO_2 is projected to decline from 31.2 million tonnes in 1993 to 4.2 million tonnes in the year 2000. Until 2030, a net sequestration of 32.1 million tonnes CO_2 is projected for this sector. Total National GHG emission (CO_2 equivalent) in the period of 1993-2030 is shown in Figure 7.6

Figure 7.6 : Total National GHG emissions (CO_2 equivalent)



7.2.2 Total National GHG abated in Abatement Scenarios:

For this study abatement scenario was developed based on the assumption in which 13 GHG mitigation options including 7 energy options and 6 non-energy options would be carried out successfully in the period of 1994-2030. EFOM-ENV and COMAP models were used for assessing mitigation options in energy and forestry sectors respectively. Amount of GHG reduction in terms of CO_2 equivalent in both short term and long term under each option is given in Table 7.2

Table 7.2: Total CO_2 Abated in Short Term and Long Term

Sector	Mitigation Options	Total CO_2 abated (1,000 tonnes)	
		Short Term	**Long Term**
Energy	Energy efficient air conditioners	70,000	158,000
	Energy efficient refrigerators	118,000	266,000
	Compact fluorescent lamps	22,000	50,000
	High efficient electric motors	94,000	212,000
	Wind power plant	46,000	104,000
	Efficiency improvement in coal cooking	98,000	212,000
	Fuel switching in existing thermal power plant	14,000	-
Forestry	Natural forest protection	1,746,100	3,162,500
	Enhanced natural regeneration	131,600	320,100
	Planting scattered trees	116,600	288,566
	Reforestation	349,100	768,533
Agriculture	Improving nutrition	1,575	8,085
	Water Management	19,530	105,100
	Total abatement	***2,826,505***	***5,654,884***

In general forestry sector has the largest mitigation potential with 2,343 and 4,540 million tonnes CO_2 abated in short term and long term respectively while agriculture has the lowest mitigation potential with 21 and 113 million tonnes CO_2 abated in the two terms. Total national GHG (CO_2 equivalent) abated in short term and long term would be about 2,827 Tg and 5,655 Tg respectively.

7.3. GHG Abatement Action Plan:

7.3.1 Energy:

The general objectives in the GHG abatement strategy of Vietnam on energy sector is to use energy efficiently in order to reduce energy losses in both supply and demand sides, to minimize the cost and to reduce the pollution emissions especially GHG emissions. The content of the strategy:

- Promotion conservation and efficient use of energy.

- Promotion rational use national energy resources.

- Utilization of new and renewable energies.

- Integration of social and environmental concerns in the implementation of program economic sustainable development.

The measures implemented in the power transmission and distribution would include :

- The system will be rehabilitated and upgraded.
- The new technology for production of standard on high efficiency forms will be installed and operated.
- The standards for medium voltage level will be selected.
- Improvement of efficiency of existing power plants.

The activities in the renewable subsector would be :

- Encourage to use new and renewable energy sources, especially wind power. Establishment wind farm with capacity 10 - 20MW.
- Maximal use hydropower resources with an especial focus on highly economic efficient project on Da river, Se San river and Dong Nai rivers.
- Substitution by less GHG emission energy sources for electricity generation.

In short term plan (before 2005)

- Large scale utilization of new and renewable resources. Develop other energy sources (nuclear 2002).

The plans developed in the energy demand side would be :

- Development of plan to collect and analyze and conduct feasibility study for standardization of electrical appliances.
- Development of plan to collect and analyze and conduct feasibility study for improvement of energy efficiency in existing state - owned industrial enterprises.
- Adopt and implement efficiency for electrical appliances.
- Develop and implement feasible standard for improvement of energy efficiency in existing and new state owned industrial enterprises and building system.

The major contents and action plans of the GHG abatement strategy are presented in Table 4.7

7.3.2 Forestry:

The general objectives for the forestry sector are well expressed in the main document on the economic and social development of Viet Nam. It is expressed in the following way:

Development of forestry, agriculture, and fishery in combination with processing industry is a most important factor in the balanced development of the rural areas of Viet Nam and in the creation of a new and stable basis for continued socio-economic development in the rural areas.

Projects prepared and implemented are multi-sectoral, covering both forestry, agriculture, and fishery, combined with processing industry and development of handicraft as suitable. Each project should be tailored to the local conditions in the area where they are to be implemented. In order to serve the projects and the general development in the areas, economic, technical, and service units should be established in the area and a suitable social and technical infrastructure should be also created.

As regards forestry, the document specifically indicates that the sector should concentrate on improvements in the economic results of the operations, increase the rate of forest plantation, speed up regreening of bare hills, improve the results of forest exploitation and also create a forest resource capable of protecting the environment and harbouring a diverse wildlife.

In general, several concrete objectives for forestry sector in the next decade are as follows:

- To strengthen the national protection capability by means of protecting 9.3 million ha of existing forests, increasing forest plantations, speeding up regreening of bare hills.

- To focus on activities concerning natural forest regeneration and establishment of new plantation in order to reforest 5 million ha in the next decades. Up to the year 2010, there will be more than 15 million ha of forests all over the country which will increase forest cover from 26% to 45% by the year 2010.

- To provide a large number of employment for local people. Gradually improve the living standard for more than 20 million people living in and around forest areas.

Besides, the sector should apply relevant research results in improving cultivation systems for sloping land; create close links between forestry and agriculture, between forest operations and forest industries; reform management in state forest enterprises in the sector; and encourage all other economic sectors to take part in forest operations.

As mentioned, several identified forestry mitigation options such as reforestation, enhanced natural regeneration, forest protection and planting scattered trees are developed for this study. It is estimated that the potential mitigation of these forestry options are substantial with 1,238 Tg C (equivalent of 4,539 Tg CO_2) abated under the mitigation scenario.

With particular reference to the proposed mitigation options, in the coming years, the sector should focus its efforts on the following activities:

1- On reforestation:

- Develop feasible reforestation projects in which more productive plantations are established in order to meet the growing demand of wood for industrial use and fuelwood in the country.

- Reforestation efforts should give more attention to:

- Local socio - economic conditions of the plantation sites and the approach of participation of the local people for planning and implementation of the plantation programmes. In fuelwood deficit areas, in particular, community forestry approach needs to be explored.

- Consideration should be given to natural reforestation schemes if necessary combined with natural regeneration, enrichment or other silvicultural measures.

- A limited number of species has used for reforestation. Research should provide locally focused advice on the right species and the best seed resource.

- Maintenance of plantations, also involving where necessary replanting, is an integral part of the reforestation effort. It ought to be realized that maintenance costs largely do determine the success or failure of a programme.

2. On forest protection:

- To improve the protection and management of the existing forest within the special - use forest land.
- To expand the protection forest area to around 7 million ha.
- Creating non - forest - based livelihood opportunities.

3. On planting scattered trees:

- Spreading the movement of planting scattered trees at a rate of 400 million trees / year.
- Allocate land to the households for practicing cultivation in agro-forestry systems.
- Expanding urban forestry.

4. Information and education:

- To raise public awareness about environment protection including forest protection and management.
- Adequate information and education campaign for each mitigation option.

For GHG abatement action plan, the following short term and long term actions are proposed.

<u>Short - term:</u>

In the period, an area of 1.85 million hectares of degraded forests will be conserved for natural regeneration in combination with reforestation at a rate of 50,000 ha/year. Conversion of more than 1,000,000 hectares of degraded forest land into forest plantation with 10-year rotation. To allocate forest lands to local households to reforestation and forest protection. To spread the movement of planting scattered trees at a rate of 400 million trees / year.

In addition, 6.5 million hectares of existing natural forest will be conserved. In the period, natural forest exploitation will be halted gradually. Annual exploitation rate of wood from the natural forest would be declined from 3 million cubic meters at previous years to 0.5 million cubic meters in the next years. Wood processing industry would be improved. Develop

plans and projects for establishing firewood plantations in order to meet firewood demand. Until 2005, nearly biomass needs of the country would come from established forest plantations.

Long term:

Continuing to carry out natural forest protection in order to maintain and improve the important carbon sinks in the country.

It is assumed that the same activities would be undertaken beyond 2015. The rate of reforestation at 120,000-150,000 hectares per year while a rate of planting scattered trees will be about 40,000-50,000 ha equivalent/year. For biomass demand, a number of forest products such as fire wood, industrial wood, round wood, timber, etc. from the areas which were under enhanced natural regeneration, reforestation and natural forest could be harvested to meet the in-country demand as well as woody export. The period is the full implementation of the selected forestry options. However, at that time there will be a need to assess the current land use in the country to consider which options should be continued, improved as well as developed to correspond with the nation's situation.

The potential GHG emissions reduction and cost of each initiative in the Forestry sector are presented in Table 7.3

Table 7.3 : Potential GHG emissions reduction and Present value of costs for Forestry Mitigation Options

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million tonne of CO2)	Present Value of Costs (US$ tonne of CO2)
Short-term (1994-2010)	- Forest protection	1,746.1	0.16
	- Enhanced natural reforestation	131.6	0.43
	- Reforestation	349.1	1.11
	- Planting scattered trees	116.6	0.56
Long-term (1994-2030)	- Forest protection	3,162.5	0.09
	- Enhanced natural reforestation	320.1	0.28
	- Reforestation	768.5	0.92
	- Planting scattered trees	288.6	0.37

In order to implement successfully the forestry mitigation options, several technical, economic, policy and institutional aspects for adoption or promotion of the options are indicated in Table 7.4 while institution required for implementing forestry mitigation options is given in Table 7.5

Table 7.4 : Technical, economic, policy and institutional aspects for promotion of Forestry mitigation options.

Options	Technical Aspects	Financial Aspects	Policies	Institutional Aspects
Reforestation, enhanced natural regeneration and scattered trees	1. Silvicultural practices for high yields 2. Short and long rotation plantations 3. Technical assistance for the farming of development plans and projects 4. Land suitability classification 5. Agroforestry and Integration trees 6. Support education	Financial sources: 1. Government's investment for establishing plantations and planting scattered trees. 2. International organizations' investigation (WB, ADB, Governments of other countries) 3. Households' investment	1. Land tenurial rights 2. Assured markets 3. Credits with preferential interest rates.	1. Strengthening local forestry agencies. 2. Renovate state forest enterprises 3. Seeds provided by the Forestry Agencies. 4. Managing communities. 5. Support farmers in marketing
Forest protection	1. Protection of natural forests and degraded forests. 2. Assisted natural regeneration 3. Prevent forest fires 4. Biodiversity conservation 5. Support education and raise people's awareness about forest protection and environment protection.	Financial sources: 1. Government's investment for forest protection. 2. International organizations' investigation (WB, ADB, WWF, Governments of other countries)	1. Allocation of forest and forest land belonging to the three kinds of forests (special-use, protection, and production) 2. Clarify the ownership rights for different kinds of forests. 3. Ban extraction of timber 4. Promote the fixed cultivation and sedentarization 5. Develop forest laws and legislation 6. Reallocate people living in protected areas	1. Strengthening local forestry agencies. 2. Renovate state forest enterprises 3. Make contracts with collectives for forest protection

Table 7.5 : Institutions required for implementing forestry mitigation options.

Mitigation options	Institution required
Forest protection, enhanced natural regeneration	- Establishing a management system from central to local levels (Ministry of Agriculture and Rural Development (MARD) → Provinces → Districts → Communes) - Strengthening existing cooperatives and establishing new ones of the farmers participating in rehabilitation projects in the uplands. - Developing a credit system to deliver directly soft credit to households. - Formulating joint committee of local forest department and village community to assist in a) selling minor forest products; b/ providing technical service; c/ training and capability building.
Short / long rotation reforestation	- Establishing a management system from central to local levels (MARD → Provinces → Districts → Communes) - Strengthening existing cooperatives. - Banks for lending soft credit to households - Formulating joint committee of local forest department and village community to assist in a) selling minor forest products; b/ providing technical service; c/ training and capability building. - Establishing commercial cooperatives related to wood trade.
Planting scattered trees	- Cooperating closely with NGOs, Associations such as Association of Viet Nam Farmers, Association of Viet Nam Women, Association of Vietnamese Gardeners, etc. to encourage the movement of planting scattered trees in all over the country. - Agro-forestry Extension Department for supporting suitable techniques and good seedlings to local people. - Banks for lending credit to farmers.

7.3.3 Agriculture:

Viet Nam agriculture has undergone various changes owing to the evolution of the political and economic environments. The Doi Moi policy and subsequent renovation process aimed at transforming the economic system from a planned to a market-oriented economy. The economic incentives farmers gained through the renovation process have enhanced agricultural production. In fact, during the last five years, gross domestic product in the agriculture sector achieved average annual growth of 4-5%.

The goals of the agricultural sector are:

- To satisfy the food requirement for the people's consumption in any situation, to sufficiently assure the food source to make a strong development of breeding and enough raw material for the industry, to further increase the export volume with high effect.

- To develop all high valuable tree kinds via the intensive cultivation, new plantation in order to respond to the requirement of raw materials for processing industry.

- To form the regions of concentrated breeding, the firms of processing food - stuffs with several shape/scale types.

These goals are supported by the following programs:

- Making intensive cultivation higher to the food crops.

- Diversification of agriculture.

The environment objective of the agriculture sector is to assure the food requirements of the country by strategies and technologies that are most appropriate, cost-efficient and environment-friendly. However the GHG reduction has not been included in this strategies.

The potential GHG emissions reduction and cost of each initiative are shown in Table 7.6 whereas the policy objectives and implementation plans in the sector are presented in Table 7.7

Table 7.6 : Potential GHG emissions reduction and Present value of costs for Agricultural Mitigation Options

Implementation time frame	GHG abatement initiative	Potential carbon abatement or sink enhancement (Million tonne of CO2)	Present Value of Costs (US$ tonne of CO2)
Short-term (1994-2010)	Improving nutrition	1.58	5.2
	Water management	19.53	13.1
Long-term (1994-2030)	Improving nutrition	8.09	5.2
	Water management	105.10	13.1

Table 7.7 : Policy objectives and implementation plans in Agriculture sector

Sectoral	Economic development	Environment	GHG Mitigation
Objectives	1. To satisfy the food requirement for people's consumption and further increase the export volume with high effect. 2. To improve the living standard of rural people, and to increase net income per capital.	1. To reduce GHG emission from rice paddy and livestock 2. To save water resources	1. To aware the public on the impact of the global warning. 2. To prevent the emission of GHG.
Implementation plan/target	1. Making intensive cultivation higher to the food crops particularly the rice crop. 2. Diversification of Agriculture. 3. Forming the regions of concentrated breeding	Rational use of national resources and Sustainability in sector	1. Water management from rice field with the intermittent draining during growing season will reduce CH_4 emission. 2. Improving nutrition through mechanical and chemical feed processing.
Status	1. Average rice productivity is about 3.6 ton/ha/crop 2. The programmes are adopted to the Government for approval	Most people do not aware of the Global warning	1. Information on climate change is still limited. 2. No exiting GHG mitigation policy.

The GHG abatement action plan shall focus on water management in rice fields and improving nutrition through mechanical and chemical feed processing.

In the Short-term: (2005 - 2010)

Within the short-term, GHG abatement shall have been a component of the environment impact assessment for agriculture related projects and activities.

Water management in the rice field with the intermittent draining during growing season will be researched and developed in the pilot area such as Red River Delta then extend to Mekong River Delta then extend to Mekong River Delta with the benefit areas of about 3.0 million ha.

At the same time, nearly 2 millions heads of buffaloes and cattle will be fed by improved method of animal nutrition through the use of mechanical and chemical feed processing.

In the Long -term: (2020 - 2030)

The same activities are assumed to be undertaken beyond 2015 with the adjustment in terms of target setting per option. The question will be raised for what new options and strategies have to be formulated.

It is continued with 5.5 million ha of rice field under water management, this total area is comprised of 1.102 million ha in the Red River Delta, 0.59 million ha of the North Central Coast, 0.497 million ha of the South Central Coast and 3.269 million ha of the Mekong River Delta.

In this period, a total of 4.4 millions head of buffaloes and cattle would be provided with the improved nutrition through mechanical and chemical feed processing.

The aspects of technical, finance, policy and institution to implement the options in agriculture sector are presented in Table 7.8

Table 7.8 : The technical, financial, policy and institutional aspects of the options in agricultural sector.

Options	Technical aspects	Financial aspects	Policies	Institutional aspects
Water Management	1. Planning water conservation in the rice cultivation areas. 2. Expansion of high yield varieties of rice. 3. Saving water on irrigation with high effectiveness	Financial sources included: 1. Government investment for main pumping system and main irrigation canal. 2. Farmers investment (in-kind). 3. Investment from oversee organization: (GEF, ADB, WB)	1. Land tenurial rights. 2. Bank for lending credit to farmers with low rate of interest. 3. Low fee for the use of irrigation system	1. Joint committee between agricultural agencies and farmers. 2. Marketing: Including the purchase of Government to farmers products.
Improving nutrition	1. Providing animal food for high yields. 2. Developing of advanced hybrid varieties. 3. Upgrading firms of producing the concentrated strains	1. Government investment for feed processing industry. 2. Farmers investment	1. Assured markets and price of animal products. 2. Bank for lending credit to farmers with low rate of interest	1. Contribution of animal food to farmer. 2. Joint committee between agricultural agencies and farmers.

8. Conclusions

1. As a Party to the United Nations Framework Convention on Climate Change (UNFCCC) Viet Nam will make its strong effort to implement the UNFCCC through effective activities in order to reduce GHG emissions as well as enhance carbon sinks in the country .

2. The UNEP/GEF Project "Economics of GHG Limitation - Phase 1: Establishment of a Methodological Framework for Climate Change Mitigation Assessment" developed by the UNEP Collaborating Centre on Energy and Environment (UCCEE) in cooperation with Lawrence Berkeley Laboratory has been deployed in Viet Nam since 1996. The project deals with GHG mitigation analysis and options, focusing on the main issues: (a) Associated macro-economics, (b) Energy, (c) Land use and forestry.

For this study, a number of different data related to energy, industry, forestry and agriculture sectors as well as Viet Nam socio-economic development up to the year 2030, are collected. Besides, several models such as MEDEE-S, EFOM-ENV, COMAP are applied for development and assessment of GHG mitigation options in the next decades. The MEDEE-S and EFOM-ENV models are used as a tool for determining the cost-effective strategies to abate GHG emissions for energy sector while COMAP model is applied for forestry sector.

3. Based on IPCC Guidelines, the 1993 National GHG inventory has been carried out in Viet Nam. The inventory result indicated that amount of GHG emission in Viet Nam is 115.2 Tg of CO_2 equivalent. It is expected that the amount will be increased dramatically in the coming decades because of fossil fuel consumption to meet energy demand in the country. Total CO_2 emissions would be increased from 101 Tg in 2000, to 139 Tg, 224 Tg and 433 Tg in 2010, 2020 and 2030 respectively

4. 13 GHG abatement options including 7 energy options and 6 non-energy options have been developed for this study. List of the options in Energy, Forestry and Agriculture sectors are as follows:

Energy sector:

1) Energy efficient air conditioner

2) Energy efficient refrigerator

3) Compact Fluorescent Lamp

4) High efficient electric motors.

5) Wind power plant

6) Efficiency improvement in coal cooking

7) Fuel switching in existing thermal power plants

Forestry sector:

1) Enhanced natural regeneration

2) Reforestation

3) Forest protection and conservation

4) Scattered trees

Agriculture sector:

1) Water management

2) Improving nutrition.

5. At present value of cost regards, in general, the model outputs showed that almost energy options have negative values whereas non-energy options in the opposite. It is found that forestry options as the options with highest abatement potential and lower costs, while agriculture options as the options with lowest potential and higher costs .

6. In order to reduce GHG emission as well as enhance carbon sinks in the country, GHG mitigation options should be focused on main activities as follows:

In Energy sector:

- Promoting conservation and efficient use of energy.

- Promoting rational use national energy resources.

- Utilizing of new renewable energy.

- Integrating of social and environmental concerns in the implementation of economic sustainable development program

In Forestry sector:

- Strengthening the national protection capability by means of protecting the existing forests, increasing the rate of forest plantation, speeding up regreening of bare hills.

- Increasing forest coverage.

- Improving economic results of sectoral operations.

- Providing a large number of employment for local people through reforestation and forest conservation activities.

In Agriculture:

- Promoting water management from rice paddy in order to increase the yield of rice.

- Improving nutrition through mechanical and chemical feed processing.

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APPENDIXES

Appendix 1-1:

Main macroeconomics indicators 1991 - 1997

Gross domestic product (Billion VND in current price)

Items	1991	1992	1993	1994	1995	1996	1997 (EST)
Gross Domestic product	**76707**	**110535**	**136571**	**170258**	**222840**	**258609**	**295700**
GDP per capita (in thousand VND)	**1131**	**1593**	**1924**	**2348**	**3011**	**3430**	**3800**
GDP per capita (in USD)	**122**	**143**	**181**	**214**	**271**	**310**	**321**
• **Agriculture, forestry and fishing**	**31058**	**37513**	**40796**	**48865**	**63219**	**70334**	**76028**
• **Industry and construction**	**18252**	**30135**	**39472**	**50481**	**66804**	**79501**	**93849**
- Industry	15193	23956	29371	37535	50912		
- Construction	3059	6179	10101	12946	15892		
• **Service**	**27397**	**42887**	**56303**	**70912**	**92817**	**108774**	**125819**
- Transport, post	2860	4662	6036	6924	8747		
- Trade	9742	15281	17549	23072	29198		
- Finance, Banking	1108	1567	2318	3450	5314		
- Administration. science, education	6807	9718	14402	18270	22770		
- Housing, hotel, tourism	6880	11659	15998	19196	26788		

Source: GSO-MPS, updating by Nguyen Quang Thai, January 1998

Appendix 1-2:

Main macroeconomics indicators 1991 - 1997

Gross domestic product (Sectoral Structure, %)

Items	1991	1992	1993	1994	1995	1996	1997 (EST)
Gross Domestic product	**100**	**100**	**100**	**100**	**100**	**100**	**100**
• **Agriculture, forestry and fishing**	***40.5***	***33.9***	***29.9***	***28.7***	***28.3***	***27.2***	***25.7***
• **Industry and construction**	***23.8***	***27.3***	***28.9***	***29.6***	***30.0***	***30.7***	***31.7***
- Industry	19.8	21.7	21.5	22.0	22.9	23.7	
- construction	4.0	5.6	7.4	7.6	7.1	7.0	
• **Service**	***35.7***	***38.8***	***41.2***	***41.7***	***41.7***	***42.1***	***42.6***
- Transport, post	3.7	4.2	4.4	4.1	3.9	4.1	
- Trade	12.7	13.8	12.8	13.6	13.1	13.1	
- Finance, Banking	1.4	1.4	1.7	2.0	2.4	2.4	
- Administration. science, education	8.9	8.8	10.5	10.7	10.2	10.7	
- Housing, hotel, tourism	9.0	10.6	11.7	11.3	12.0	11.8	

Source: GSO-MPS, updating by Nguyen Quang Thai, January 1998

Appendix 1-3:

Main macroeconomics indicators 1991 - 1997

Gross domestic product (Annual growth rate in 1989, %)

Items	1991	1992	1993	1994	1995	1996	1997 (EST)
Gross Domestic product	**6.0**	**8.6**	**8.1**	**8.8**	**9.5**	**9.3**	**9.0**
• **Agriculture, forestry and fishing**	***2.2***	***7.1***	***3.8***	***3.9***	***5.1***	***4.4***	***4.5***
• **Industry and construction**	***9.0***	***14.0***	***13.1***	***14.0***	***13.9***	***14.4***	***13.2***
- Industry	9.9	14.6	12.1	12.9	14.0	14.5	
- construction	5.0	11.0	18.3	19.4	13.7	14.1	
• **Service**	***8.3***	***7.0***	***9.2***	***10.2***	***10.6***	***10.0***	***9.6***
- Transport, post	6.5	6.3	6.5	7.0	11.0	11.0	
- Trade	4.8	6.1	6.0	9.0	11.2	11.6	
- Finance, Banking	18.2	10.7	16.5	22.8	27.6	6.1	
- Administration. science, education	6.2	7.0	9.3	13.2	9.4	10.3	
- Housing, hotel, tourism	12.4	7.5	11.7	8.3	8.6	8.9	

Source: GSO-MPS, updating by Nguyen Quang Thai, January 1998

Appendix 1-4:

Main macroeconomics indicators 1991 - 1997

Gross domestic product (Annual growth rate in 1989, %)

Items	1991	1992	1993	1994	1995	1996
Source	**80632**	**115051**	**148867**	**187124**	**243659**	**294294**
- GDP	76707	110135	136571	170258	222840	258609
- Import Surplus	3925	4516	12296	16866	20819	35685
User	**80632**	**115051**	**148867**	**187124**	**243659**	**294294**
- Final consumption	68959	95314	116719	141175	180522	217345
- Gross capital formation	11506	19498	34020	43375	60488	72117
- Error	167	239	-1872	2574	2649	4832
GDP as percent of source (%)	95.1	96.1	91.7	91.0	91.4	87.9
Import as percent of source (%)	4.9	3.9	8.3	9.0	8.5	12.1
Final consumption as of GDP (%)	89.9	86.2	85.5	82.9	81.0	84.0
Gross domestic saving as percent of user (%)	10.1	13.8	14.5	17.1	19.0	16.0
Final consumption as of user (%)	85.5	82.8	78.4	75.4	74.1	73.9
Gross capital formation as percent of user (%)	14.3	16.9	22.8	23.2	24.8	24.5

Source: GSO-MPS, updating by Nguyen Quang Thai, January 1998

Appendix 1-5:

Low Scenario

National Social - economic development scenario projecting to 2030

	1997	2000	2010	2020	2030
• Population (mill)	76.8	81	94	106	115
• Growth rate (%)	1.87	1.8	1.5	1.2	0.8
• GDP (bill VND 1994)	223766	283450	557588	1016670	1874426
- Agriculture, Forestry	55924	63819	94467	126956	162514
- Industry, Construction	75013	105388	249491	514210	965242
- Service	92829	114243.2	213629.8	405504.4	746669.9
• GDP Growth rate (%)	9	8.2	7	6.5	6
- Agriculture, Forestry	4.5	4.5	4	3	2.5
- Industry, Construction	13.3	12	9	7.5	6.5
- Service	8.6	7.2	6.5	6.6	6.3
• GDP Structure (%)	100	100	100	100	100
- Agriculture, Forestry	25.7	21.2	14.2	9.9	7.3
- Industry, Construction	31.7	34.1	40.1	42.2	41.6
- Service	42.6	44.7	45.7	47.9	51.1
- Foreign exchange (VND/US$)	12650	14644	21677	27748	33825
- GDP/per capita (US$)	304	388	706	1289	2266

Source: Development Strategy Institute. January,1998.

Appendix 1-6:

Medium Scenario

National Social - economic development scenario projecting to 2030

	1997	2000	2010	2020	2030
• Population (mill)	76.8	81	94	106	115
• Growth rate (%)	1.87	1.8	1.5	1.2	0.8
• GDP (bill VND 1994)	223766	285814	605719	1191540	2257775
- Agriculture, Forestry	55924	63271	95473	128307	169115
- Industry, Constructure	75013	106806	277026	598079	1176512
- Service	92829	115737.7	233219.8	465154.1	912148.7
• GDP Growth rate (%)	9	8.5	7.8	7	6.6
- Agriculture, Forestry	4.5	4.2	4.2	3	2.8
- Industry, Constructure	13.3	12.5	10	8	7
- Service	8.6	7.6	7.3	7.1	7.0
• GDP Structure (%)	100	100	100	100	100
- Agriculture, Forestry	25.7	20.8	12.7	8.0	5.8
- Industry, Constructure	31.7	34.2	40.2	42.1	41.0
- Service	42.6	44.9	47.2	49.9	53.3
- Foreign exchange (VND/US$)	12650	16024	23720	30363	37012
- GDP/per capita (US$)	304	358	730	1469	2744

Source: Development Strategy Institute. January,1998.

Appendix 1-7:

High Scenario

National Social - economic development scenario projecting to 2030

	1997	2000	2010	2020	2030
• Population (mill)	76.8	81	94	106	115
• Growth rate (%)	1.87	1.8	1.5	1.2	0.8
• GDP (bill VND 1994)	223766	289783	655196	1414518	2782571
- Agriculture, Forestry	55924	63271	93656	132111	177546
- Industry, Constructure	75013	108236	301835	714553	1405634
- Service	92829	118276.9	259704.9	567854.4	1199392
• GDP Growth rate (%)	9	9	8.5	8	7
- Agriculture, Forestry	4.5	4.2	4	3.5	3
- Industry, Constructure	13.3	13	10.8	9	7
- Service	8.6	8.4	8.2	8.1	7.8
• GDP Structure (%)	100	100	100	100	100
- Agriculture, Forestry	25.7	20.3	10.9	6.2	4.1
- Industry, Constructure	31.7	33.9	39.4	40.7	41.0
- Service	42.6	45.8	49.7	53.2	54.9
- Foreign exchange (VND/US$)	12650	16024	23720	30363	37012
- GDP/per capita (US$)	304	367	834	1963	4087

Source: Development Strategy Institute. January,1998.

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 2) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by Fuel	A Consumption (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ)					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A Fuel Combustion Activities													
(choose relevant f0uels from section 1.2 of the Reporting instructions)													
Coal (Anthracite)	77.751	7,489	0.778	4.587	18.348	15.161	NA						
FO	28.536	2,186	0.046	1.313	0.424	0.485	NA						
DO	64.948	4,768	0.136	0.539	21.362	6.962	1.369						
Gasoline	46.616	3,227	0.951	0.984	10.818	103.753	14.624						
Kerosene	8.2	563	0.013	0.377	1.271	0.139	NA						
		18233	1.924	7.800									

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 3) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by Fuel	A Consumption (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ)					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A1 Fuel Combustion Activities													
(choose relevant Fuels from section 1.2 of the Reporting instructions)													
Coal (Anthracite)	63.550	6,120	0.636	3.749	14.997	12.392	NA	96.301	0.010	0.059	0.236	0.195	NA
FO	26.281	2,013	0.042	1.209	4.074	0.447	NA	76.592	0.0016	0.046	0.155	0..017	NA
DO	48.026	3,521	0.077	2.209	7.444	0.816	NA	73.314	0.0016	0.046	0.155	0.017	NA
Gasoline	8.118	557	0.013	0.373	1.258	0.138	NA	68.607	0.0016	0.046	0.155	0.017	NA

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 4) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by Fuel	A Consumption-on (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ)					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A1 a Electricity and Heat Production													
(choose relevant Fuels from section 1.2 of the Reporting instructions)													
Coal (Anthracite)	12.30	1,185	0.123	0.726	2.903	2.399	NA	96.301	0.010	0.059	0.236	0.195	NA
FO	13.12	1,005	0.021	0.604	2.034	0.223	NA	76.592	0.0016	0.046	0.155	0.017	NA
DO	11.70	858	0.019	0.538	1.814	0.199	NA	73.314	0.0016	0.046	0.155	0.017	NA

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 6) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by Fuel	A Consumption-on (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ)					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A1 c Solid fuel Transformation and Other Energy Industries *													
(Where appropriate, choose relevant fuels from section 1-2 of the Reporting instructions)													
Coal (Anthracite)	51.250	4,935	0.152	3.024	12.095	9.994	NA	96.301	0.010	0.059	0.236	0.195	NA
Gasoline	8.118	557	0.013	0.373	1.258	0.138	NA	68.607	0.0016	0.046	0.155	0.017	NA
DO	36.326	2,663	0.058	1.671	5.631	0.618	NA	73.314	0.0016	0.046	0.155	0.017	NA
FO	13.161	1,008	0.021	0.605	2.040	0.224	NA	76.592	0.0016	0.046	0.155	0.017	NA

* Record here consumption and emissions results from the combustion of each of the fuels used in solid fuel and other transformation processes

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 8) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by Fuel	A Consumption (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ)					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A3 Transport*													
Choose relevant fuels from section 1-2 of the Reporting instructions)													
1A3 a Civil Aviation													
i. International Aviation Gasoline	2.496	178.5	0.005	N/A	0.72	0.3	0.045	71.5	0.002	N/A	0.29	0.12	0.018
ii. Domestic Aviation: Gasoline	2.309	165.1	0.004	N/A	0.67	0.28	0.041	71.5	0.002	N/A	0.29	0.12	0.018
1A3b Road Transportation (Gasoline)													
- Motorcycles	9.811	680.9	0.68	0.088	0.49	130.5	64.6	69.4	0.07	0.09	0.05	1.33	6.59
- Cars, light buses	5.54	384.4	0.15	0.005	2.5	21.8	4.26	69.4	0.027	0.009	0.45	3.93	0.77
1A3b Road transportation (Diesel Oil)													
- Light duty trucks	1.854	137.2	0.002	0.007	4.49	2.13	2.28	74.0	0.001	0.004	2.42	1.15	1.23
- Heavy duty trucks and Buses	9.991	739.3	0.06	0.03	49.9	38.8	9.69	74.0	0.006	0.003	5.00	3.89	0.97

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 9) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by Fuel	A Consumption (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ)					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A3c Railways :													
Diesel oil	0.801	58.71	0.004	0.001	1.44	0.489	0.104	73.3	0.005	0.002	1.8	0.61	0.13
Coal	0.425	41.76	0.004	0.025	0.10	0.083	NA	98.27	0.01	0.059	0.236	0.195	NA
1A3d Navigation													
i. International Marine : Diesel oil	1.507	116.64	N/A	0.003	3.16	0.07	N/A	74.4	N/A	0.002	2.1	0.046	N/A
ii. International Navigation : Diesel oil	2.202	161.4	0.011	0.004	3.52	1.1	0.242	73.3	0.005	0.002	1.6	0.5	0.11

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 11) - Detailed Technology Based Calculation

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data by fuel	A Consumption-on (PJ)	B Quantities Emitted (Gg of Full Mass of Pollutant)						C Emission Factor (t Pollutant/ TJ) C= B/ A					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
1A4 a + b Commercial/ Institutional + Residential													
(Choose relevant fuels from section 1.2 of the Reporting instructions)													
Coal	13.776	1,327	0.138	0.813	3.251	2.686	NA	96.3013	0.010	0.059	0.236	0.195	NA
Gasoline	12.956	889	0.021	0.596	2.008	0.220	NA	68.607	0.016	0.046	0.155	0.017	NA
Kerosene	8.2	563	0.013	0.377	1.271	0.139	NA	68.607	0.016	0.046	0.155	0.017	NA
DO	6.56	481	0.010	0.302	1.017	0.112	NA	73.314	0.016	0.046	0.155	0.017	NA
FO	2.255	173	0.004	0.104	0.350	0.038	NA	76.592	0.016	0.046	0.155	0.017	NA

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1A Fuel Combustion Activities (Sheet 16) - Traditional Biomass Burned for Energy

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSIONS ESTIMATES						AGGREGATE EMISSION FACTORS					
Sector Specific Data(Units)	A Apparent Consumption -on (kt dm)	B Quantities Emitted (Gg)						C Emission Factor (t/ t dm) C= B/ A					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Fuelwood	28,672.2	45,732	199.959	1.372	49.588	1746.137	NA	1.595	0.00697	0.0000479	0.00173	0.0609	-
Agricultural wastes													
Dung													
Charcoal Consumption													
Charcoal Production													
Other (Specify)													

Note : CO_2 emissions from biomass, although reported, should not be included in national total CO_2 emissions

Appendix 2-1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1B1 Fugitive Emissions from Fuels (Coal mining)

SOURCE AND SINK CATEGORIES	ACTIVITY DATA PRODUCTION (Mt)	METHANE EMISSIONS (Gg)	EMISSION FACTORS (m^3/ t)
			C=B/A
I B I Soil fuels			
I B I a Coal mining			
I B I ai Underground Mines	2.125	25.628	12.060
Underground activities	ditto		
Post - mining activities	ditto		
I B I aii Surface Mines	3.775	2.909	0.770596
Surface Activities	ditto		
Post - mining activities	ditto		
IBI b Solid Fuel Transformation			
IBI c Other			

Appendix 2 -1: IPCC Data table - Energy sector

Standard data table 1

Energy : 1B 2 Fugitive Emissions from Fuels (Oil and Natural Gas)

SOURCE AND SINK CATEGORIES	ACTIVITY DATA	EMISSION ESTIMATES			AGGERATE EMISSION FACTORS		
	Fuel Quantity (PJ)	CH_4 (Gg)	CO_2 (Gg)	NMVOC (Gg)	CH_4 (Kg/GJ)	CO_2 (Kg/GJ)	NMVOC (Kg/GJ)
1B2 a. Oil							
i Exploration (no. of wells drilled)	70 (1)	-	-	-	- (1)	- (1)	- (1)
ii Production of Crude Oil	263.366	-	-	-	-	-	-
iii Transport of Crude Oil (Qnty. Loaded on tankers)							
iv Refining/ Storage (Qnty. Refined)							
v Distribution of Oil Products[2] (Qnty. consumed)							
vi Other							
1B2 b. Natural Gas							
i Production/ Processing (Qnty. Produced)							
ii Transmission/ Distribution (Qncy. consumed)							
iii Other Leakage (Qncy. consumed)							
1B2 c Venting and Flaring							
i Oil (Qnty. Produced)							
ii Natural Gas (Qnty. Produced)							
iii Combined (Qnty. Produced)							

[1] Activity data represents the number of wells. Emission factors are Gg/Well

2 Primarily related to NMVOC emission. See detailed Standard Data Table (1B2 Supplement to report data by fuel product

Appendix 2 - 2

The result of Model calculation

1. Fuel price assumptions

Basic assumptions	Base year	2005/10	2020/30
International (CIF) price of crude oil, US$/toe	160	200	220
International (CIF) price of crude coal, US$/toe	71	75.7	78.6
Local price of fueloil, (US$/toe)	190	210	215
Local price of gasoil/diesel, (US$/toe)	350	360	370
Local price of natural gas, (US$/mill.btu)	1.7	2.0	2.0
Local price of gasoline, (US$/toe)	350	360	370
Local price of coal, (local currency VND/Kcal)	43.0	64.4	87.0
Local price of fuel 1, local currency/Gj			
Local price of fuel 2, local currency/Gj			

2. Energy sector (a)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Reference scenario total	531.71	1858.94	5762.67
Oil products	191.10	778.24	2529.83
Natural gas	0.0	213.38	394.01
Coal product	87.48	376.48	1993.30
Hydropower	77.97	339.58	571.06
Nuclear	0.0	16.90	125.85
Fuelwood	175.14	131.17	142.30
Other Renewables 1	0.0	1.57	3.14
Other Renewables 2	0.0	1.57	3.14

Appendix 2 - 2

The result of Model calculation (cont.)

2. Energy sector (a)

Total final energy by sector (PJ)	Base year	2005/10	2020/30
Reference scenario total	451.64	1431.67	4387.31
Industry	109.23	676.09	2420.33
Agriculture	14.81	29.05	46.52
Service	11.46	41.69	111.47
Residential	228.96	328.09	334.96
Transport	87.14	356.72	1067.95

Electricity supply (GWh)	Base year	2005/10	2020/30
Reference scenario total	10333.16	70856.74	238853.95
Oil	1831.86	0.0	0.0
Natural gas	0.0	26039.02	43953.49
Coal	957.91	6859.30	104189.53
Hydro	7446.51	32415.12	54534.88
Nuclear	0.0	4627.91	34453.49
Renewables (incl. Geothermal)	0.0	861.40	1722.56
Net import			

Appendix 2 - 2

The result of Model calculation (cont.)

3. Energy sector (b1)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	525.23	1824.54	5674.60
Oil products	191.05	778.35	2505.18
Natural gas	0.0	213.38	381.04
Coal product	81.17	333.76	1887.02
Hydropower	77.94	350.57	571.06
Nuclear	0.0	14.25	125.85
Fuelwood	175.06	131.04	198.11
Other Renewables 1 Geo thermal	0.0	1.57	3.14
Other Renewables 2 Wind	0.0	1.57	3.14

3. Energy sector (b1)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10329.67	69713.72	236121.39
Oil	1831,86	0,0	0,0
Natural gas	0,0	26093,03	43953,49
Coal	957,91	5382,56	101456,98
Hydro	7443,02	33473,26	54534,88
Nuclear	0,0	3903,49	34453,49
Renewables (incl. geothermal)	0,0	861,40	1722,56
Net import			

ENV1 : Efficiency improvement in coal cooking

Appendix 2 - 2

The result of Model calculation (cont.)

4. Energy (b2)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	524.67	1852.59	5747.19
Oil products	186.61	778.26	2529.83
Natural gas	0.0	213.38	394.01
Coal product	87.48	367.40	1977.82
Hydropower	75.42	344.72	571.06
Nuclear	0.0	14.49	125.85
Fuelwood	174.93	131.17	142.30
Other Renewables 1	0.0	1.57	3.41
Other Renewables 2	0.0	1.57	3.41

4. Energy (b2)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10080.26	57297.13	189373.92
Oil	2239.73	0	0
Natural gas	0	18972.00	31954.80
Coal	1134.97	6108.24	94897.20
Hydro	6705.56	30648.55	50772.68
Nuclear	0	1288.60	11189.76
Renewables (incl. geothermal)	0	279.74	559.48
Net import			

ENV2 : Compact Fluorescent Lamps

Appendix 2 - 2

The result of Model calculation (cont.)

5. Energy (b3)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	531.71	1835.05	5610.79
Oil products	191.10	778.24	2529.83
Natural gas	0.0	213.38	394.01
Coal product	87.48	360.33	1841.42
Hydropower	77.97	340.04	571.06
Nuclear	0.0	8.69	125.85
Fuelwood	175.14	131.17	142.30
Other Renewables 1	0.0	1.57	3.41
Other Renewables 2	0.0	1.57	3.41

5. Energy (b3)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10333.16	67097.44	224063.27
Oil	1831.86	0.0	0.0
Natural gas	0.0	26093.02	43953.49
Coal	957.91	5288.37	89398.84
Hydro	7446.51	32473.25	54534.88
Nuclear	0.0	2381.40	34453.49
Renewables (incl. geothermal)	0.0	861.40	1722.56

ENV3 : Energy efficient refrigerators

Appendix 2 - 2

The result of Model calculation (cont.)

6. Energy (b4)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	528.69	1840.83	5671.04
Oil products	191.10	778.24	2529.83
Natural gas	0.0	213.38	394.01
Coal product	87.48	360.00	1901.67
Hydropower	74.95	343.72	571.06
Nuclear	0.0	11.12	125.85
Fuelwood	175.14	131.17	142.30
Other Renewables 1	0.0	1.57	3.14
Other Renewables 2		1.57	3.14

6. Energy (b4)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10044.79	78090.46	257539.98
Oil	183186	0.0	0.0
Natural gas	0.0	26093.02	43953.49
Coal	957.91	11925.58	122875.58
Hydro	7158.14	30031.39	54534.88
Nuclear	0.0	9179.07	34453.49
Renewables (incl. geothermal)	0.0	861.40	1722.56
Net import			

ENV4: Energy efficient air conditioners

Appendix 2 - 2

The result of Model calculation (cont.)

7. Energy sector (b5)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	531.71	1857.83	5743.01
Oil products	191.10	778.24	2529.83
Natural gas	0.0	213.38	394.01
Coal product	87.48	375.98	1973.64
Hydropower	77.97	339.34	571.06
Nuclear	0.0	16.53	125.85
Fuelwood	175.14	131.17	142.30
Other Renewables 1 Geothermal	0.0	1.57	3.41
Other Renewables 2	0.0	1.57	341

7. Energy sector (b5)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10333.16	70697.44	23646.98
Oil	1831.86	0.0	0.0
Natural gas	0.0	26093.02	43953.49
Coal	957.91	6811.63	102282.55
Hydro	7446.51	32403.49	54534.88
Nuclear	0.0	4527.91	34453.49
Renewables (incl. geothermal)	0.0	861.40	1722.56
Net import			

ENV5: High efficiency electric motors

Appendix 2 - 2

The result of Model calculation (cont.)

8. Energy (b6)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	529.71	1853.44	5686.41
Oil products	191.10	778.24	2553.52
Natural gas	0.0	314.14	540.08
Coal product	87.48	373.97	1747.28
Hydropower	75.98	250.63	571.06
Nuclear	0.0	2.10	125.85
Fuelwood	175.14	131.17	142.30
Other Renewables 1	0	1.57	3.41
Other Renewables 2	0	1.57	3.41

8. Energy (b6)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10325.95	70860.24	237933.48
Oil	2015.34	1177.91	594.65
Natural gas	0.0	37026.29	65255.81
Coal	977.91	7320.93	81372.09
Hydro	7255.81	23896.51	54534.88
Nuclear	0.0	577.21	34453.43
Renewables (incl. geothermal)	0.0	861.40	1722.56
Net import			

ENV 6: Fuel switching in existing thermal power plants

Appendix 2 - 2

The result of Model calculation (cont.)

9. Energy (b7)

Total energy requirement (PJ)	Base year	2005/10	2020/30
Mitigation scenario total	531.71	1838.65	5723.29
Oil products	191.10	778.26	2529.83
Natural gas	0.0	213.38	394.01
Coal product	87.48	367.15	1933.47
Hydropower	77.97	317.64	571.06
Nuclear	0.0	13.72	125.85
Fuelwood	175.14	131.17	142.30
Other Renewables 1	0.0	1.57	3.41
Other Renewables 2	0.0	15.73	23.59

9. Energy (b7)

Electricity supply (GWh)	Base year	2005/10	2020/30
Mitigation scenario total	10333.16	70857.44	238627.55
Oil	1831.86	0.0	0.0
Natural gas	0.0	26093.02	43953.49
Coal	7446.51	30315.12	54534.88
Hydro			
Nuclear	0.0	3758.14	34453.46
Renewables (incl. geothermal)	0.0	4737.68	7321.74
Net import			

ENV 7: Wind Power Plants

Appendix 2 - 3

10. Individual Energy Option Data

Option number and name : High efficiency refrigerators

Costs in Local currency	Mitigation option	Reference option
Electricity consumption	521	613
Capacity of unit	102	120
Efficiency		
Fuel type		
Fuel consumption		
Annual fuelcost		
Investment (Million US$)	42842	43800
Lifetime (years)	8	8
Discount rate %	10	10
Levelized investment		
Annual O & M		
Total annual cost		
CO_2 emission Million Tons	7254	7520
N_2O emission		
CH_4 emission		
Total CO_2 equivalent		
Number of installed units		

Local currency/ton CO_2 eq.	-46800 VND

Appendix 2 - 3

10. Individual Energy Option Data (cont.)

Option number and name : Compact fluorescent Lamps

Costs in Local currency	Mitigation option	Reference option
Electricity consumption(KWh)	23	109.5
Capacity of unit (W)	14	75
Efficiency		
Fuel type		
Fuel consumption		
Annual fuelcost		
Investment (Million US$)	43631	43800
Lifetime (years) (hour)	8000	1000
Discount rate %	10	10
Levelized investment		
Annual O & M		
Total annual cost		
CO_2 emission Million Tons	7470	7520
N_2O emission		
CH_4 emission		
Total CO_2 equivalent		
Number of installed units		

Local currency/ton CO_2 eq.	-43940 VND

Appendix 2 - 3

10. Individual Energy Option Data

Option number and name : Efficient Air conditioning

Costs in Local currency	Mitigation option	Reference option
Electricity consumption Capacity of unit Efficiency Fuel type Fuel consumption	1548	1987
Annual fuelcost Investment Lifetime (years) Discount rate % Levelized investment Annual O & M Total annual cost	 43101 10 10	 43800 10 10
CO_2 emission Million N_2O emission CH_4 emission Total CO_2 equivalent	7362	7520
Number of installed units		

Local currency/ton CO_2 eq.	-57460 VND

Appendix 2 - 3

10. Individual Energy Option Data

Option number and name : More efficient Industrial Motors

Costs in Local currency	Mitigation option	Reference option
Electricity consumption	57692	61047
Capacity of unit	15	15
Efficiency	91	86
Fuel type		
Fuel consumption		
Annual fuelcost		
Investment Million US$	43159	43800
Lifetime (years)	20	20
Discount rate %	10	10
Levelized investment		
Annual O & M		
Total annual cost		
CO_2 emission Million Tons	7308	7520
N_2O emission		
CH_4 emission		
Total CO_2 equivalent		
Number of installed units		

Local currency/ton CO_2 eq.	-39260 VND

Appendix 2 - 3

10. Individual Energy Option Data

Option number and name: Efficiency improvement in coal cooking

Costs in Local currency	Mitigation option	Reference option
Electricity consumption Capacity of unit Efficiency Fuel type Fuel consumption	 25 Coal	 17 Coal
Annual fuelcost Investment Lifetime (years) % Discount rate % Levelized investment Annual O & M Total annual cost	 43414 10	 43800 10
CO_2 emission Million Tons N_2O emission CH_4 emission Total CO_2 equivalent	7299	7520
Number of installed units		

Local currency/ton CO_2 eq.	22750 VND

Appendix 3-1:

WORKSHEET 5-1: Changes in Forest and Other Woody Biomass Stocks

MODULE			**LAND USE CHANGE AND FORESTRY**				
SUBMODULE			**CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS**				
WORKSHEET			**5-1**				
SHEET			**1 OF 3**				
STEP 1							
			A Area of Forest/Biomass Stocks (kha)	B Annual Growth Rate (t dm/ha)	C Annual Biomass Increment (kt dm)	D Carbon Fraction of Dry Matter	E Total Carbon Uptake Increment (kt C)
					C=(AxB)		E=(CxD)
Tropical	Plantations	Acacia spp	120	8.45	1,014	0.5	507
		Eucalyptus spp	479	6.75	3,233	0.5	1,617
		Tectona grandis				0.5	
		Pinus spp	40	4.50	180	0.5	90
		Other species	160	6.30	1,008	0.5	504
	Natural Forest	Evergreen	1,335	0.6	801	0.5	400.5
		Secondary	4,825	4.0	19,300	0.5	9,650
		Mixed	392	4.0	1,568	0.5	784
		Young	1,453	4.0	5,812	0.5	2,906
		Bamboo	580	4.5	2,610	0.5	1,305
		Other	45	2.0	90	0.5	45
	Savannas	Woody	3,334	2.5	8,335	0.5	4,168
		Shrub	3,323	2.0	6,646	0.5	3,323
		Grass	4,134	2.5	10,335	0.5	5,168
		Rocky	628	1.0	628	0.5	314
	Other						
Boreal							
Non-Forest Trees (specify type)			A Number of Trees (1000s of trees)	B Annual Growth Rate (kt dm/1000 trees)			
			1,278.4	0.0055	7.03	0.5	3..5
						Total	30,784.5

Appendix 3-1:

WORKSHEET 5-1: Changes in Forest and Other Woody Biomass Stocks (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS**
WORKSHEET	**5-1**
SHEET	**2 OF 3**

	STEP 2							
Harvest Categories (specify)	F Commercial Harvest (if applicable) ($1000m^3$ roundwood)	G Biomass Conversion/ Expansion Ratio (if applicable) (t dm/m^3)	H Total Biomass Removed in Commercial Harvest (kt dm)	I Total Traditional Fuelwood Consumed (kt dm)	J Total Other Wood Use (kt dm)	K Total Biomass Con-sumption (kt dm)	L Wood Removed From Forest Clearing (kt dm)	M Total Biomass Consump-tion From Stocks (kt dm)
			H=(FxG)	(From column H. Worksheet 1-2)		K=(H+I+J)	(From column M. Worksheet 5-2 sheet 3)	M=K-L
Hard wood	1,440	1.05	1,512.0					
Soft wood	1,442	0.75	1,081.5					
Bamboo	-	-	300.0		750			
				28,672			1,372	
Totals	2,882		2,893.5	28,672	750	32,315.5	1,372	30,943.5

Appendix 3-1:

WORKSHEET 5-1: Changes in Forest and Other Woody Biomass Stocks (cont.)

MODULE	**LAND USE AND FORESTRY**
SUBMODULE	**CHANGES IN FOREST AND OTHER WOODY BIOMASS STOCKS**
WORKSHEET	**5-1**
SHEET	**3 OF 3**

STEP 3			
N Carbon Fraction	O Annual Carbon Release (kt C)	P Net Annual Carbon Uptake (+) or Release (-) (kt C)	Q Covert to CO_2 Annual Emission (-) or Removal(+) (Gg CO_2)
	O=(MxN)	P=(E-O)	Q=(Px[44/12])
0.5	15,471.8	15,312.7	56,146.6

Appendix 3-2:

WORKSHEET 5-2: Forest and Grassland Conversion

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**FOREST AND GRASSLAND CONVERSION**
WORKSHEET	**5-2**
SHEET	**1 OF 6**

STEP 1									
Land types				A Area Converted Annually (kha)	B Biomass Before Conversion (t dm/ha)	C Biomass After Conversion (t dm/ha)	D Net Change in Biomass Density (t dm/ha)	E Annual Loss of Biomass (kt dm)
							D=(B-C)	E=(AxD)
Tropical	Moist Forests	Primary		6	200	30	170	1,020
		Secondary		22	120	20	100	2,200
	Seasonal Forests	Primary						
		Secondary						
	Dry Forests or Woody Savannas	Savanna		420	35	10	25	10,500
		Degraded						
Temperate	Evergreen	Primary						
		Secondary						
	Deciduous	Primary						
		Secondary						
Boreal	Primary							
	Secondary							
Grassland								
Other								

Appendix 3-2:

WORKSHEET 5-2: Forest and Grassland Conversion (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**								
SUBMODULE	**FOREST AND GRASSLAND CONVERSION**								
WORKSHEET	**5-2**								
SHEET	**2 OF 6**								
				STEP 2					
Land types				F Fraction of Biomass Burned On site	G Quantity of Biomass Burned On Site (kt dm)	H Fraction of Biomass Oxidized On Site	I Quantity of Biomass Oxidized On Site (kt dm)	J Carbon Fraction of Above-ground Biomass (burned on site)	K Quantity of Carbon Released (from biomass burned) (kt C)
					G=(ExF)		I+(GxH)		K=(IxJ)
Tropical	Moist Forests	Primary		0.35	357	0.9	321.3	0.5	160.7
		Secondary		0.45	990	0.9	891.0	0.5	445.5
	Seasonal Forests	Primary							
		Secondary							
	Dry Forests or Woody Savannas	Savanna		0.65	6,825	0.9	6,142.5	0.5	3,0713
		Degraded							
Temperate	Evergreen:	Primary							
		Secondary							
	Deciduous	Primary							
		Secondary							
Boreal	Primary								
	Secondary								
Grassland									
Other									
								Subtotal	3,677.5

Appendix 3-2:

WORKSHEET 5-2: Forest and Grassland Conversion (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**FOREST AND GRASSLAND CONVERSION**
WORKSHEET	**5-2**
SHEET	**3 OF 6**

			STEP 3						STEP 4	
Land types			L Fraction of Biomass Burned Off Site	M Quantity of Biomass Burn Of Site (kt dm)	N Fraction of Biomass Oxidised Off Site	O Quantity of Biomass Oxidised Off Site (kt dm)	P Carbon Fraction of Above-ground Biomass (burned off site)	Q Quantity of Carbon Released (from biomass burned off site (kt C)	R Total Carbon Released (from on & off site burning) (kt C)	S Total CO_2 released (from on & off site burning) (kt CO_2)
				M=(ExL)		O=(MxN)		Q=(OxP)	R=(K+Q)	S=Rx[44/12]
Tropical	Moist	Primary	0.1	102	0.9	91.8	0.5	45.9	206.6	757.5
	Forests	Secondary	0.1	220	0.9	198.0	0.5	99.0	544.5	1,996.5
	Seasonal	Primary								
	Forests	Secondary								
	Dry Forests	Savanna	0.1	1,050	0.9	945.0	0.5	472.5	3,543.8	12,993.9
	or Woody Savannas	Degraded								
Tem-perate	Evergreen:	Primary								
		Secondary								
	Deciduous	Primary								
		Secondary								
Boreal	Primary									
	Secondary									
Grass-land										
Other										
			Subtotal	1,372			**Subtotal**	617.4	4,294.9	15,747.9

Appendix 3-2:

WORKSHEET 5-2: Forest and Grassland Conversion (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**FOREST AND GRASSLAND CONVERSION**
WORKSHEET	**5-2**
SHEET	**4 OF 6**

STEP 5											
Land types			A Average Area Converted (10 Year Average) (kha)	B Biomass Before Conversion (t dm/ha)	C Biomass After Conversion (t dm/ha)	D Net Change in Biomass Density (t dm/ha)	E Average Annual Loss of Biomass (kt dm)	F Fraction Left to Decay	G Quantity of Biomass Left to Decay (kt dm)	H Carbon Fraction in Above-ground Biomass	I C.Released from Decay of Above-gound Biomass (kt C)
						D=(B-C)	E=(AxD)		G=(ExF)		I=(GxH)
Tropical	Moist	Primary	6. 9	200	30	170	1,173	0.55	645.2	0.5	322.6
	Forests	Secondary	25.3	120	20	100	2,530	0.45	1,138.5	0.5	569. 3
	Seasonal	Primary									
	Forests	Secondary									
	Dry Forests	Savanna	483	2.5	10	25	12,075	0.25	3,018.8	0.5	1,509.4
	or Woody Savannas	Degraded									
Temperate	Evergreen:	Primary									
		Secondary									
	Deciduous	Primary									
		Secondary									
Boreal	Primary										
	Secondary										
Grassland											
Other											
									Subtotal		2,401.3

Appendix 3-2:

WORKSHEET 5-2: Forest and Grassland Conversion (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**FOREST AND GRASSLAND CONVERSION**
WORSHEET	**5-2**
SHEET	**5 OF 6**

STEP 6									
Land Type				A Average Annual Forest/ Grassland Converted (25 year average) (kha)	B Carbon Content of Soil Before Conversion (t/ha)	C Total Annual Potential Soil Carbon Losses (kt C)	D Fraction of Carbon Released over 25 years	E Carbon Release from Soil (kt C)
Tropical	Moist Forests	Primary		7.2	115	828	0.5	414
		Secondary		26.4	115	3,036	0.5	1,518
	Seasonal Forests	Primary						
		Secondary						
	Dry Forests or Woody Savannas	Savanna		504	60	30,240	0.5	15,120
		Degraded						
Temperate	Evergreen:	Primary						
		Secondary						
	Deciduous	Primary						
		Secondary						
Boreal	Primary							
	Secondary							
Grassland								
Other								
							Subtotal	17,052

Appendix 3-2:

WORKSHEET 5-2: Forest and Grassland Conversion (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**FOREST AND GRASSLAND CONVERSION**
WORKSHEET	**5 - 2**
SHEET	**6 OF 6**

STEP 7				
A Immediate Release From Burning (kt C)	B Delayed Emissions From Decay (kt C) (10 - ear average)	C Long Term Emissions From Soil (kt C) (25 - year average)	D Total Annual Carbon Release (kt C)	E Total Annual CO_2 Release (Gg CO_2)
			D = (A + B + C)	E = (D x [44/12])
4,294.9	2,401.3	17,052.0	23,784.2	87,076.7

Appendix 3-3:

WORKSHEET 5-3: On-site Burning of Forests

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**ON-SITE BURNING OF FORESTS**
WORKSHEET	**5-3**
SHEET	**1 OF 1**

STEP 1				STEP 2			
A Quantity of Carbon Released (kt C)	B Nitrogen-Carbon Ratio	C Total Nitrogen Released (kt N)		D Trace Gas Emissions Ratios	E Trace Gas Emissions (kt C)	F Conversion Ratio	G Trace Gas Emissions from Burning of Cleared Forests (Gg CH_4 CO)
(From columns K.sheet 2.of Worksheet 5-2)		C=(AxB)			E=(AxD)		G=(ExF)
3,677.5	0.01	36.775	CH_4	0.012	44.13	16/12	58.9
			CO	0.06	220.65	28/12	514.9
					kt N		Gg $N_2O.NO_x$
					E=(CxD)		G=(ExF)
			N_2O	0.007	0.26	44/28	0.4
			NO_x	0.121	4.45	46/14	14.6

Appendix 3-4:

WORKSHEET 5-4: Abandonment of Managed Lands

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**ABANDONMENT OF MANAGED LANDS**
WORKSHEET	**5-4**
SHEET	**1 OF 3**

STEP 1

Regrowth Land Type		A 20 year Total Area Aban-doned and Regrowing (kha)	B Annual Rate of Above-ground Biomass Growth (t dm/ha)	C Annual Aboveground Biomass Growth (kt dm)	D Carbon Fraction of Aboveground Biomass	E Annual Carbon Uptake in Aboveground Biomass (kt C)
				C=(AxB)		E=(CxD)
Tropical Forests	Moist					
	Seasonal					
	Dry	100	3.7	370	0.5	185
Temperate Forests	Evergreen					
	Deciduous					
Boreal Forest						
Grasslands						
Other						
					Subtotal	185

Appendix 3-4:

WORKSHEET 5-4: Abandonment of Managed Lands (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**ABANDONMENT OF MANAGED LANDS**
WORKSHEET	**5-4**
SHEET	**2 OF 3**

		STEP 2		STEP 3				
Regrowth Land Type		F Annual Rate of Uptake of Carbon in Soils (t C/ha)	G Total Annual Carbon Uptake in Soils (less than 20 years) (kt C)	H Total Area Abandoned More than Twenty Years (kha)	I Annual Rate of Above-ground Biomass Growth (t dm/ha)	J Annual Above-ground Biomass Growth (kt dm)	K Carbon Fraction of Above-ground Biomass	L Annual Carbon Uptake in Aboveground Biomass (kt C)
			G=(AxF)			J=(HxI)		L=(JxK)
Tropical	Moist							
Forests	Seasonal							
	Dry	1	100					
Temperate Forests	Evergreen							
	Deciduous							
Boreal Forest								
Grasslands								
Other								
		Subtobal	100					

Appendix 3-4:

WORKSHEET 5-4: Abandonment of Managed Lands (cont.)

MODULE	**LAND USE CHANGE AND FORESTRY**
SUBMODULE	**ABANDONMENT OF MANAGED LANDS**
WORKSHEET	**5-4**
SHEET	**3 OF 3**

		STEP 4		STEP 5	
Regrowth Land Type		M Annual Rate of Uptake of Carbon in Soils (t C/ha)	N Total Annual Carbon Uptake in Soils (kt C)	O Total Carbon Uptake from Abandoned Lands (kt C)	P Total Carbon Dioxide Uptake ($Gg\ CO_2$)
			N=(HxM)	O= (E+G+L+N)	P= (Ox[44/12])
Tropical Forests	Moist				
	Seasonal				
	Dry			285	1,045
Temperate Forests	Evergreen				
	Deciduous				
Boreal Forest					
Grasslands					
Other					
		Subtotals		285	1,045

Appendix 3-5:

INDIVIDUAL FORESTRY OPTION DATA

Option F1: Enhanced Natural Regeneration

Cost in local currency (VND)	***Mitigation option***	***Reference option***
Brief description	1.85 million ha of degraded forest areas would be protected and improved for natural regeneration in the period 1994 - 2030 at a rate of 50,000 ha/year	1.1 million ha of degraded forest areas would be protected and improved for natural regeneration in the period 1994 – 2030 at a rate of 30,000 ha/year
Initial cost (VND/ha)	1,650,000	1,650,000
Maintenance cost VND/ha/year	22,000	22,000
Rotation period (years)	20	20
Discount rate (%)	10	10
Endowment VND/ha (Present value of cost)	499,620	342,540
CO_2 abated (1,000 tonnes)	320,100	58,300

VND/tonne CO_2 eq. VND 3,080

Appendix 3-5:

INDIVIDUAL FORESTRY OPTION DATA (cont.)

Option F2: Reforestation

Cost local currency (VND)	***Mitigation option***	***Reference option***
Brief description	Reforestation of 1.95 million ha of degraded forest lands under short rotation (10 years) at a rate of 130.000 ha/year	Reforestation of 1.95 million ha of degraded forest lands under short rotation (10 years) at a rate of 100.000 ha/year
Initial cost (VND/ha)	3,740,000	3,740,000
Maintenance cost (VND/ha/year)	55,000	55,000
Rotation period (years)	10	10
Discount rate (%)	10	10
Endowment VND/ha (Present value of cost)	3,863,090	2,854,720
CO_2 abated (1,000 tonnes)	768,533	589,233

VND/tonne CO_2 eq. VND 10,120

Appendix 3-5:

INDIVIDUAL FORESTRY OPTION DATA (cont.)

Option F3: Natural Forest Protection

Cost local currency (VND)	***Mitigation option***	***Reference option***
Brief description	Protection of 6.5 million ha of natural forest areas up to the year 2030. Deforestation to be controlled by conducting intensive forest protection.	Conservation of 2.4 million ha of existing protection forests up to the year 2030. Logging in the areas to be prohibited
Initial cost (VND/ha)	110,000	110,000
Maintenance cost (VND/ha/year)	44,000	33,000
Discount rate (%)	10	10
Endowment VND/ha (Present value of cost)	477,950	372,130
CO_2 abated (1,000 tonnes)	3,162,500	1,353,623

VND/tonne CO_2 eq. VND 990

Appendix 3-4:

INDIVIDUAL FORESTRY OPTION DATA (cont.)

Option F4: Planting Scattered Trees

Cost local currency (VND)	***Mitigation option***	***Reference option***
Brief description	4 billion scattered trees, equivalent of 1.65 million hectares, will be planted in waste land up to 2030 at a rate of 44,000 ha/year	3 billion scattered trees, equivalent of 1.2 million hectares, will be planted in waste land up to 2030 at a rate of 32,000 ha/year
Initial cost (VND/ha)	1,760,000	1,760,000
Maintenance cost (VND/ha/year)	22,000	22,000
Rotation period (years)	12	12
Discount rate (%)	10	10
Endowment VND/ha (Present value of cost)	650,870	538,450
CO_2 abated (1,000 tonnes)	288,566	143,366

VND/tonne CO_2 eq. VND 4,070

Appendix 3-6:

COMAP Model Output for Forestry Mitigation Options

Main indicators	**Enhanced natural regeneration**	**Short rotation plantation**	**Natural Forest protection**	**Scattered trees**
1. Land area (kha)	1,850	1,950	6,500	1,640
2. Mitigation potential (Sum of annually created incremental pool per ha) (t of C abated / ha)	47.2	107.3	132.7	47.7
3. Initial cost:				
$/tC	0.6	1.7	0.1	0.7
$/ha	24.1	173.2	10.0	29.1
4. Life-cycle cost:				
$/tC abated	1.0	3.4	0.3	1.4
$/ha	45.2	351.2	43.5	59.2
5. Cost - benefit analysis:				
$ NPV/tC	1.3	5.5	0.7	9.3
$ NPV/ha	55.6	577.1	91.0	404.3

Appendix 4-1:

The Emission factors from various animal types

Type of Animal	*Enteric Fermentation (Kg/head/year)*	*Manure (Kg/head/year)*
Dairy cattle	56	27
Non Dairy cattles	44	2
Buffalo	55	3
Swine	1	7
Horse	18	2.2
Sheep	5	0.22
Poultry	0	0.023

Source : IPCC Guidelines for national GHG inventories-1995 , Reference manual (Vol III)

Appendix 4-2 :

Animal population projection to 2030

Unit : million head

No	*Animal type*	*1993*	*2000*	*2010*	*2020*	*2030*
1	Dairy-cattle	0.016	0.030	0.044	0.060	0.080
2	Non-dairy cattle	3.317	4.300	5.776	7.440	9.000
3	Buffalo	2.960	3.090	3.605	4.463	4.600
4	Sheep	0	0	0	0	0
5	Goat	0.353	0.54	0.65	0.60	0.60
6	Horse	0.133	0.16	0.18	0.40	0.50
7	Poultry : Chicken	133.4	180.0	274.0	330.0	390.0
8	Swine	14.874	21.305	25.04	37.80	40.00

Source : Institute for Agricultural Planning and Projection

Appendix 4-3:

Rice Harvested Area with Water management regime in 1993

Water Management regime	***Harvested Area (Mh)***		
	1990	***1993***	***1994***
Irrigated	5.045	5.460	5.472
Deep water (<100 cm)	461	458	451
Rainfed (< 50 cm)	521	641	675
Total sowing area	6.027	6.559	6.598

Source : Institute for Agricultural Planning and Projection

Appendix 4-4:

Distribution of harvested area in regions of Vietnam

Regions		***Harvested Area (1000 ha)***	***Per total area (%)***
The North of Vietnam (1)	1. North Mountain and Midland	812	12.38
	2. Red River Delta	1033	15.75
	3. North central coast	674	10.27
Sub total		2,519	38.40
The South of Vietnam (2)	4. South Central coast	525	8.00
	5. Central Highland	187	2.85
	6. North East of South	335	5.12
	7. Mekong River Delta	2,993	45.63
Sub total		4,040	61.60
Total		6,559	100%

Source : Institute for Agricultural Planning and Projection

The figures in Table 4.4 show:
(1) In the North of Vietnam, Rice fields is applied by organic and chemical fertilizers.
(2) In the South of Vietnam, applied by chemical fertilizers.

Appendix 4-5:

Emission Factors for Methane Emissions For Rice Ecosystems

Relative To Continuously Flooded Fields (Without Organic Amendments)

Category	Sub-category			Area (m.ha) $=10^6$ha	Scaling factor	Emission Factor $E_f(g/m^2)$	Total Emission Tg Y^{-1}
Upland	None			0	0	0	0
Lowland	Rainfed	Flood prone		0.641	0.8	16	0.1026
		Drought prone			0.4	8	
	Irrigated	Continuously flooded		5.460	1	20	1.0920
		Intermittently flooded	Single aeration		0.5	10	
			Multiple aeration		0.2	4	
	Deep Water	Water depth - 50 -100cm		0.458	0.8	16	0.0733
		Water depth >100cm			0.6	12	
Total				6.559			1.2678

Source : Institute for Agricultural Planning and Projection .

Note: For irrigated and continuously flooded, lowland rice ecosystems, the default seasonally integrated methane emission is 20 g/m^{-2} for soil without organic amendments. For conversion to CH4 emission from soil with organic amendments, apply a defaults correction factor of 2 (Range 2-5) to the corresponding rice ecosystem for the without organic amendment category

Appendix 4-6 :

The rice harvested area projection to 2030

Unit : million ha

No	**Rice field** *category*	*1993*	*2000*	*2010*	*2020*	*2030*
1	100% flooded irrigation (constantly flooded irrigation)	5.46	6.019	6.94	7.45	7.77
2	Deep water rice	0.458	0.429	0.252	0.250	0.230
3	Rainfed	0.641	0.623	0.123	0	0
4	Total	6.559	7.071	7.315	7.70	8.00

Source : Institute for Agricultural Planning and Projection

Appendix 4-7:

N Fertilizer with N content

Nitrogen Sources	N Fertilizer x 1000 tonnes		
	1993	1994	N content (%)
Chemical fertilizer:			
- Rice	591.120	617.630	46
- Field crops	79.560	84.310	46
- Industrial crop	49.110	51.120	46
- Fruit	11.150	10.710	46
Subtotal	730.940	763.870	
Organic fertilizer:			
- Swine	30,524	32,058	0.6
- Buffalo + Cow	38,142	40,072	0.29
- Other	7,619	8,015	1.0
Subtotal	76,285	80,145	
Total	77,015.940	80,908.870	

Source : Institute for Agricultural Planning and Projection

Appendix 4-8:

Nitrogen input into soils - 1993.

	N Fertilizer x 1000 tonnes	*N content (%)*	*N input (1000t/year)*
Chemical fertilizer	730.940	46	336.232
Sub total	730.940		336.232
Organic fertilizer			
- Swine	30,524	0.6	183.144
- Buffalo + Cattle	38,142	0.29	110.612
- Other	7,619	1.0	76.190
Sub total	76,265		369.946
Total	77,015.940		706.178

Source : Institute for Agricultural Planning and Projection

Appendix 4-9:

Estimated Nitrous oxide emission from Agricultural soil in 1993

	N input (1000 tonnes)	*N_2O emission (Gg)*		
		Low	*Median*	*High*
Chemical fertilizer	336.232	0.168	1.210	13.113
Organic fertilizer	369.946	0.185	1.332	14.428
Total	706.178	0.353	2.542	27.541

Source : Institute for Agricultural Planning and Projection

Appendix 4 -10:

WORKSHEET 4-1:

Methane emission from domestic livestock enteric fermentation and manure management

Module		Agriculture				
Submodule		Methane emissions from domestic livestock enteric fermentation and manure management				
Worksheet		4-1				
Sheet		1 of 1				
Livestock Type	A Number of Animals (1000 head)	B Emissions Factor for Enteric Fermenta-tion (kg/head/ year)	C Emissions from Enteric Fermenta-tion (t/year)	D Emissions Factor for Manure Management (kg/head/ year)	E Emissions from Manure Management (t/year)	F Total Annual Emissions from Domestic Livestock (Gg)
			C=(AxB)		E=(AxD)	F=(C+E)/ 1000
Dairy Cattle	16	56	896	27	432	1.328
Non-Dairy Cattle	3317	44	145948	2	6634	152.582
Buffalo	2960	55	162800	3	8880	171.680
Sheep						
Goats	353	5	1765	0.22	78	1.843
Camels						
Horses	133	18	2394	2.20	293	2.687
Mules & Asses						
Swine	14874	1,0	14874	4	104118	118.992
Poultry	133400	0	0	0.023	3068	3.068
		Totals	328 677		123503	425.18

Appendix 4-11:

WOPRKSHEET 4-3:

Prescribed burning of savannas

Module	Agriculture
Sub module	Prescribed burning of savannas
Worksheet	4-3
Sheet	1 of 3

STEP 1					STEP 2		
A Area Burned by Category (specify) (k ha)	B Biomass Density of Savanna (t dm/ha)	C Total Biomass Burning (Gg dm)	D Fraction Actually Burned	E Quantity Actually Burned (Gg dm)	F Fraction of Living Biomass Burned	G Quantity of Living Biomass Burned (Gg dm)	H Quantity of Dead Biomass Burned (Gg dm)
		C=(AxB)		E=(CxD)		G=(ExF)	H=(E-G)
1.Shrub Savanna 308	40	12,320	0.8	9,856	0.7	6,899	2,957
2. Grass Savanna 88	30	2,640	0.85	2,244	0.8	1,795	449

Appendix 4-11:

WOPRKSHEET 4-3:

Prescribed burning of savannas (cont.)

Module	Agriculture		
Submodule	Prescribed Burning of savannas		
Worksheet	4-3		
Sheet	2 of 3		
STEP 3			
I Fraction Oxidized of living and dead biomass	J Total Biomass Oxidized (Gg dm)	K Carbon Fraction of Living & Dead Biomass	L Total Carbon Released (Gg C)
	Living : J =(GxI) Dead : J = (HxI)		L=(JxK)
Living 0.8	5,519.2	0.45	2,483.6
Dead 1.0	2,957	0.40	1,182.8
Living 0.8	1,436.0	0.45	646.2
Dead 1.0	449	0.40	179.6
Living			
Dead			
Living			
Dead			
Living			
Dead			
Living			
Dead			
Living			
Dead			
		Total	4492.2

Appendix 4-11:

WOPRKSHEET 4-3:

Prescribed burning of savannas (cont.)

MODULE	AGRICULTURE
SUBMODULE	PRESCRIBED BURNING OF SAVANNAS
WORKSHEET	4-3
SHEET	3 OF 3

STEP 4					STEP 5	
L Total Carbon Released (Gg C)	M Nitrogen-Carbon Ratio	N Total Nitrogen Content (Gg N)	O Emissions Ratio	P Emissions (Gg C **or** Gg N)	Q Conversion Ratio	R Emissions from Savannas Burning (Gg)
		N=(LxM)		P=(LxO)		R=(PxQ)
4492.2	0.006	26.953	0.004	17.969	16/12	23.959CH_4
			0.06	269.532	28/12	628.908 CO
				P=(NxO)		R=(PxQ)
			0.007	0.189	44/28	0.297N_2O
			0.121	5.4673.261	46/14	10.715NO_x

Appendix 4-12:

WOPRKSHEET 4-4:

Field burning of agriculture residues

MODULE	AGRICULTURE
SUBMODULE	FIELD BURNING OF AGRICULTURAL RESIDUES
WORKSHEET	4-4
SHEET	1 OF 3

	STEP 1			STEP 2		STEP 3		
Crops (specify locally important crops)	A Annual Production (Gg crop)	B Residue to Crop Ratio	C Quantity of Residue (Gg biomass)	D Dry Matter Fraction	E Quantity of Dry Residue (Gg dm)	F Fraction Burned in Fields	G Fraction Oxidized	H Total Biomass Burned (Gg dm)
Rice	22836.6	1.4	31971.24	0.83	26,536.129	0.25	0.90	5,970.6
							Total	13163.572

Appendix 4-12:

WOPRKSHEET 4-4:

Field burning of agriculture residues (cont.)

MODULE	AGRICULTURE			
SUBMODULE	FIELD BURNING OF ACRICUL TURAL RESIDUES			
WORKSHEET	4-4			
SHEET	2 OF 3			
	STEP 4		STEP 5	
	I Carbon Fraction of Residue	J Total Carbon Released (Gg C)	K Nitrogen-Carbon Ratio	L Total Nitrogen Released (Gg N)
		J=(HxI)		L=(JxK)
Rice	0.4144	2,474.2	0.014	34.639
Total:		2,474.2		34.639

Appendix 4-12:

WOPRKSHEET 4-4:

Field burning of agriculture residues (cont.)

MODULE	AGRICUL TURE			
SUBMODULE	FIELD BURNING OF AGRICUL TURAL RESIDUES			
WORKSHEET	4-4			
SHEET	3 OF 3			
STEP 6				
	M Emission Ratio	N Emissions (Gg C **or** Gg N)	O Conversion Ratio	P Emissions from Field Burning of Agricultural Residues (Gg)
		N=(JxM)		P=(NxO)
CH_4	0.005	12.371	16/12	16.495
CO	0.06	148.452	28/12	346.388
		N=(LxM)		P=(NxO)
N_2O	0.007	0.242	44/28	0.380
No_x	0.121	4.191	46.14	13.770

Appendix 4-13: The projection of rice harvested area and rice area under water management

unit : million ha

No.	*Year*	*Rice harvested area*	*Rice area under water management*
1	1993	6.559	0
2	1994	6.598	0
3	1995	6.693	0
4	1996	6.778	0
5	1997	6.883	0
6	1998	6.978	0.2
7	1999	6.978	0.4
8	2000	7.071	0.6
9	2001	7.095	0.8
10	2002	7.119	1.0
11	2003	7.143	1.2
12	2004	7.167	1.4
13	2005	7.191	1.6
14	2006	7.215	1.8
15	2007	7.239	2.0
16	2008	7.263	2.2
17	2009	7.287	2.4
18	2010	7.315	3.0
19	2011	7.353	3.1
20	2012	7.391	3.2
21	2013	7.429	3.3
22	2014	7.467	3.4
23	2015	7.505	3.5
24	2016	7.543	3.6
25	2017	7.581	3.7
26	2018	7.619	3.8
27	2019	7.657	3.8
28	2020	7.700	3.8
29	2021	7.730	3.8
30	2022	7.760	4.0
31	2023	7.790	4.2
32	2024	7.820	4.3
33	2025	7.850	4.5
34	2026	7.880	4.7
35	2027	7.910	4.9
36	2028	7.940	5.1
37	2029	7.970	5.3
38	2030	8.000	5.5

Appendix 4-14:

The projection of animal (cattle and buffaloes) population and number of population provided by improved nutrition.

Unit : million head

No.	*Year*	*Animal population*	*Population provided by improved nutrition*
1	1993	6.293	0
2	1994	6.454	0
3	1995	6.615	0
4	1996	6.776	0
5	1997	6.937	0
6	1998	7.098	0.1
7	1999	7.259	0.2
8	2000	7.42	0.4
9	2001	7.62	0.6
10	2002	7.82	0.8
11	2003	8.02	1.0
12	2004	8.22	1.2
13	2005	8.42	1.4
14	2006	8.62	1.6
15	2007	8.82	1.8
16	2008	9.02	1.9
17	2009	9.22	2.0
18	2010	9.425	2.0
19	2011	9.679	2.1
20	2012	9.933	2.2
21	2013	10.187	2.3
22	2014	10.441	2.4
23	2015	10.695	2.5
24	2016	10.949	2.6
25	2017	11.203	2.7
26	2018	11.457	2.8
27	2019	11.711	2.9
28	2020	11.963	3.0
29	2021	12.135	3.1
30	2022	12.307	3.2
31	2023	12.479	3.3
32	2024	12.651	3.4
33	2025	12.823	3.5
34	2026	12.995	3.6
35	2027	13.167	3.8
36	2028	13.339	4.0
37	2029	13.511	4.2
38	2030	13.680	4.4