Lao people's Democratic Republic
Peace Independence Democracy Unity Prosperity

Assessment Report
On Technology Needs and Priorities
For Mitigating Greenhouse gas Emissions

Prepared by
Science Technology and Environment Agency
For Climate Change Enabling Activity Phase II

April 2004

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Prepared by
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In collaboration with Technical Working Group on Climate Change:

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- Ministry of Agriculture and Forestry (Department of Forestry, Department of Agriculture, Department of Meteorology and Hydrology)
- Ministry of Industry and Handicraft (Department of Industry, Department of Electricity)
- Ministry of Communication ,Transport, Post and Construction (Department of Transport)
- Ministry of Public Health (Department of Hygiene)
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For Climate Change Enabling Activity Phase II

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I. Introduction

The economic development in the Lao PDR is mostly relied on utilizing the natural resources as to make a useful source of the country incomes. The Government has implemented the innovative guideline in an attempt to gradually increase the ratio of highly economic growth since 1986. This innovative guideline has been acknowledged to the role and importance of the natural resources for which the economic development and the negative impact towards the natural resources if without organizing the appropriate management. With regard to this problem, the stronger enhancement of the environmental protection and improvement policy on a number of the economic sectors to which it has been legislated for the purpose of achieving the socio-economic development. This is not only prevailing for the sustainable national economy, but also for reducing the least impact on the environment. Thus, the environmental protection policy is regarded as the most important issue in which it has been decreed under the Newly Issued Improved Constitution enforced in 2003, Article 19, which determined that: "***Every organization, every resident population is obliged to protect and take care of the environment and the natural resources including those existed on the ground, underground, forests, wild animals, water resources and the surrounding air.***"

The sustainable development of the country is principally depended on the foundation of science and technology and the change in conformity with both the developed and developing countries. There is a rapidly growing mode of the economic development in a great many developing countries; however, there is no such sustainability if those countries are still regardless of the consequences and carrying on the ever-lesson experience formerly happened with a large number of industrialized countries (Muna Singha & Swart, 2000). The rapid development in connection with the newly discovered knowledge is considered positive effects to prevail a large number of opportunities for us so as to avoid the formerly and negatively affected results in preparation to, not only rapidly advance towards modernized science and technology, but participate in a variety of institutes as well. In order to achieve these objectives, developing countries need the assistance for developing the field of personnel competence (knowledge, expertise, science and the management competency), the development of the sundry institutes in conformity with appropriately working connection implementation as well as creating and improving a number of mechanics which assist any specific task movement. Therefore, the technology transferring issues must be widely and profoundly considered including the challenging software and hardware and the opinion logging-in into the computer in order to help search for the new methods of sustainable economic development channels. Generally speaking, the current environmental condition is mainly affected by the exercise of the former science and technology.

By the same token, in the Lao PDR, the economic development as well as the actually national priority action plans have to be improved and equipped with the appropriately and adequately scientific and technological implementation to suit the real circumstances in our country. The Lao PDR has ratified the Convention on Climate Change in January, 5th 1995 and has been financially supported from the Global Environment Facility (GEF) through the UNDP to the Lao PDR so as to upgrade the Government staff capacity in successfully carrying out own commitment towards the above-mentioned convention. In particular, it is mainly emphasized on the Article 4 and the Article 12 of the convention. The National Greenhouse gas Inventory Project has been implemented during the middle of the 1997.

This Assessment Report on Technology Needs and Priorities has been developed with the aim of analyzing in conformity with the noteworthy significance of technological options, so as to achieve the national development objectives. In addition, it needs to synthesize a number of total necessary technological development projects involved with related economic fields to possibly support the national development objectives.

II. The Economic Development

In order to enable to the Lao PDR refrain from the state of being underdeveloped, one of the most generally important guidelines for the socio-economic development up until the year 2020, the Policy on the Environment Protection has been circulated as such "**The socio-economic development must be carried out efficiently, continuously and consistently, guarantee the balance of between the economic growth and the socio-cultural development and the permanently environmental protection.**" (*Draft of the National Environment Strategies, 25/10/03*).

The previous period of the socio-economic development and the National Strategic Plan are considered the advantageous conditions for the provision of the direction in the National Economic Development within the next two decades' time, from which this has been noticed within the Gross Domestic Product (GDP) of the continuously growth of various sectors as indicated in details in Table 1.

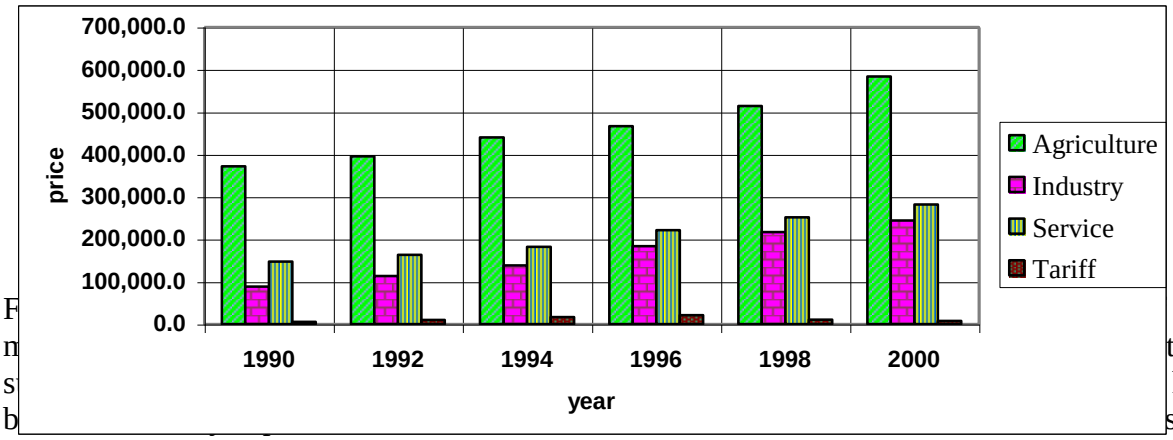
Table 1: Gross Domestic Product (GDP) of various sectors (Million Kip)

Gross Domestic Product (GDP) of Various Sectors							
Sectors	Fiscal Years						
	1990	1992	1994	1996	1998	2000	Compared to Year: 90/00 (Times)
Agriculture	371,835.4	395,537.0	439,979.6	466,205.5	514,071.4	583,590.8	1.56
Rice Production	224,974.4	221,166.1	221,633.6	222,393.3	269,712.2	346,562.7	
Livestock Husbandry and Fishery	127,363.4	158,850.5	172,568.6	183,940.8	192,972.3	202,098.4	
Forestry	19,497.6	15,520.4	45,777.4	59,871.4	51,386.9	34,929.7	
Industry	88,104.9	113,587.1	138,633.8	183,996.7	21,078.7	244,283.4	2.71
Mining	895.9	931.9	1,658.7	2,774.4	4,056.6	5,488.7	
Factory	60,462.4	85,775.4	98,797.7	137,265.2	164,454.7	188,803.3	
Construction	17,908.0	19,055.1	25,925.7	31,104.7	28,054.1	25,328.9	
Electricity	8,838.6	7,824.7	12,251.7	12,852.4	20,513.3	24,662.5	
Service	116,609.4	122,740.8	138,587.0	165,724.1	193,585.4	214,558.6	1.83

Retail and Wholesale trade	41,967.0	49,415.0	63,158.0	76,773.4	93,396.7	105,131.8	
Transportation Post and Telecommunication	31,687.4	34,333.0	36,920.1	48,010.9	56,389.8	65,014.8	
Finance	6,938.9	6,907.9	8,465.2	11,700.5	13,006.4	8,611.3	
State Service	35,633.0	31,034.0	28,922.8	27,743.3	29,217.2	33,400.3	
Other service	383.1	1,050.9	1,120.9	1,496.0	1,575.3	2,400.4	
Tariff	5,364.0	9,635.2	16,667.9	21,438.8	10,504.2	7.748,8	1.44

Source: National Statistics Centre, 2002

Figure 1: Gross Domestic Product (GDP) of Various Sectors (Million Kip)



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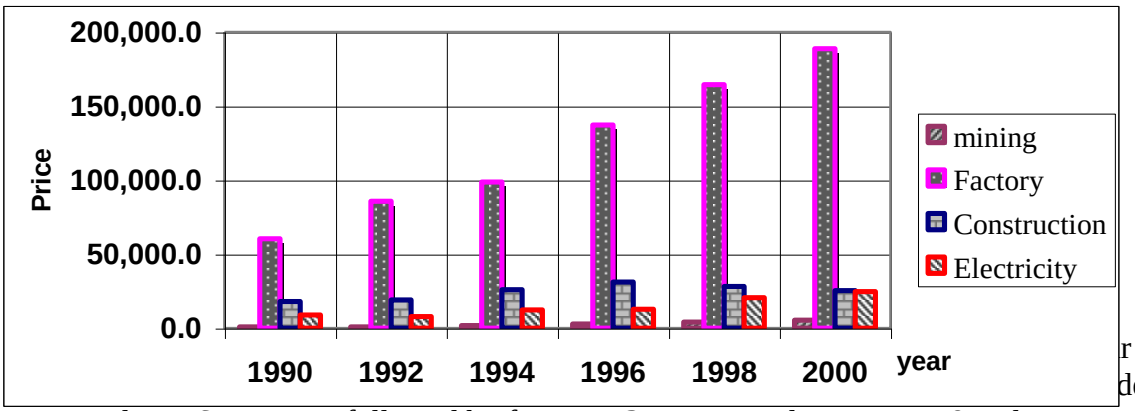
year of 2000 when compared with the fiscal year 1990 respectively.

The details of the Industrial Sector's Gross Domestic Product, Agriculture and Service have been explained in Tables 2, 3 and 4 respectively as follows:

Figure 2: The Gross Domestic Product of the Industrial Sector



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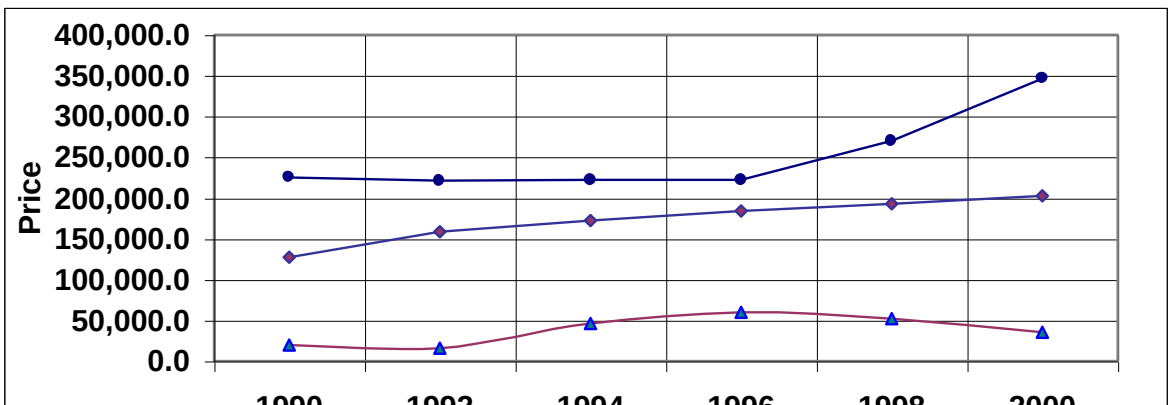
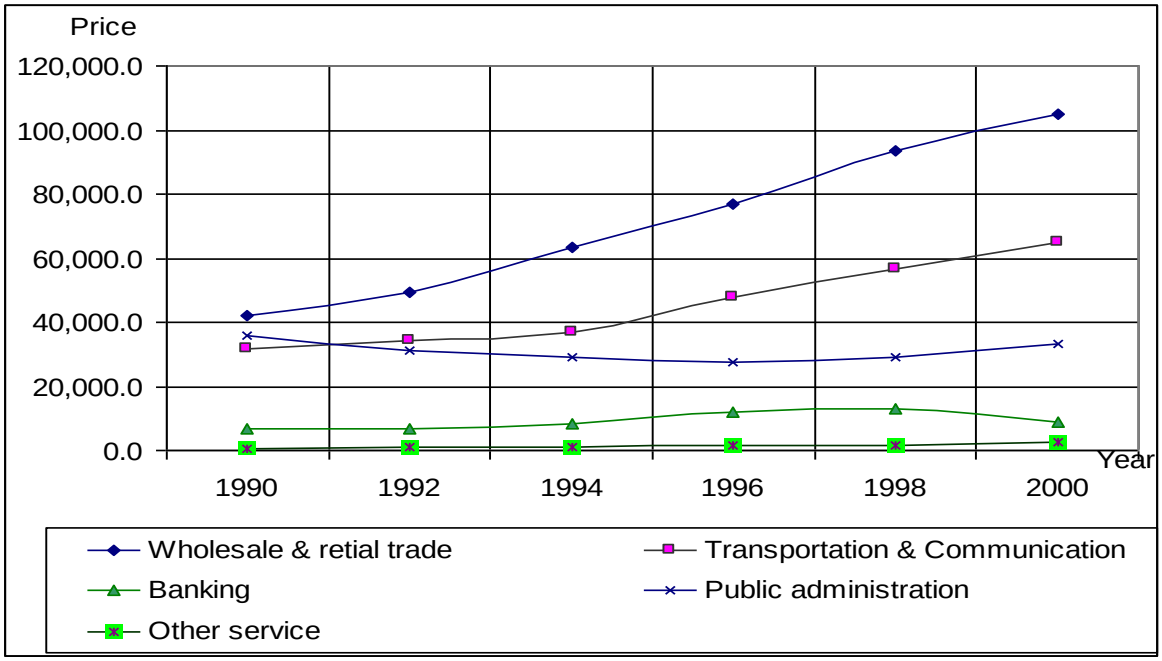
increased into 6.12 times, followed by factories 3.12 times, electricity 2.79 and construction 1.41 times.

Figure 3: The Gross Domestic Product of the Agricultural Sector



From Figure 3 Gross Domestic Product of the Agricultural Sector between the fiscal year period 1900 and 2000, is can be seen that there was a slightly little expansion in almost every sector as such Cultivation 1.79 times, Livestock Husbandry and Fishery 1.58 and Forestry 1.54 times.

Figure 4: Gross Domestic Product of the Service Sector



From Figure 4, the gross domestic product of the service sector between the fiscal year period 1990 and 2000 can be noticed that the Private Service Sector accounted for approximately 6.26 times, whereas the Retail and the Wholesale trade accounted for 2.50 times, Communication, Transportation, Post and Telecommunication constituted 2.05 times, Finance accounted for 1.24 times and the State Service constituted 0.97 times.

III. The Technology needs and priorities for mitigating greenhouse gas emissions.

3.1 The Greenhouse Inventory for Lao PDR

The first national inventory on the greenhouse gases was started to conduct in 1997 by utilizing the Guideline of the Intergovernmental Panel on Climate Change (IPCC). The inventory has been profoundly conducted in 4 main fields such as the field of energy, the forestry and land use change, agriculture and the waste. The greenhouse gases, which have been survey, are carbon dioxide ($CO_{2)}$, methane ($CH_{4)}$, carbon monoxide (CO), nitrous oxide (N_2O), nitrogen oxide ($NO_{x)}$. The assessment on the emissions of the greenhouse gases was based on the volume of tasks, the certainty in the emissions of the greenhouse gases assessment and mostly the absorption of the greenhouse gases from the globally atmospheric

layers are depended on the precision of the information and data in each task and the multiplier of the various gases emissions. The total multipliers used in this inventory was utilizing the absolute value of the Intergovernmental Panel on Climate Change regarding the de fault values (IPCC de fault values). As for the Lao PDR, the cost benefit analysis has noticed that it was the appropriate procedure in order to prioritize technologies so as to reduce the greenhouse gases. In along the line with depending on the foreign experts' support in order to analyze the problems in the case of there are other relevant factors and according to the standardization of the Intergovernmental Panel on Climate Change (IPCC).

From the most significant survey results, the emissions of the greenhouse gases of the various sectors as indicated in Table 2 below, it can be noticed that the distribution of the carbon dioxide (CO_2) is mostly created by the forestry sector; for instance, it was caused by the putrefaction which reached to 9,247.84 Gg, followed by the on-the-spot burning up to 6,752.67 Gg, the external burning up to 628.16 Gg and the energy sector up to 414.9 Gg. However, the natural absorbing resources as well as the forest changing conditions and a variety of plants are still abundantly being capable of absorbing those toxic gases, which increased up to 104,570 Gg annually. As for the distribution of methane gas (CH_4) is found everywhere. As for CO, N_2O and NO_x gases, they are found in the fields of energy and forestry.

Table 2: The National Inventory on the Greenhouse gases Emissions in 1990 (Gg*)

	CO_2	**CH_4**	**CO**	**N_2O**	**NO_x**
Energy sector					
Fossil Fuel consumption	414.9				
Traditional biomass burned for energy		22.75	157.92	0.12	4.18
Agriculture sector					
Enteric fermentation		97.92			
Manure Management		14.38			
Rice cultivation		158.97			
Forestry sector					
Change in Forest and woody Biomass	-121,614.00				
Forest conversion: Aboveground CO_2 released from on-site burning	6,752.67	29.5	257.8	0.2	7.3
Forest conversion: Aboveground CO_2 released from off-site burning	628.16				
Aboveground CO_2 release from decay	9,247.84				
Waste					
Landfills		11.2			
Waste water		0.23			
Grand Total:	**-104,570**	**312**	**258**	**0**	**7**

Source: Science, Technology & Environment Agency, 2000. (STEA)

* $1Gg = 10^9$ g

3.2 Technology needs and priorities for mitigating Greenhouse gas emissions in the Energy Field

As for the Lao PDR, the natural resources, which have been utilized as the energy source, consist of 3 main resources such as water, forest and minerals.

- Hydro Energy:

From the Food and Agriculture Annual Report 2000, it has noticed that the Lao PDR has possessed abundant water and water resources, fresh and good quality water. The annually average flowing water amount accounts for approximately 8,500 cubic metres/second within a total number of the Mekong River's Tributary Streams and they are capable of contributing the amount of water to the Mekong Basin, which constitutes approximately 35%. During the rainy season, there is the amount of flowing water up to 80% and in the dry season up to approximately 20% of the annually total amount of flowing water. At the present time, the water utilization is mainly in the agriculture sector; for example, irrigation, fishery, cultivation and animal husbandry. Apart from that, water is still used in the electric hydropower development that potentially possesses approximately 23,000 megawatts, within which less than 5% of the total potential has been used. The Lao PDR's abundant water resources have created the up-stream and down-stream transportation convenience in the wet season, been supplied for a variety of the industrial sectors and water supplies for people in towns and cities which approximately constitutes 60% and 51% in the rural areas' clean water supplies consumption (*Draft of the National Environmental Strategies, 25/10/03*).

- Forestry:

The latest studies has officially been approved in 1989 that the Lao PDR has been covered with the proportion of the approximately 47% of the total forest coverage or constitutes approximately 11.2 million hectares. The forest is classified into 7 types such as Production Forest, Conservation Forest, Protection Forest, Rehabilitation Forest, and Exploited Forest. In the Lao PDR, there are 20 National Biodiversity Conservation Areas, 2 Adjacent Zones, 57 Provincial Biodiversity Conservation Areas, 144 Urban Biodiversity Conservation Areas, 23 Provincial Protected Forests, and 52 Urban Protected Forests, which have added up to the total amount of conservation forest areas of 5.3 million hectares or 22.6% of the total territory of the Lao PDR. The forest resources have played the important roles in accumulating the national incomes, been the foodstuff and the additionally rural grass-root people's incomes. The forest reduction ratio has resulted from the agriculture area expansion, wild fire-burning forests, slash-and-burn shifting cultivation, poorly disciplined and badly planned timber-cutting practices, the imbalance of infrastructure development and the inappropriately harvesting forest products which are exceeding the supplies from the availability of the nature (*Draft of the National Environmental Strategies*, 25/10/03).
Fire wood is the people's main energy. About 85% have been used for house hold consumption. The average of fire wood utilization is about 0.75-2.92 m^3 or 0.58-2.26 T/Pers/year (National Biodiversity Strategy Action Plan).

- Minerals:

The Lao PDR has a variety of valuable mineral potentials, of which those minerals have only been mined in a small-scale. In particular, our country has a large number of various types of coal deposits, which can be used, in the field of energy resources. Mostly, anthracite and lignite have been utilized in the manufacturing industry. Only a small amount of coal, which has been used as fuel energy for the people's handcraft of brick-burning process. During the period of 1995 to 2001, the Viengphoukha Coal Mining Company has been mining the coal up to the total amount of approximately 3,750 tonnes for domestic sales and 803,787 tonnes for exporting abroad (to Thailand). The above-mentioned company will continue to mine coal up until 2015, from which the result of the survey has revealed the total coal deposits of up to approximately 9,565,000 tonnes. Whereas, another good quality coal deposits have been found in the Vientiane Province with the annually coal mining amount of up to approximately over 23,000 tonnes. Besides, Peat, a kind of coal, is still used for cooking energy; however, the statistics of using Peat as cooking energy is not clearly surveyed in greater details yet. (*Department of Geology-Mining and the Viengphoukha Coal Mining Company, 2000*).

To avoid the utilization of the energy resources namely petrol, kerosene, diesel and coal, including the firewood and charcoal use as already mentioned above as they are the main cause of the global gas emissions. Therefore, technology and modes of production using the electric power is regarded as a better appropriate option and there is a possibility in the energy field as follows:

3.2.1 The Electricity Sector

- *Technology Needs and Priorities:*

- **Hydropower**

The stream of big and small rivers that flow throughout the year in some areas is potentially capable of generating electric hydropower by constructing the hydropower dams. Besides, water in a large-scale irrigation canals' plain area can be used to operate a small-scale electric hydropower station as well. This mentioned technology is considered the centrally planned electric hydropower production, which has the cost of electricity production up to US$0.03 / Kilowatt-hour.

- **The Flowing River Electric Hydropower**

A water current of some small flowing streams may have potentials, which can be applied to produce a small-scale electric hydropower station. The above-mentioned mode of electricity production has been applied as the foreign technology, which covers the production capacity of up to 60 to 200 watts. This above-mentioned mode of electric hydropower production is called the isolated or the single type of electricity production, which has the cost of production of up to US$0.036/Kilowatt-hour.

- **The Solar Photovoltaic Energy Production**

The Solar Photovoltaic Panel can turn the sunrays into the direct electric current with the physical process. The above-mentioned equipment consists mainly of 3 peripheral items such as Solar Panel, Battery and Battery Control Unit. The estimated cost of the solar photovoltaic production is US$2.60/Kilowatt-hour.

- **The Biomass gasified Electricity Power**

In this mode of electricity production, the solid fuel substance has been reactively changed through the thermo-chemical process such as the dehydration process, the heat obtained from hydrolysis, the cause of oxidation and the decrease of the chemical reactivity until it becomes the fuel in the form of gas called: burning gas. The value of this thermo-energy of this burning gas accounts for 1,000 to 1,200 kilocalories /Newton cubic metres. In modern technology, the above-mentioned gas has been used for the direct burning; for example, in the thermo-electricity generators. This mode of electricity production is used from 300 to 500 kilowatts or higher than this. However, in the case of the Lao PDR, it is determined by the specific using system (the single sing system). The cost of production system is the use of the waste from vegetables or other agricultural wastes which accounts for US$0.13/Kilowatt-hour.

Table 3 below illustrates the options of basic technology and the cost of electric energy production.

Table 3: General summary regarding the assessment of the cost of electric energy production

Technology	**Price of Electricity Energy (US$/Kilowatt-hour)**
The Centrally-Integrated Electricity Production System	
- Hydropower	0.03
The Single or Isolated Type of Electricity Production	
- The Water Flowing Hydropower	0.036
- The Solar Photovoltaic Power	2.60
The Biomass Gasified Electricity Production	
- Using the Vegetables and Agricultural Wastes	0.15
- Using firewood	0.13

Source: STEA, the National Greenhouse Gas Inventory Project, 1998.

From the table above, we can classify the sequences of modes of electricity production in terms of the effective reduction of the greenhouse gas emissions and the valuable cost; for example, the first place is the hydropower. The latter is the flowing stream of electricity power generation, the wood burning as energy for electricity production, the vegetable waste and the agricultural waste as a source of fuel and the solar photovoltaic panel as the final energy stage.

- *The Disadvantages and Shortcomings:*

With regard to technology needs and priorities within the above-mentioned sectors, it is obviously seen that there are a number of main difficulties as follows:

- Although the Centrally-Integrated Electric Hydropower Network Mode is considered the form of low investment cost per unit price, rather dangerously risky and excessively expensive cost of the electric power cable extension network to the rural remote poverty-stricken areas due to our country's geographical landscapes are mainly covered with the mountainous areas. Therefore, the investment towards the rural remote poverty-stricken areas is extremely expensive

in terms of expenditures, in which the rural electricity development is considered the most tremendously difficult field of development.

- The biomass gasified electric power production is another option with the lower cost of production; however, it mainly needs the utilization of wood and it is still regarded as an appropriately optional mode of the power production.
- The Solar Photovoltaic Power in the tropical countries' electric current consumption for the household lights use only is still possible, but the cost of production is relatively high.

➢ *The Methods of Problem Solution*

To overcome the above-mentioned difficulties, it is necessary to be aware of some of the most important measures as follows:

- The utilization of the locally existing potentials is primarily necessary for the expenditure comparison of the construction of some small-scale hydropower dams or the utilization of the kerosene is another optional way, which should be considered.
- The construction of the small-scale electric power stations do not have high cost of production and is realized that there are a great many areas with prevailing conditions for electricity development due to the areas have been possessed with geographically higher altitudes of landscapes and abundantly saturated with water resources.
- To enhance the energy conservation and to apply the utilization of the higher efficient technology.
- To extend the utilization of the advanced technology.
- To open the account on the social awareness and acknowledgement about the efficient energy consumption.

3.2.2 Dwelling Sector

➢ *Technology Needs and Priorities:*

- **The Optional Ways for the Energy Utilization into Cooking**

In Table 4, it shows the price-benefit analysis results of various types of cooking stoves. From this table, it is noticed that a miscellaneous ways of cooking has to be changed into the utilization of the economized cooking stoves, which can be economically carried out in many methods such as the cost and the fuel. The use of electric cookers is a better and more appropriately optional aspect than the use of other kinds of cooking utensils because of the lower cost and lower fuel consumption as compared to the utilization of the charcoal stoves and the gas stoves, but the method of using the electric cooking stove is appropriately used only within the areas where there is the electricity power supplies.

Table 4: The Cost Benefit Analysis Regarding Various Cooking Stoves

A Variety of Cooking Stoves	Total Cost (US$)	Annual Fuel Utilizing Cost (US$)	CO_2 Emission (Tonnes/Year)

Traditional Cooking Stoves			
- Wood-burning Stove	16	15	5.25
- Charcoal Stove	58	55	1.90
Economized Cooking Stoves			
- Economized Wood-burning Stove	12	10	3.52
- Economized Charcoal Stove	41	39	1.33
- Gas Stove	85	10	0.54
- Electric Cooker	33	13	0

Source: Science, Technology & Environment Agency, 1998

Remark: No emission of toxic gases from the use of a variety of electric cookers in the Lao PDR due to the energy resources for electricity production comes from replaceable resources; therefore, there is no toxic gas emissions from the electric hydropower stations.

- **The Optional Ways for the utilization of the light**

Table 5 below shows the efficient development of the light, which has been utilized in cities, towns, countryside and commercial sectors. The energy reduction methods below which use the energy with high efficiency (33-watt neon light tube, compact fluorescent tube and electronic light tube) or a number of advanced technology using recycling energy (solar photovoltaic energy lamp and household solar photovoltaic energy system).

Table 5: The Efficient Development of the Electric Light/Lamp

Currently Utilized Technology	Recommended to Change to Utilize New Technology	Sector	The Increase of Light Efficiency (%)
Light bulb	36-watt neon light	Household	17
40-watt neon light	36-watt neon light	Household	8
40-watt neon light	Compact Fluorescent Tube	Household	70
Light bulb	36-watt neon light	Commercial	17
40-watt neon light	Neon light	Commercial	8
36-watt neon light	Compact Fluorescent Tube	Commercial	70

Remark: The light bulbs are meant to indicate a variety of generally used light bulbs.

The annual energy-economizing assessment and benefit receiving (per year) is shown in Table 6 below:

Table 6: The General Summary of the Assessment on the Utilization of the Energy for Lights

Currently Utilized Technology	Recommended to Change to Utilize New Technology	Sector	Annual Energy Saving (Kilowatt/Year)	Received Benefit (Year)

Light bulb	36-watt Neon light	Household (in cities)	21.9	10.64
40-watt Neon light	36-watt Neon light	-//-	8.76	0.00
39-watt Neon light	Compact Fluorescent	-//-	76.65	11.36
Light bulb	36-watt Neon light	Household (in rural)	18.25	20.43
40-watt Neon light	36-watt Neon light	-//-	7.30	0.00
39-watt Neon light	Compact Fluorescent	-//-	11.68	21.81
Light bulb	36-watt Neon light	Commercial		2.66
40-watt Neon light	36-watt Neon light	-//-		0.00
39-watt Neon light	Compact Fluorescent	-//-	102.28	2.84

The cost of investment for the change to the new technology recommended utilizing be estimated as follows:

Compact Fluorescent Light	US$13.22
40W Neon Light	US$ 3.18
39W Neon light	US$ 3.18

- **The Optional Ways for the utilization of Solar Photovoltaic Energy and Household Solar Photovoltaic Energy System**

The solar photovoltaic energy lamp is a single light bulb and a mobile type. The compact fluorescent lights are generally ranging from 6 Watts and 7 Watts, while the solar panel is not necessarily installed on the house roof and its size is only 10 WP. The above-mentioned technology system consists of one unit of 6Amphour-dry-cell battery. The solar photovoltaic energy lamp can be basically used up to 2-3 hours which is depended on the battery charge, the household solar photovoltaic energy system (SHS) is used to light. However, this can be used with television sets, radio and other less power consuming utensils. This technology comprises 2 light bulbs (generally, 18W neon light); a rechargeable unit; a 12-voltage battery ranging from 40-100 ampere-hour and the 35-100 WP solar panel. The utilization of the solar photovoltaic energy depends on its system size; particularly, its solar panel and battery units. Whereas, the household solar photovoltaic energy system can be used up to 4-5 hours, but its duration of utilization is depended on it system size as well. The solar photovoltaic energy lamp can replace the use of a normal light bulb. The household solar photovoltaic energy system can be used to replace up to 3-4 normal light bulbs.

Table 7: The General Summary of the Assessment on the Recycling Energy Utilization as the Lights

	Light Bulb	**Solar Photovoltaic Lamp**	**Household Solar Photovoltaic Energy System**

Total Cost (US$)	1	29	181
Cost/Energy used (US$/Megajoule)	0.003	0.075	0.153

Remark: The household solar photovoltaic energy system can be used to replace 3 normal light bulbs.

The optional way of utilization of the energy into cooking is regarded as using of electric cooking stove as being more appropriate way than another due to its low cost and energy saving. Whereas, the optional way of the light utilization, it is regarded as the use of 36W neon light tube can economize energy better than the other types of light tubes. The option of the recycling energy utilization for lighting purposes is considered better because the solar photovoltaic energy lamp that has low cost equipment installation and it could save energy appropriately better.

- *The Disadvantages and Shortcoming:*

With regard to the needs for the technology and priorities within the above-mentioned sector, some main difficulties as follows:

- The utilization of the electric cooking stove is considered low cost and fuel saving, but it is particularly suitable for only electricity reaching areas.
- The electricity current cost is still expensive when compared with the Government staff's incomes.
- The cost of the solar photovoltaic energy system is relatively high.
- The energy production of the solar photovoltaic system is depended on the nature and there are some constraints in its utilization.

- *The Problem Solving Procedures:*

To overcome the above-mentioned problems, it is necessary to be aware of some important measures as follows:

- Economized charcoal stove should be used.
- Use compact fluorescent lamps.
- Government should consider some measures on the cost of importing some equipment units, which are regarded, as the most important and necessary.
- Provide an awareness of the energy conservation the society (the public); especially, the problems that are involved with energy used in the householders' lives and people's ways of life in community.
- Develop people's self responsibility and efficiently build up betters habit for general public in economizing energy consumption as follows:
  - Switch off the light before leaving the room.
  - Put out the fire in the stove when cooking is finished or not cooking.
  - Use low energy consumption of electric appliances.

3.3 Technological Options and Reduction of Greenhouse Gas Emissions in Transportation Field

Vehicles in the Lao PDR are composed of different types and brands with which its growth rate is rapidly increased annually; especially, motorcycles. The overwhelming majority of vehicles belong to private ownership and a large number of used vehicles

imported from abroad. These vehicles do not only consume diesel, but also use a great deal of petrol. Transportation services comprise two categories such as transportation of goods and public transportation. An urban type of the public transportation consists of; for example, tricycles with engines (*Tuk Tuk* and *Jumbo*), taxis, two-row-seat minibuses, vans and buses. Whereas, the vehicles for goods transportation are small-scale lorries, medium type trucks and large and heavy loaded trucks. Those above-mentioned vehicles are fairly old with worn-out engines and not only technically adapted, but also technically lacking inspection and used for many years. Therefore, those vehicles are considered the main cause of increasingly air pollution problems in big towns and cities nowadays. Apart from that, they are still creating traffic problems in big cities ranging from traffic flow complication, rush hour traffic jam, road accidents and careless practice in urban road-using regulations. With regard to the scientific research and the comparison of exhausted gas emission ranging from carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxide (NO_X) and other gases from a large number of different vehicles in the transportation system can be noticed that; for example, the usage of the mass or public transportation in big cities is the best choice. In an attempt to better reduce toxic gas emission, such as CO_2, into the atmosphere, road accidents and manage to concretely control and get rid of the above-mentioned problems, Periodically, Government should determine some appropriate measures and procedure step by step as follows:

- *The Technology Needs and Priorities:*
  - Use high technology and good quality vehicles,
  - Use fuel economized and less toxic gas emitted vehicles; especially, mass or public means of transportation such as buses in big cities instead of using petrol-mixed consuming tricycles with engines like *Tuk Tuk-Jumbo*, using 4-stroke motorbikes instead of 2-stroke ones,
- *The Disadvantages and Shortcomings:*

With reference to the needs for the technology and prerequisite in the above-mentioned sector, obviously it can be considered that there are some relevantly difficult aspects as follows:

- Expensive prices of vehicles,
- Lack of restrictive vehicles and petrol control procedures,
- Lack of adequate and concise rules and regulations

- *The Problem solving Procedures:*

In order to overcome the above-mentioned problems, it is necessary to be aware of some important measures as follows:

- Strictly control the import of used vehicles in correlation with the determined technical standard,
- Issue rules and regulations on the prohibition not to produce and import all types of petrol-mixed consuming *Tuk Tuk - Jumbo*,
- Strictly control on the import of less petrol standard, leaded petrol and environmentally harmful petrol,
- Determine standard on exhausted/toxic gas emissions of urban vehicles,
- Pass the rules and regulations to prohibit the import of the 2-stroke motorbikes,
- Strictly control the technical inspections on vehicles with the use of modernized circumspectly inspecting apparatus,

- Strictly enforce the rules and regulations and the laws and orders,
- Develop the mass or public means of transportation (buses) in big cities in order to reduce the use of *Tuk Tuk-Jumbo*, taxis and private cars (short-term),
- Support the use of the 4-stroke motorbikes in replace of the use of the 2-stroke ones (medium-term),

3.4 Technological Options and Priorities on Reduction of Greenhouse Gas Emissions in Agricultural Field

➢ *The Technology Needs for and Priorities:*

As it is all well known, the greenhouse gas emitted from all sorts of agricultural field is called *methane* at which this toxic gas is developed through maturity or cattle's mastication, wet rice plantation and the use of the natural fertilizers. The optional ways for reduction of the greenhouse gas in the agricultural field include 3 main natures as follows:

- The Breeding of Masticating Animals:

Possible options are to improve the animal feeds through the chemical improving process, add additional animal feeds to accelerate the production, which will reduce the naturally bred animals so as to change into breeding animals in enclosure farms. Supplementary animal feeds (MUB) is enriched with minerals and essential proteins, but the problem is the purchase funding and the domestic animal feed producing possibility is still low.

- The Wet Plantation:

In order to reduce methane gas, there are 2 ways for the rice plantation: firstly, expand the second season rice crop plantation. As for the all-time-water-flooding land, it is advised to drain water away or allow it to be dry for a period of time. Secondly, it is to increase the rice plantation productivity. In ordinary wet rice plantation, mostly farmers use the indigenous rice species; whereas, the second rice crop plantation, it is recommended to use the newly mixed hybrid rice species so as to suit with newly applied techniques of rice plantation.

- The Use of Natural Fertilizers (Manure or Vegetable Waste Matters):

Through the studies of collection of animal dung or natural fertilizers at the hole of the waste dump according to applied techniques, methane gas can be produced for the cooking fuel and for other purposes, which is regarded as effective results and harmless to the environmental atmosphere. On the contrary, the remaining matured waste can be used as fertilizers that do not emit methane at all. Therefore, the appropriate method to reduce greenhouse gas in using natural fertilizers is to enhance the use of the biogas digester.

Table 8: General Summary of the Methane Gas Reduction (CH_4) in Agricultural Field

The Original Source of (CH_4) in Agricultural Field	**The Reduction Methods**
- Masticating Animals	- Improve animal feeds through additional animal feed strategies
- Wet Rice Plantation	- Soil Drying Techniques

- Use Natural Fertilizers	- Use biogas digester with a small-scale cooking stove (8-16 m^3), - Use biogas digester with a large-scale cooking stove (> 30 m^3),

The methods of methane gas reduction (CH_4) in the agricultural field in the Lao PDR; especially, the breeding of the masticating animals should have to improve the animal feeds through the supplementary animal feed strategies, while the cultivation (rice plantation) should have to use the soil drying techniques. As for the use of the natural fertilizers, it needs to isolate the methane gas (CH_4) by using the biogas digester.

➢ *The Disadvantages and Shortcomings:*

With reference to the technological needs and prerequisite in the above-mentioned sector, a number of difficulties can be distinguished as follows:

- Animal breeding is still implemented in a natural and scattered ways.
- Rice plantation is still naturally depended on the monsoon rainwater, using the indigenous rice species, the second hybrid-mixed rice crop species is still limited and in some areas where used-to-be-second rice crop plantation land is now deserted and not farmed any longer.
- Natural fertilizer utilization in people's rice farms is not technically matured through the methane isolation process (CH_4)

➢ *The Problem solving Procedures:*

With regard to the above-mentioned problems, it is necessary to be aware of some important measures as follows:

- Support the enclosure animal breeding and enhance the use of the supplementary animal feeds.
- Expand the second rice crop farming areas and increase the rice plantation productivity.
- Promote farmers to learn to practise a variety of newly developed rice production techniques.
- Support farmers who raise animals to construct the complete unit of the biogas digester.

3.5 Technological Options and Priorities on Reduction of Greenhouse Gas Emissions in Forestry Field

➢ *The Needs for Technology and Priorities:*

The methods of reduction of the greenhouse gas emissions are appropriately applied in the Lao PDR as follows:

1. The Conservation of the Natural Carbon Dioxide Absorption Resources, which consists of:

- The Conservation Areas Construction: In 1993, the Government of Lao PDR has announced the establishment of 18 Conservation Forest Areas, in accordance the Prime Ministers Decree No.: 164/PM, in which they are well known as the National Biodiversity Conservation Areas up until the present time. Since 1993, 2 more forest areas have been additionally announced, which has been accounted for 20 areas (NBCA) covering 3.3 million hectares, which constitutes approximately 14% of the total area of the country (*Lao-Swedish Forest Co-operation Project, 2001*).
- The Permanent Cessation of Slash-and-Burn Shifting Cultivation Method: In order to protect the environment and forest resources, the permanent cessation of slash-and-burn shifting cultivation method is determined to the priority within the national level action plans. Hence, to reduce the shifting cultivation areas from 25,000 hectares in 2001 to 17,000 hectares and leading to entirely the permanent cessation of slash-and-burn shifting cultivation method in 2003.
- The Forest Administration-Management: From the 1993 World Bank Report, it was acknowledged that the unplanned timber cutting has led to the annual loss of 30,000-hectare-forest areas and from the wrong timber cutting techniques to the annual loss of 10,000 hectares.

2. The Expansion of the Naturally Carbon Dioxide Absorption Resources, which comprises:
   - The Forest Rehabilitation: During the period of 1975-1992, there was an assessment of the Teak plantation which accounted for approximately 6,676 hectares and during the period of 1993-1997, there was approximately 42,194 hectares, in 1997 approximately 14,000 hectares, between 2001-2002 approximately 23,000 hectares. And it is expected that in 2005 there will be the tree-farmed areas, which account for 30,000 hectares.
   - The Villagers' Forest Management: This idea stimulates the people's co-operation and contribution in forest conservation and forest protection.

The conservation and the expansion of the carbon absorption considered the best method of reduction of the Greenhouse-effect-toxic-gas emissions is appropriately applied in the Lao PDR. One of the most important strategic action plans is the action plan of the slash-and-burn shifting cultivation cessation, which is the entirely important tasks and directly involved, in the living condition of all mountainous people.

➢ *<u>The Disadvantages and Shortcomings</u>:*

With regard to the technological needs and prerequisite in the above-mentioned sector, a number of difficulties that can be identified as follows:

- The implementation of the rules and regulations and the laws and orders is not appropriately carried out.
- The rules and regulations of the forest, land and village forest classification are not concisely implemented.
- The annually governmental planned-timber-cutting-permitting quota is not exactly carried out in principles in some rural areas.

- The forest equipment, tools and vehicles used for the forest administration and management are not adequately provided.
- Knowledge and experience in the management of the tree-farmed forests are not adequately high.

➢ *The Problem Soving Procedures:*

With regard to the above-mentioned problems, it is necessary to be aware of some important measures as follows:

- The short-term and long-term guidelines in the implementation of the slash-and-burn shifting cultivation methods are as follows:

Short-term Guidelines	**Long-term Guidelines**
Aiming to guarantee staple food and creating family incomes, it should promote the agriculture and forest activities in the former slash-and-burn shifting cultivation areas.	Aiming to reduce the slash-and-burn-shifting cultivation areas by increasing the rice productivity using a variety of hybrid grains. Promote the use appropriately well grown plants within the certain areas.
Guarding the relocation of people to live in the highly mountainous areas. Improving areas to become more and more abundantly wealthy.	Using the rules of laws to protect indigenous natural forests.

- Increase the efficiency in timber cutting with the appropriately correct woodcutting technique manual textbooks.
- Increase the efficiency in timber processing on the basis of the industrial development patterns.
- Encourage the tree sapling plantation for farmers and people.
- Encourage and support the integrated farming and animal husbandry in parallel with tree farming activities.
- Precisely determine each forest classification provided in accordance with the forest law (Forest Act).
- Prohibit any actions to adapt or destroy the abundantly wealthy forest areas for the tree-planting purposes.
- Organise the grant-land-forest permission to local people.
- Upgrade the forests' staff quality and quantity.

3.6 Technological Options and Priorities on Reduction of Greenhouse Gas Emissions in the Toxic Waste Field

The methane gas emissions into the atmospheric layer is caused partly by the chemical reaction processes of the waste matters dumped in the garbage dumping areas. The data collection on waste materials in the Lao PDR at present is not systematically conducted yet. Hence, the average value of the waste matter variables has mainly derived from the

survey results in 5 large cities; for example, Vientiane Capital, Luangprabang, Savannakhet, Champasak and Saravan.

At the present time, the waste material assessment and the burning of the waste material are not systematically carried out; therefore, the evaluation of the greenhouse effect toxic gas emissions with which the waste matters has not been mentioned due to the lack of waste matter composition data; particularly, in urban areas. The waste matter destruction is mostly operated within the garbage dumping fields only in large cities; whereas, in the rural areas, waste material is scattered and decayed around without treating them in the properly arranging manners. The Greenhouse effect toxic gas emissions in the rural areas are regarded as less than the total amount in big cities. In 1990, the total amount of waste matters accounted for 88 Gg; in this case, approximately 0.62% could be dumped and the methane emissions accounted for 11.2 Gg (*The First Issue of Mass Communicative Correspondence Release on Climate Change, STEA, October, 2000*).

Wastewater consists of high level of organic matters including wastewater running from households, shopping centres and certain amount from manufacturing industries. Wastewater running from these places can emit methane gas, to a large certain amount, into atmospheric layer. The indicator, which indicates the value of wastewater from households and shopping centres, is administered to find the BOD value and that from manufacturing industry is tested to find the COD value. At present, in the Lao PDR, there is no complete detail of data and information on wastewater drained throughout the country. The currently wastewater assessment is based mainly on the number of citizens living in the urban areas; particularly, in households and commercial shopping areas. The BOD value and the toxic gas emission assessment are applied with the absolute value, which the Intergovernmental Panel on Climate Change (IPCC) has determined. From the 1990 data, it is found that the BOD value in wastewater accounted for 0.0146 mg/l (*calculated from 5 towns with approximately 708,000 inhabitants*), from which this wastewater could be technically treated constituting only 10%. The methane gas distribution in 1990 accounted for up to 0.23 Gg. However, in the near future, it is necessary to be better aware of the waste material; especially, on the survey and planning tasks in getting rid of garbage or treating wastewater. It is also necessary not only better treating techniques, but also finding out appropriate places where the greenhouse effect toxic gas emissions will emerge as follows:

- Wastewater and polluted water from industry and handicraft,
- Use of the fairly out-of-date technology, which modernized advanced countries have not allowed using any longer, and constituted less than 70%.
- Caused by the use of fuel into the steam boiler such as, firewood, sawdust and wood shavings, diesel and bunker/fuel oil, and coal.
- Caused by the use of chemical substances into the process of production.
- Caused by the inappropriately eliminating practice of the waste material from factories themselves.

➢ *<u>The Needs for Technology and Priorities</u>:*

In order to resolve and reduce the greenhouse gas emissions in the waste matter field, the needs for technology and priorities are importantly required as follows:

- Utilization of modernized advanced technology with efficiency, which constitutes more than 80%.
- Industrialized and handicraft development must be closely related with environmental protection as follows:

- Construct the safe storehouses and isolate the waste matters within the factories correctly and appropriately.
- Construct the polluted water treatment system correctly and appropriately so as to guarantee the tested results to suit the standard determined.
- Construct the polluted toxic smoke and dust treatment system in manufacturing industries and handicraft where the steam boilers are used.

➢ *The Disadvantages and Shortcomings:*

With regard to the technological needs and priorities in the above-mentioned sector, a number of difficulties that can be indicated as follows:

- It is seen that waste material elimination is treated with careless manner and incorrectly applied to suit the technically approved principles; for example, the waste material elimination tends to be carried out by the factories themselves or on-the-spot burning.
- Polluted water treatment was carried out in a careless manner with quality less than the approved standard levels.
- With the out-of-date style of technology and with utilisation efficiency lower than 70%.
- With the fuel utilization in the steam furnace such as firewood, sawdust, wood shavings, diesel, coal, and so on.

➢ *The Problem soving Procedures:*

In order to overcome a number of above-mentioned difficulties, it is necessary to be aware of some important measures as follows:

- To draw attention to implement and diversify the rules and regulations which are related to the environmental tasks.
- To draw attention to implement and diversify the rules and regulations which are related to the environmental tasks.
- To utilize the advanced technology into eliminating, reusing, recycling and/or reclaiming waste materials.
- Industry and handicraft development must be affiliated with the environmental protection.
- To improve the existing polluted water treatment system to become appropriately operated.

V. Conclusion and Recommendations

As for the Lao PDR, the socio-economic development must be implemented with efficiency, continuation and stability so as to guarantee the balance between the economic growth and the social and cultural development as well as the eternally sustainable environmental protection. Consequently, the utilization of advanced technology is considered which needs to be developed and resolved to suit the real situation of each field of work.

In order to achieve the above-mentioned issues for supporting the additionally technical know-how, capacity and expertise of the technocrats; hence, the staff must be

supported and promoted. To take for example, it is essential to make use of all-existing technocrats' competency so as to systematically train them in the environmental field as well as carefully set plans of human resource development within this field of work. It is urgently necessary to guarantee providing the fund for the environmental protection. Thus, one of the most important things is to raise money for the contribution for the National Environmental Fund simultaneously in an attempt to not only search for the financial assistance from the friendly international agencies, but also to better promote the bilateral and multilateral cooperation.

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