BIOGAS PRODUCTION FROM ELEPHANT DUNG AT THE NATIONAL ELEPHANT INSTITUTE

SUBMITTED TO

BOARD OF JUDGES

ON

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BY

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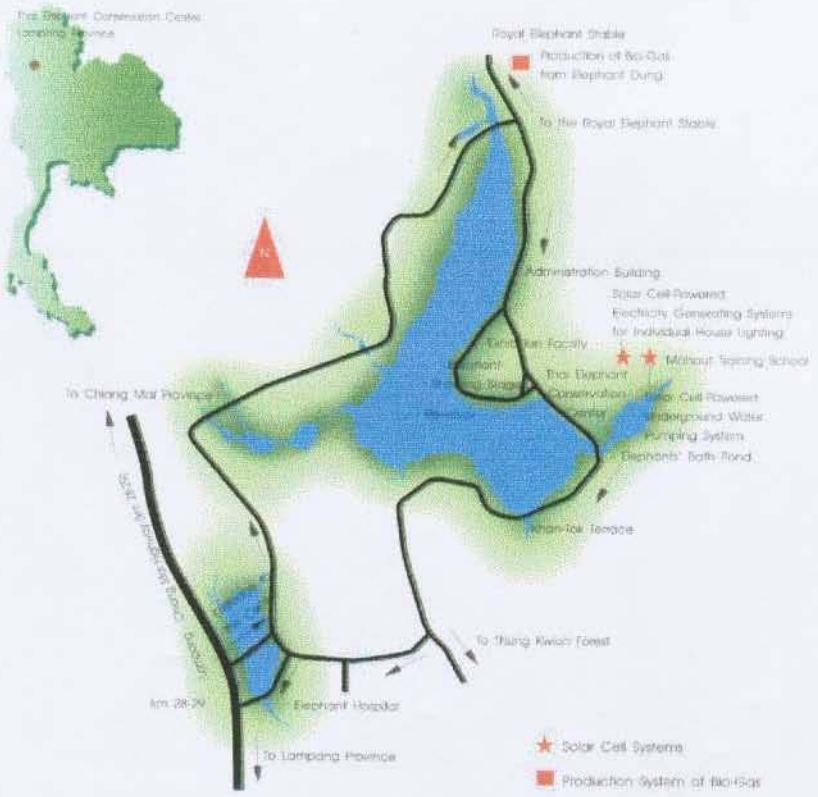
Introduction

The Thai Elephant Conservation Center under the Forest Industry Organization (FIO), named to the National Elephant Institute (NEI) since January 13, 2002, to enlarge the scope of work and relieve the problems faced by the elephant. This institute is located on 301 acres of national forest reserve, the 28th-29th kilometer beside the Lampang-Chiang Mai Highway, Wiang Tan Sub-district, Hang Chat District, Lampang Province. The main objectives in establishing the new National Elephant Institute are:

- To make the NEI the main entity responsible for cooperation in conserving Thai elephants.
- To establish standards for domestic elephant care, personnel and promote quality tourism and products.
- To cooperate in creating work for communities dealing with elephants and building medium-size non-governmental businesses to encourage self-improvement.
- To propose in come and other guidelines for communities that keeps elephants, so the they can earn enough money and have enough space to keep elephants and sustain their career in tourism and at other legal jobs, rather than begging or illegal logging.

Figure 1 : Site Map of the Nation Elephant Institute



1. Originality

In 1986 the first Royal elephant[1] was led out of the Royal elephant stable at Chitralada Villa, Bangkok and sent by the FIO to the Young Elephant Training Center at Baan Pang La, Baan Huat Sub-district, Lampang Province. Subsequently, in 1989, two more Royal white elephants were sent to the Young Elephant Training Center. At the end of 1993, the FIO moved these three Royal elephants to the NEI, where they remain today. On November 8, 1995 His Majesty the King commissioned the transfer of the two new white Royal elephants to the NEI. In 1996 one more Royal elephant was discovered, and sent to the NEI likewise.

The Royal stable, which accommodates six Royal elephants, produces 250-300 kg. of elephant dung daily or approximately 7.5- 9.0 tons per month. Such an amount of elephant dung has never been used in any productive manner before. Moreover, the traditional way that NEI used to get rid of elephant dung is piling the dung on the outside yard and left it naturally dried out and decomposed and this way made the air and water polluted, including protection and controlling the contagious diseases from carrier animals. Therefore, there is the urgent need for properly elephant dung management to reduce its bad odor and negative image for tourism at NEI.

On the great auspicious occasion of His Majesty the King 6th Cycle Birthday Anniversary, 5th December 1998, the Department of Alternative Energy Development and Efficiency (DEDE) proposed the project concerning the Renewable Energy Utilization in the Royal Initiative Project Areas, supported by the Energy Conservation Promotion Fund, to jubilate the King's Birthday. At that time, the NEI had strong determination to join this project and requested DEDE to design and installation the bio-gas production system from elephant dung at NEI in order to have the proper management on elephant dung and getting the benefits from energy saving and environment conservation. The produced bio-gas can be replaced the LPG for cooking and pumping water for greenery while the fermented elephant dung is used as fertilizer for soil improvement.

Figure 2 : A Royal Elephant in Royal Stable, NEI

[1] The Elephant with good appearance : have a big body, big head, wide forehead, clear eyes and strong legs. Elephant's back must be a bit higher in the middle of the back. The tusks must be straight and not twisted.

1.1 Design

Due to the large amount of elephant dung per day, 250-300 kg., the project, fixed dome design, was designed into two digester systems situated near utilization areas. The total biogas production of both systems is 26 m^3/day. The first system, 50 m^3, produces 8 m^3/day of biogas. The 3.27 m^3/day is used for cooking, (equivalent to LPG 60 kg./month), while the left is used for water pumping. Another system, 100 m^3, produces 18 m^3/day of biogas, is used only for water pumping.

1.2 Application

There are many benefits from the biogas fermentation from elephant dung beyond using biogas as fuel for cooking, water pumping and electricity generation.

Some of the separated effluent liquid left over from digestion can be reused to dilute at the mixing tank. The remainder, which contains various micro-organisms, can be pumped to water the plants, or used for produce the bio-extracted liquid fertilizer and also used for waste water treatment in stead of using the EM, Effective Micro-organism.

The overflow fermented dung is brought to mix and cement with the other materials and then pressed into block for gardening purposes. This not only did the lower expense on buying the plastic bags for cultivating seedlings and plantation, but also make more comfortable on carrying the young plants and reduce the problem of plastic disposal.

Recently the residue of elephant dung is employed to produce the fiber paper, and its process is the same as the mulberry-pulp paper production. The decorative paper from elephant dung can be used to package souvenirs such as artificial flowers, photo frames and small boxes.

The applications of the bio-gas from elephant dung illustrated in Figure 2 to 9

Figure 2: Water Pumping Operation

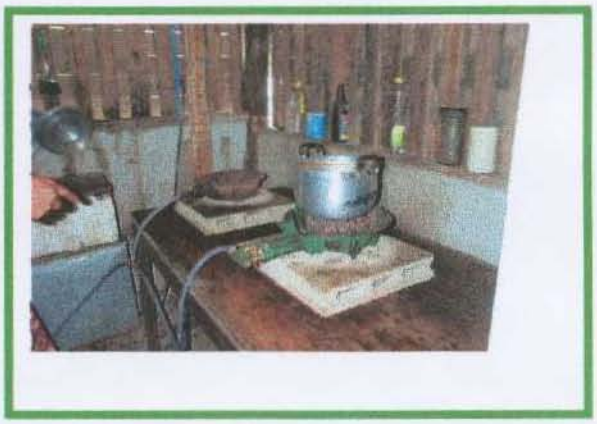


Figure 3: Cooking

Figure 4 : Lighting

Figure 5 : Block for Gardening Purposes

Figure 6 : Liquid Fertilizer

Figure 7 : Fermented Elephant Dung Fertilizer

Figure 8 : Elephant Dunk Fiber Paper

Figure 9 : Souvenir made from Elephant Dunk Fiber Paper

1.3 Approach

Apart from the biogas production for cooking and water pumping at the mahout houses and tourist home-stays as shown in Figure 10 and 11, this project maximize use the residues to produce the gardening block for multi- purposes, elephant dung fiber paper, liquid fertilizer. This project is account for a proper model in converting waste to energy and improving environment.

Successfully operated of bio-gas production from elephant dung, at NEI, Lampang Province, the similar projects can be applied to the large number of elephant stables located in every region of Thailand (more than 20 elephant stables). Recently, there are 7 sites (4 sites in Chonburi Province, 1 site in Kanchanaburi Province, 1 site in Prachaubkeereekhan, Province and 1 site at Mahout Training School, Lampang Province) extending the previous project as the prototype.

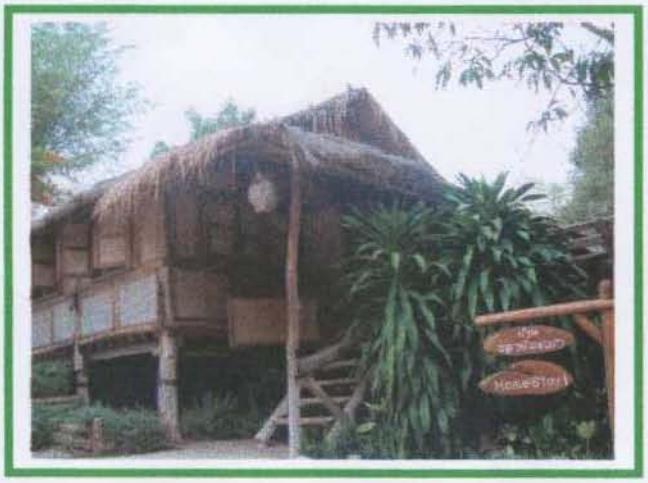


Figure 10 : Home Stay Ambiance

Figure 11 : View of Bedroom in Home Stay

2. Environment and Social Consideration

2.1 Amount of Emission

The bio-gas generally comprise 2 main components, i.e. methane gas (CH_4), between 50-75% and Carbondioxide gas (CO_2), in the range of 36-39%, therefore, the bio-gas property depends on the proportion of CH_4. By calculation, 1 m^3 of bio-gas containing CH_4 60% can produce the heat value 5,000-5,500 kilo-calories which equivalents to 0.46 kg of LPG or 0.6 liter of diesel oil.

Since the 2 digester systems (50 m^3 system and 100 m^3 system) produce 26 m^3 of bio-gas/day. This amount is partly used for cooking, 3.27 m^3 /day, which can replace the LPG 549 kg/year, and the left, 22.73 m^3 /day, is substitute for diesel 4,978 liter/year. The reduction on CO_2 emission is 14.20 ton/year. The LPG and Diesel substitution in these systems are detailed in Table 1.

Table 1 : Fuel Substitution by using Bio-gas at NEI

No.	System	Biogas Production (m^3/day)	Use for Cooking (m^3/day)	LPG Substitution (kg/year)	Use for Water Pumping (m^3/day)	Diesel Substitution (liter/year)
1.	Anaerobic Digester : 50 m^3	8.00	3.27	3.27 x 0.46 kg x 365 days = 549	4.73	4.73 x 0.6 kg x 365 days = 1,036
2.	Anaerobic Digester : 100 m^3	18.00	-	-	18.00	18 x 0.6 kg x 365 days=3,942
	Total	**26.00**	**3.27**	**549.00**	**22.73**	**4,978.00**

2.2 Community/People Participation

The main purpose of this project is to demonstrate and promote the renewable technology application. The NEI has employed its own staff to operate and maintenance the systems with DEDE's technical advice.

There are lots of people coming to see the elephant shows and NEI's activities of the NEI, therefore, this bio-gas project is a proper lesson-learned on how bio-gas can be produced in lower reasonable expense but higher benefit, even though this is one small unit.

The project also campaign for people to be conscious on economic and environment aspects. Using the renewable energy with least impact to the environment replaces the fossil energy, both of community and country will gain the benefit from having the clean air back to environment and reducing loss of foreign currencies from oil imports. Furthermore, this project have been promoted the people, private and public organizations to understand their roles in participating on environment protection and using local or domestic resources to produce energy efficiently

2.2.1 Benefit to User

- Saving energy cost from buying diesel used for water pumping and buying LPG for cooking.
- Bio-gas using for water pumping to make the NEI having a lots of green trees.
- The staff of NEI have learned how to operate and maintenance system by themselves for project sustainable
- Ease on controlling and protecting people from contagious diseases that fly, mouse and cockroach are the carriers.
- A good experience for mahouts trained from NEI to realize on energy beneficiary and environmental aspect. They can disseminate the biogas from elephant dung project to the other areas.

2.2.2 Benefit to Community

- Solving the problem of low quality of natural water resources that used to be ruined for people living down stream.
- Alleviation on the odor from bad smell and toxic gas to the neighboring communities
- The by-product, i.e. fiber paper from elephant dung, is promoted and sold as OTOP goods (One-Tambon-One-Product). This income can be partly supported the NEI expense and leveraged the quality of life for people living in community.
- Having environment sound and good scenery to attract the tourist to visit the NEI.
- The lesson learned for the other elephant stables to apply and benefit from having good management on the balance of reduction energy cost and environmental improvement.

2.2.3 Benefit to Country

- An example of using the renewable energy sources to replace the fossil energy that creates global warming from CO_2 emission.
- A Good model for growing people awareness on the environment problem and efficiently use of energy.
- The new approach for children and students to understand the bio-gas technology and develop their environmental consciousness.

3. Technical, Economic and Market Consideration

3.1 Installed Capacity

The project employed fixed dome design with two digester systems. The volume of each systems was designed and constructed to fit with the amount of elephant dung collected daily, 250-300 kg., including consideration on utilizing conditions. Their volumes are 50 m^3 and 100 m^3.

3.2 Technical Design

The reasons in designing the fixed dome type to the projects are :

- The structure is simple design and it can be easily constructed with local materials.
- Reasonable price and long term use, more than 15 years
- Most of system structure is set up at the underground level, hence, it does not reduce the usage the ground area.

The steps for preparation, design, testing and selection system before setting up the bio-gas production project are indicated as follows:

*1. **Survey on necessary data used for design and installation system***

- Survey on the necessary data used in calculation and design the fermentation digester, e.g., weight and the water contained of dung collected nearby, to determine the volume of fermentation chamber.
- Survey on the landscape, soil conditions and ground water for selecting the most appropriate location for system construction.

- Survey on energy consumption in the NEI to produce the magnitude of bio-gas from elephant dung fermentation properly and efficiently.

2. Laboratory Test

Since the elephant dung is fibrous, at that time, in 1998, the both of public and private agencies in Thailand had never produced bio-gas from elephant dung before. For this reason, it initiated the laboratory unit of Bureau of Energy Research, DEDE, to do laboratory testing on elephant dung anaerobic fermentation and calculate the appropriate ratio for efficient produce gas and peak organic emission which was 1 : 3 (dung : water); and later install pilot fixed dome digester, with capacity of 16 m^3, at Regional Energy Center, Chiangmai Province.

3. Selection on Bio-gas Production System Type

The elephant dung nature is quite rough due to having a lot of fibers, so it is unable to be decomposed in a short period, approximately 30-40 days. It needs the long HRT (Hydraulic Retention Time) that may be cause to construct the large digester volume and together with the problem of high volume of fermented dung overflow. As a result, the DEDE determine to select fixed dome digester for bio-gas production from elephant dung. The reasons can be detailed as follows:

- The high pressure inside the digester will lift the fermented dung with fiber left through over flow pit.
- Construction cost is cheaper than the other systems because it made from bricks with cement cover and save the expense on a lining board and steel structure
- Short period for construction
- Lot of skilled workers, trained by the Department of Agriculture Promotion, having understand on this technique and easily found in many provinces.

The fixed dome system construction are shown in Figure 12-15

Figure 12 : Fixed Dome (Under Construction)

Figure 13 : Fixed Dome System (after Land Reclamation)

Figure 14 : Mixed Pond

Figure 15 : Grinding Machine

4. Low Rate Digester System Design

The low rate digester uses the anaerobic fermentation process to decompose the organic matters in the blend of elephant dung and water. The Organic Loading to digester should range from 1.5 to 2.0 kg./m^3/day and the hydraulic retention time is approximately 30-40 days. The bio-gas produced is 0.2-0.5 m3/day, however the bio-gas volume will be depend on the COD Loading, HRT and performance in digester.

5. Detailed Components of System and Work Process of the Bio-gas System

The detailed components are illustrated in Figure 16: Section - 100 m^3 Hydraulic bio-gas system and work process of the bio-gas production is explained below:

1. **Water pumping (P)** has pumped the waste water from **Waste Storage Tank (5)** and feed to until the water level is sufficient, normally the system having volume 100 m^3 and 50 m^3 using water 2,000 litter and 1,000 litter consequently.
2. The elephant will be ground by grinding machine (electric motor, phase I, 220 Volt, 50 Hz., 5 Hp.) then pour into the Inlet. The system having volume 100 m^3 and 50 m^3 using elephant dung weighted 650 kg and 300 kg., respectively.
3. Blending the elephant dung and water with the proportion 1:3 then open the **Inlet** 's valve **(1)** in order to let the influent solution flow into **Fermentation Chamber (2)**
4. The decomposition process of anaerobic digestion produces the bio-gas containing the methane gas (CH_4) as a main component. The gas occurred will be stored on the top inside the **Fermentation Chamber (2)**

5. The influence solution inside the **Fermentation Chamber (2)** will be replaced with the bio-gas and flow into the **Hydraulic Chamber (3)** and overflow when the volume of bio-gas or the influent solution is over limit.
6. The influent solution overflowed from the **Hydraulic Chamber (3)** will run through the **Outlet (4)** to separate residue and water. The liquid part flow into **Waste Water Storage Tank (5)** and can be utilized by mixing with the elephant dung and put back to the **Fermentation Chamber (2)** or used as fertilizer.
7. During the bio-gas is fed out, the effluent solution in **Hydraulic Chamber (3)** will flow back to **Fermentation Chamber (2)** and then will pressure the bio-gas reversed through the gas pipeline for utilize it. This process is working all the time.

3.3 Technical Performance

The efficient tested result of organic matters decomposition of bio-gas production from elephant dung is shown in Table 2:

Table 2: Efficient Tested Result of Organic Matters Decomposition of Bio-gas Production

System Volume (m^3)	Efficiency (%)	Gas Production Rate (m^3/day)
Bio-gas production system, volume of 50 m^3	84	8
Bio-gas production system, volume of 100 m^3	90	18

3.4 Investment Cost

Total investment cost of project as shown in Table : 3

Table 3 : Investment Cost

Item	Expense (Baht)	Expense ($US)
1. Research Cost (Sunk Cost)	85,719	2,143
2. System Installation Cost		
- Volume 50 m^3	311,045	7,776
- Volume 100 m^3	500,000	12,500
Total Cost	**896,764**	**22,419**

3.5 Financial Scheme/Livelihood Project, Funder(Government and Non-Government)

This project design, construction was supported by the Energy Conservation and Promotion Fund. After the construction completed, the NEI has assigned local staff to operate and maintenance the systems by themselves for project's long life. The NEI also raises the money to support the project and create income for local community by launching the products and by-product from elephant dung using its own brand name, such as liquid fertilizer, fiber elephant paper.

3.6 Market Size

As previously mention in section 1.3 that there are more than 20 elephant stables in Thailand can used this project of bio-gas production from elephant by adjusting appropriately to their own areas. Presently, there are 7 sites located in Chonburi Province, Kanchanaburi Province, Prachaubkeereekhan Province, Mahout Training School, Lampang Province) already applied this project as the prototype. Furthermore, this project can be applied to the elephant stables in other countries.

3.7 Local and Manufacturing/Content of the System

The project design, civil works, materials for construction, equipment and system components (water pumping, waste storage tank, fermentation chamber, hydraulic chamber, inlet and outlet) were locally supplied, including the skill workers. The only import components are 2 centrifugal pumps and 2 gas flow meters at the price of 51,500 Baht ($US1,275) which their values around 5.7% of total project cost.

3.8 Energy Saving/ Emission Avoid

The advantages of bio-gas production from elephant dung project are local material use and domestic technology employment, therefore, it is no need to import technology. Furthermore, using bio-gas for water pumping can reduce on using diesel oil, which has to import in the amount of 5,694 Liter/year. Another point of view, using bio-gas for rice cooking can replace the LPG, the fossil fuel and depleting natural resource, 9,490 kWh/year. If we can calculate the energy savings in terms of CO_2 emissions/year the details are shown in Table 4 :

Table 4 : The Amount of CO_2 Reduction

Fuel Type	Carbon Content (t C/TJ)	Oxidized (%)	Emission Factor G/MJ	CO_2 Emission (kg/liter)	Quantity Substituted by Bio-gas (Liter)	Reduction on CO_2 Emission (kg)
Diesel	20.20	0.990	73.33	2.67	4,978	13,291.26
LPG	17.20	0.990	62.44	1.66	549	911.34
Total	-	-	-	-	-	**14,202.6**

4. Operating and Maintenance Scheme

4.1 . Operational hours (per day/per month/ per year)

The two bio-gas systems, 50 m^3 and 100 m^3, are operational approximately 1.08 hr/day (394.2 hr/year) and 2.81 hr./day (1,025.62 hr/year), subsequently.

4.2 Maintenance Scheme

1) Maintenance on the Fermentation Chamber

- Using the fresh elephant dung and grinding every time before putting in to the fermentation chamber.
- Have to check the ratio of elephant dung and water and stir until blending well together.
- Be careful on the other things such as small pebble, sand, engine oil and insolvent substances go into the fermentation chamber.
- Clean the inlet every time after adding the grinding elephant into the fermentation chamber
- Keep adding the clean water and closed the chamber cover to protect the water evaporation.
- Open the fermentation cover at least once a year to check it and take out the scum

- Keep on the hydraulic chamber not to be clogged up
- Close the outlet for avoiding the animals fall in to or the rain leaking to inside

2) Maintenance on Water Tap

- Open the water tap for 3-5 second, without closing the valve at the man hole, in order let the water occurred run out and then close the water tap for avoiding the the water to block the gas flow. Do this step every two weeks.
- Observe the gas pressure on the Manometer scale. If the water level is moving up and moving down, it is required to open the water tap to feed out the water left in the gas pipe.

3) Maintenance on **Gas** *Pipeline and Manometer*

- If the Manometer showing the gas pressure is lower than usual, there must be some leak areas, check the joint between gas pipeline and three direction valve by using the soup liquid rubbing on the suspected area and fixed them immediately. Do this step every two weeks.
- Adding the water in the Manometer rubber tube to make the gas pressure at zero level, when closing the valve at manhole fermentation Chamber.

4) Maintenance on Grinding Machine

- Switch on and warm the machine for 30 seconds
- Slowly pour the elephant dung to protect the blades and motor for long life use.
- Switch off and cleaning the machine after use and avoiding the switch and motor from moisture.
- Keep checking the machine belt tension.

5) Annual Maintenance

- Opened the fermentation chamber cover to spoon out the insolvent matter and the other things that can not be decomposed.
- Examine cracks and leakages on the fermentation chamber and fix them at once (if found).

4.3 Other Maintenance Measures (Training, after Sales Service)

After the completion of installation and system testing, the DEDE has provided the training for NEI system operators and also the other requested elephant stables. The training covered the specially train on the process of bio-gas production, operation and system maintenance, including how to fixed or change the equipment. This system is a prototype project opening for people/students to visit or study and they can perceive the knowledge both of theory from the disseminated document provided and from seeing the concrete operating system.

4.4 Local Service Content

The NEI is in charge of raising the budget to keep running, operating and maintenance the project by oneself, the DEDE is still providing the technical advice, however. This can be the keen example on self- reliance project that the other elephant stables can bring to practice.

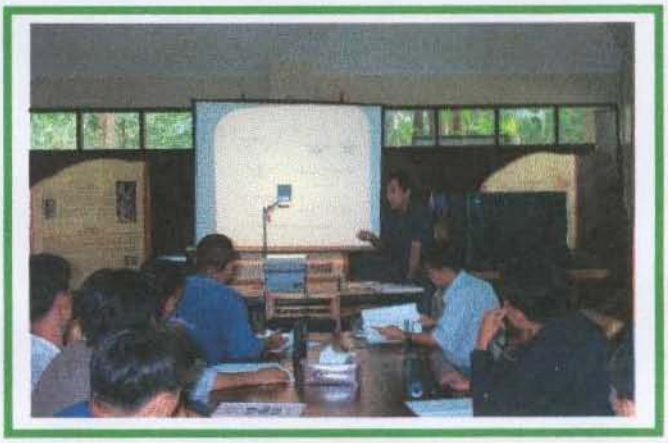


Figure 13 : Training for the Bio-gas System Operators in Technical Section

Figure 14 : Training for the Bio-gas System Operator on Operation Process

Figure 15: Training on Operating Water Pumping

5. Replicability

5.1 Replicability Project

The Bio-gas Production from Elephant Dung Project at the Royal stable, NEI, completed in year 2001. This project is practical for the other elephant stables in Thailand, including some developing countries, to apply and make some adjustments for their owns elephant stables. The replicate of this system is applied to install at many sites as previous mentioned. This can reflect the widely utilization of bio-gas and make people to have good attitude on the contribution of renewable energy.

5.2 Life of Project

After three year passing, the system has been work very well. There are many organizations, from private and public, the elephant stable owners for tourism has

interested and employed the principle and process of the prototype to set up their own systems. Normally, the Project life is 15 years longer, in the conditions of properly system operation and having good maintenance.

5.3 Cost Effectiveness (No cost, Low cost, High cost)

The NEI found that each digester system has the FIRR and EIRR as follows :

Table 5 : Cost Effectiveness of 2 Bio-gas Systems

System Volume	Bio-gas production system, volume of 50 m^3	Bio-gas production system, volume of 100 m^3
FIRR/ Pay Back Period	5.19% / 11 years*	7.64% / 9.45 years*
EIRR/Pay Back Period	12.05%/ 7.89 years*	12.27% / 7.95 years*

Remark : The FIRR and EIRR calculation did not cover the income generated from selling elephant dung paper, liquid fertilizer and value of gardening block in terms of money. If these values are considered, the pay back period must be less than 4 years.

5.3 Sustainability of Project

Owing to the very successful and vastly well-known of the project on Bio-gas Production from Elephant Dung, the NEI has made progression on running the new project concerning the Integrated Sanctuary Elephant Park which is continue and relate to this first project in the purpose of produce local energy sources with environmental balance.

In sum, the bio-gas process from elephant dung fermentation is suitable and efficient for elephant dung elimination. Most of materials, apparatus using for construction, including workers and operators, are domestic content. The technology is reliable and also not depends on imported technology. As results, this project is sustainable. However, the project's sustainability not only depends on technologies, but some factors must be concerned, i.e., system and personnel management. The chief of NEI, staffs, system operators have to realize and deep understand on renewable energy and energy saving for fully cooperation.

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