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GREEN STOVE DISSEMINATION VIA COMMUNITY EDUCATION TO FACE FIREWOOD SCARCITY and FINANCING POSSIBILITY THROUGH C-TRADING

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Abstract

This paper describes a way to help people who depend on firewood to switch to a renewable harvested biomass either in city or in rural area of Indonesia; via education training to provide the knowledge necessary. This paper describes a designed approach and actions to demonstrate the chances of change through wider community participation and to demonstrate a frugal innovation related to limited funding and firewood scarcity to develop the economic situation of firewood consumers. The proposed site selections, CO2 emission reduction, monitoring and collecting data needed for evaluation are also described.

Keywords: *Kerosene, Liquefied Petroleum Gas, Green stove, Renewable source of firewood, Frugal innovation.*

1. Introduction

The program "LPG to replace kerosene for cooking" in Indonesia started in 2007 which distributes a set of tube filled with 3 kg-LPG, gas burner and accessories to replace kerosene brazier. It was started with 4,030,683 set in the year 2007; 15,407,777 set in 2008; 24,156,307 set in 2009; 4,239,078 set in 2010; and 5,283,834 set in 2011 for 21 provinces: Aceh, North Sumatera, Riau, Riau Island, Jambi, South Sumatera, Lampung, Banten, DKI Jakarta, West Java, Central Java, DI Yogyakarta, East Java, Bali, West Kalimantan, South Kalimantan, East Kalimantan, North Sulawesi, Gorontalo, West Sulawesi, South Sulawesi [1]. It is rated success, but people always try to save their energy expenditure by the use of a traditional 3-stone fireplace.

This paper describes a proposed solution to provide thermal energy through introduction of Green Stove that uses small pieces of firewood to be combined with the gas/kerosene brazier for cooking. These small pieces of firewood are classified as a renewable source of energy.

The idea is to show a way to provide inexpensive stove to the people, make them experience and witness its efficiency in saving firewood, to reduce people's resistence to change and help them appreciate the efforts of change.

Result related to saving the household energy expenditure, improve health due to switching from 3-stone fireplace to more efficient stove and income generation from selling food cooked with the stove that save energy expenditure are close related to Millennium Development Goals.

The concept of this project is adopting the concept applied and lessons taught from the former projects Indonesian Sun Cooking that disseminated the solar oven in Indonesia **[2; 3; 4; 5]**.

The duration can be 5-year and 50,000 units of efficient stoves or GREEN STOVES might be disseminated in various districts. This cooking technology is transferred through training to provide the knowledge necessary

The project will aim:

- To contribute to sustainable development and to improve the livelihood of firewood consumers with the involvement of the locals.
- To save consumption of LPG or kerosene in order to save the household energy expenditures and also to save firewood that is used in stove as replacement for LPG/kerosene brazier.
- To reduce emission of greenhouse gases. Saving the use of firewood means reduce CO2 emission.
- To clean the surrounding areas from waste and dead wood, which otherwise would attract insects and cause methane gas emissions.
- To demonstrate an appropriate solution in facing firewood scarcity in the future.
- To save time and human energy for firewood collection, especially in barren areas where the green resources are becoming scar. The firewood demand and the growing speed of trees are not in balance.
- To demonstrate a possible income generation from the food sells, such as baking cake, frying vegetable, boiled water for making a local drink, meat balls soups, etc.
- To reduce toxic smoke /particulates resulting from the burning fuel that might degrade the people health.

Wood smoke is a complex mixture of substances produced during the burning of wood. The major emissions from wood stoves are carbon monoxide, organic gases, particulate matter, and nitrogen oxides. The particulate matter is small particles of solid, carbon char, soot carbon, dust, smoke and inorganic ash. The occurrence of respiratory illness in children has been shown to increase with increased exposure to wood smoke. The particles in wood smoke are too small to be filtered by the nose and upper respiratory system, so they wind up deep in the lungs. This gives a risk of lower respiratory infections. Wood smoke irritates the eyes, the nose, the throat and triggers allergies. Long-term exposure may lead to emphysema, arteriosclerosis, acute pneumonia, chronic bronchitis which are major causes of disease and death in young children **[6; 7; 8; 9].**

2. BACKGROUND IN SELECTING THE LOCATION

In East Nusa Tenggara (NTT), the population depends on the kerosene and firewood, with the poor using firewood only. Traditional 3-stone fireplaces, see Fig. 1 are used widely. Statistics Indonesia 2009 says 83.51% household in NTT use firewood, see Fig. 2. The program "LPG to replace kerosene for cooking" has not reached NTT yet. Firewood is a buffer to get the energy need. This leads to firewood scarcity in barren area such as NTT, more and more as the population increase. Often, they need to cut a tree, make the green vanish. Usually firewood must be transported from the green areas and is traded. People should buy it from the retailers, while logging of trees is forbidden.

***Figure 1:** The 3-stone fireplace*

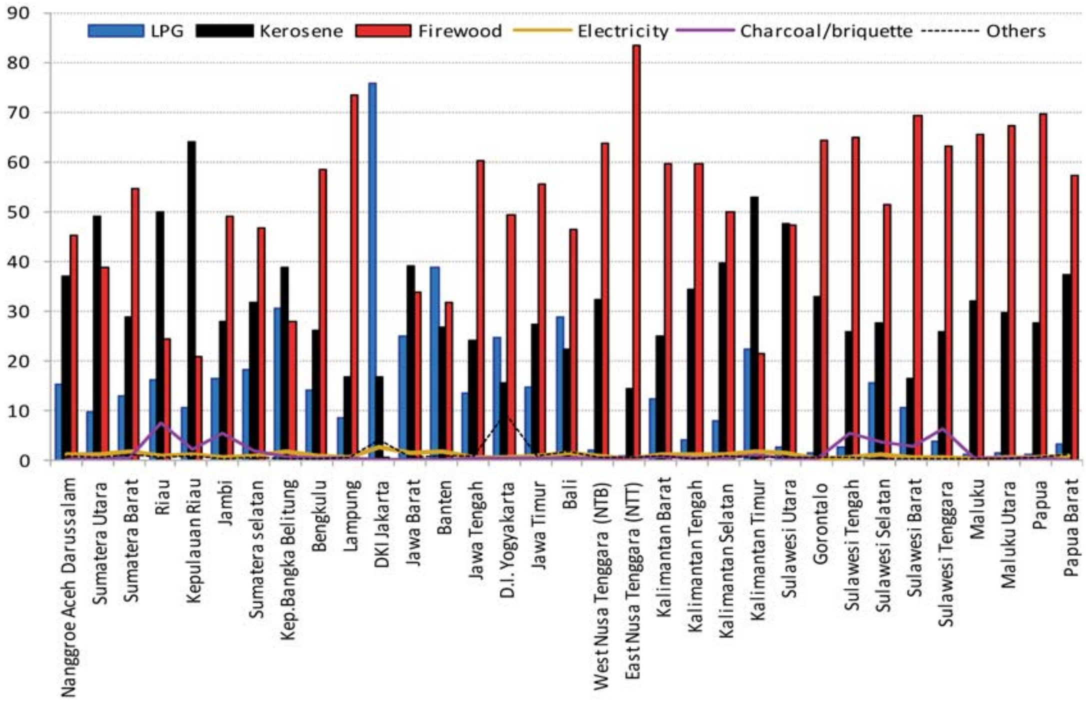


Figure 2: *Red bar is the percentage of households that use firewood by province. Black bar is the percentage of households that use kerosene. Source: Statistics Indonesia 2009 [10].*

Following is the comment stated by the person using kerosene and firewood for cooking: *"Getting kerosene is becoming more and more difficult. We could not buy direct as take and pay . We should queue to get 10 litres kerosene per week. Often we leave a small plastic drum (jirigen) at the retailer shop and take the filled drum per week. If we cannot get kerosene we use our firewood stock collected from our garden. In May until November we use firewood to boil water in the garden as we only need to put three stones as fireplace. We can save 65.000 IDR per month. The price of subsidized kerosene is 3000 IDR/litre. This means we save 48% of our energy expenditure. Lately we only get 5 litres kerosene for weekly need. The firewood becomes scare. We use whatever dry wood we found. The famous Kosambi wood is difficult to find today."* Ignas, via sms communication on 20 July 2012.

Population in East Nusa Tenggara (NTT) is 4,619,700 people. The number of poor people in urban and rural areas is 1,013,100 people. The poverty line in urban and rural areas is 218,796 IDR/capita/month and 142,478 IDR/capita/month respectively, see **Table 1** to compare with the other provinces.

The average need of kerosene in middle to upper level in the society is 1.5 litres/day, the maximum is 2 litres/day. The average need of kerosene in lower level is 0.5 litres/day, the maximum is 1 litre/day.

Different economical situation causes a different ability to buy the energy need and the raw cooking materials. The average of kerosene need is between: 1 - 1.5 litres kerosene per day.

Table 1: Population, number and percentage of poor people in Indonesia, poverty line in urban and rural areas and number of people living below these poverty lines, by province, in 2009.
Source: BPS, "Statistics Indonesia 2009", page 82, 182, 183, 184, Jakarta, Indonesia

Province	Population (T3.1.1)	number of poor people in urban and rural areas (T4.6.2)		URBAN (T4.6.3) poverty line in urban areas	URBAN (T4.6.3) number of people live below this poverty line	RURAL (T4.6.4) poverty line in rural areas	RURAL (T4.6.4) number of people live below this poverty line
	thousand	thousand	%	IDR/capita/month	thousand	IDR/capita/month	thousand
Nanggroe Aceh Darussalam	4363.5	892.8	20.5	292428	182.2	249546	710.7
Sumatera Utara	13248.4	1499.7	11.3	234712	688	189306	811.6
Sumatera Barat	4828	429.3	8.89	248525	115.8	201257	313.5
Riau	5306.5	527.5	9.94	265707	225.6	226945	301.9
Kepulauan Riau	1515.3	128.2	8.46	308210	62.6	256742	65.6
Jambi	2834.2	249.7	8.81	244516	117.3	178107	132.4
Sumatera selatan	7222.6	1167.9	16.2	247661	470	190109	697.8
Kepulauan Bangka Belitung	1138.1	76.6	6.73	272809	28.8	261378	47.8
Bengkulu	1666.9	324.1	19.4	242735	117.6	192351	206.5
Lampung	7491.9	1558.3	20.8	224168	349.3	175734	1209
DKI Jakarta	9223	323.2	3.5	316936	323.2		
Jawa Barat	41501.5	4983.6	12	203751	2531.4	175193	2452.2
Banten	9782.8	788.1	8.06	212310	348.7	178238	439.3
Jawa Tengah	32864.6	5725.7	17.4	196478	2420.9	169312	3304.7
D.I. Yogyakarta	3501.9	585.8	16.7	228236	311.5	182706	274.3
Jawa Timur	37286.2	6022.6	16.2	202624	2148.5	174628	3874.1
Bali	3551	181.7	5.12	211461	92.1	176003	89.7
West Nusa Tenggara (NTB)	4434	1050.9	23.7	213450	557.5	164526	493.4
East Nusa Tenggara (NTT)	4619.7	1013.1	21.9	218796	109.4	142478	903.7
Kalimantan Barat	4319.1	434.8	10.1	194881	93.9	166815	340.8
Kalimantan Tengah	2085.8	165.9	7.95	209317	35.8	199157	130.1
Kalimantan Selatan	3496.1	176	5.03	216538	68.7	181059	107.3
Kalimantan Timur	3164.8	239.2	7.56	283472	77.1	224506	162.2
Sulawesi Utara	2228.9	219.6	9.85	193251	79.3	178271	140.3
Gorontalo	984	224.6	22.8	173850	22.2	156873	202.4
Sulawesi Tengah	2480.3	489.8	19.7	217529	54.7	182241	435.2
Sulawesi Selatan	7908.5	963.6	12.2	177872	124.5	142241	839.1
Sulawesi Barat	1047.7	158.2	15.1	175901	43.5	156866	114.7
Sulawesi Tenggara	2118.3	434.3	20.5	175070	26.2	157554	408.2
Maluku	1339.5	380	28.4	230913	38.7	199596	341.2
Maluku Utara	975	98	10.1	226732	8.7	190838	89.3
Papua	2097.5	760.3	36.2	285158	28.2	234727	732.2
Papua Barat	743.9	256.8	34.5	304730	8.6	269354	248.3
INDONESIA	**231369.5**	**32529.9**		**av. 222.123**	**11910.5**	**av. 179835**	**20619.5**

The project will offer the green stove to be combined with the gas/kerosene brazier for cooking. The dry trees branches having diameter less than 2 cm can be used. This type of firewood can be easily found in the yard surround the local house. Small branches with diameter of 1-1.5 cm and length of 6-8 cm are best, see Fig. 3. It can also be made by chopping a dead wood of a bigger size. The use of the so-called a renewable harvested firewood gives a chance for the tree to grow and to keep the environment stay green. Making paper briquette is easy: Put the paper in the water, take a part and squeeze it with your hand, then dry it under the sun. The Net Heating Value of various wood, agriculture waste, charcoal, coal and kerosene is given in Tabel 2. Preliminary test shows the stove might reduce the use of firewood until 50 %. Hopefully, the stove is accepted without colliding with the culture.

***Fig. 3:** left: Small pieces of firewood, middle: Paper briquette (pb), right: 100 gram pb and 210 gram small wood are used in the green stove for boiling 5 litres of water.*

Table 2. Net Heating Value agriculture waste, firewood, charcoal, coal and kerosene
Source: Lembaga Penelitian Hasil Hutan, Bogor, 1978 [11]
Default IPCC: Energy content of wood is 15 Mega Joules/kg

		Water content of sample at dry air basis	*Net Heating Value *) at dry air basis*	*Net Heating Value at dry air basis*
	Biomass	**(%)**	**kcalories/kg sample**	**MJ/kg sample**
1	*Rice husk* (sekam)	20.7	3052.9	12.78
2	*Rice stem / trunk* (jerami)	18.9	2914.5	12.20
3	*Rice straw* (merang)	15.1	3205.4	13.42
4	*Corn cob* (janggel)	30.5	3523.9	14.75
5	*Corn stem/ trunk*	19.5	3674.6	15.38
6	*Leaf-skin of corn-kernel* (kelobot)	17.6	3620.6	15.16
7	*Casava stem/ trunk*	11.8	3894.5	16.31
8	*Peanut bushes*	15.7	3545.6	14.84
9	*Soy bean bushes*	24.1	3479.8	14.57
10	*Green bean bushes*	21.4	3472.5	14.54
11	*Bagasse* (ampas tebu)	23.2	3791.5	15.87
12	*Peanut shells*	14.3	4146.8	17.36
13	*Coconut shells*	14.6	4128.9	17.29
14	*Coconut fibers*	14.8	4004.8	16.77
15	*Kernel shell of palm-oil* (tempurung kelapa sawit)	13.3	4327	18.12
	Firewood of			
16	*Old rubber tree*	13.9	3957.1	16.57
17	Kaliandra *tree*	14.9	4035.4	16.90
18	Kemlandingan *tree*	24.1	3578.9	14.98
19	Angsana *tree*	16.9	3763.4	15.76
20	*Bamboo branches*	17.9	3851.7	16.13
21	*Saw dust of teak wood*	13.1	4543.6	19.02
22	*Saw dust of mixture-wood*	19.6	3992.6	16.72
23	*Charcoal*	7.2	7110	29.77
	Fossil fuel			
24	*Coal*	1.9 - 15.5	6038 -8264	25.28
25	*Kerosene*, solar		10500 -10700	43.96

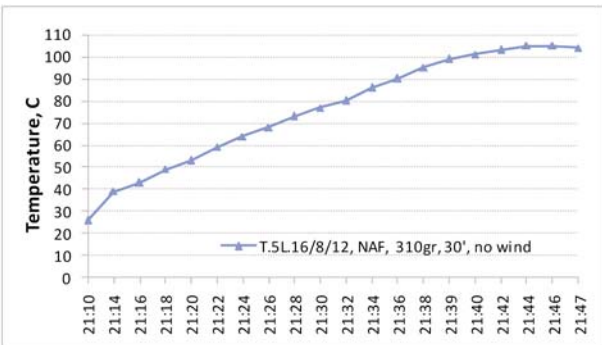
3. THE STOVE

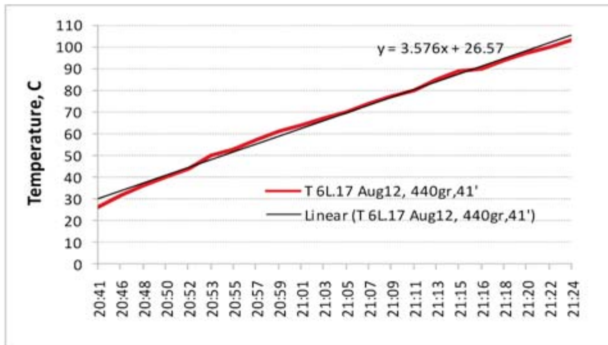
The popular and easier pronouns name is GREEN STOVE, see Fig. 4. The other name is the Stove THE+S1 that means Tungku Hemat Energi + Sehat 1. One means serial number of design. It was bought from Sanu Kaji Shrestha in Katmandu, Nepal. The tests proved that the design allows a good air circulation and leads to a complete combustion and less smoke. At start, 100 gr paper briquettes are ignited with a candle placed at the lower side. The paper briquette will burn within 1.5-2 minutes. Then 250 gram of small pieces of dry wood follows. The ash should be removed in order to keep the pathway for air circulation to move up-draft. Experiences show that the supply of the small pieces of wood can be managed comfortably. Boiling water is a standard load in testing of various cooking technology. This test makes the work to compare various stoves become easier. The boiling water tests are given in **Table 3.**

Table 3: The Boiling Test to rate the performance.

No.	Date	Volume of water	Time	boiling period	Fuel			Total fuel	charging speed	wind condition	stove number*, position of stove
					Paper briquette	Small rambutan wood					
				minutes	pb	gram		gram	gram/min		
1	June 5,2012	5 litres, boil		34	150 gr = 15 pb	250	various diameter < 1.5 cm	400	11.76	no wind	2, Excessive Air Flow (EAF)
2	June 5,2012	5 litres, boil	short 2	32	135 gr = 14 pb	190	diameter 0.7-1.2 cm	325	10.1	no wind	2, Normal Air Flow + (NAF+)
3	June 7,2012	5 litres, boil		45	360 gr = 36 pb	_	_	360	8	windy	2, NAF
4	June 7,2012	5 litres, boil		45	340 gr = 36 pb	_	_	340	7.55	no wind	2, NAF
5	June 13,2012	5 litres, boil		42	320 gr = 34 pb	_	_	320	7.51	no wind	2, NAF
6	June 13,2012	6 litres, 90C		60	340 gr = 36 pb	_	_	340	5.66	no wind	1, NAF
	On 10 July, experiment to ignite paper briquette in ANGLO fail, so much smoke produced. ANGLO is not appropriate to ignite briquette as the air flow not good										
7	10-Jul-12	5 litres, boil		40	300 gr + 6 pb	_	_	360	9	no wind	2, NAF
8	11-Jul-12	5 litres, boil	short 1	30	350 gr = 28 pb	_	_	350	11.6	no wind	2, NAF
9	13-Jul-12	5 litres, kemrengseng	22:48-23:24		Try to save fuel, but need longer time to boil	_	_			no wind	2, NAF
10	14-Jul-12	5 litre, boil	15:10-15:45	35	75 gr = 8 pb	325	various diameter < 1.5 cm	400	11.4	no wind	2, NAF
11	15-Jul-12	5 liter, stopped to much smoke	22:28-23:08		150 gr = 17 pb	175	Briket kayu Surabaya				
12	15-Aug-12	6 litres, boil		50	400 gr = 45 pb	_	_	400	8	windy	3, NAF
13	**16-Aug-12**	**5 litres, boil**	**shortest, least fuel: 310 gr**	**30**	**90 gr = 10 pb**	**220**	**diameter 0.7-1.2 cm**	**310**	**10.3**	**no wind**	**3, NAF**
14	17-Aug-12	6 litres, boil		41	150 gr = 17 pb	290	diameter 0.7-1.2 cm	440	10.7	no wind	3, NAF
15	18-Aug-12	5 litres, boil		36	120 gr = 13 pb	210	diameter 0.3-0.7 cm	330	11	no wind	3, NAF

Note *: 1. Old black stove made in 2008; 2. new black stove made in June 2012: 3. green stove made in August 2012
From data no. 8 and no. 2, then it is conclude that to boil 5 litres of water from 27C to 100C needs 30 minutes and 350 grams firewood
The experiment to recheck (no.13), PROVED that to boil 5 litres of water from 26C to 100C needs 30 minutes and 310 grams mix fuel





Bacteria often transmitted among human beings via food include: salmonella typhosa, vibrio comma, shigella dysentriae, staphylococa. These bacteria could not stand to heat, they are killed at 80oC.

During boiling process, when water temperature has reach 85-86oC, the hot water will produce a soft voice. In Java language this voices is named "kemrengseng". In recession 1963-1966, many people's turn off their kerosene braziers after they hear this voice to save fuel **[3; 12].**

After you hear "kemrengseng" voice, speed up the boiling process by adding more wood to make a bigger fire. Upon boiling, the water will boil continuously even only the glowing-firewood left.

After some tests, the Stove THE+S1 is rated appropriate to be used widely in Indonesia. It uses firewood efficiently, not expensive, durable, light weight makes it portable. The stove is suitable for preparing all usual dishes. Therefore, it is expected that the stove will be easily adopted by people.

Comparision with the former project, Indonesian Sun Cooking, shows that one progress has been achieved. A massive production has been communicated with industry in Jakarta to back up the dissemination speed to the targeted sites of Indonesia Archipelago. This enables production in large quantities: 200 stoves per day.

The material of the inner part in contact with the flames has been improved and made of stainless steel to get a longer life time, until 10 years in appropriate use. Then, the serial number of the Stove is THE+S3.

The stove THE+S1 can boil 5 litres of water from 27°C within 30 minutes and needs 350 grams of small pieces of dry wood mix with paper briquette. Energy content of wood is 15 MJ/kg **[13]**. The specific heat of water is 4.18 kilo Joules/kg/K. The nominal effective power (P_{stove}) to boil 5 litres of water is:

$$P_{stove} = 5\ kg * 4.18\ kJ/kg/K * (100 - 27)\ K / (30 * 60\ s) = 0.8476\ kilo\ Watt \quad (1)$$

$$\text{The stove efficiency} = \{5\ kg * 4.18\ kJ.kg * (100\text{-}27)\} / (0.35\ kg * 15000\ kJ/kg) = 0.29 \quad (2)$$

(a) (b) (c)

Fig. 4: (a) The stove THE+S1, (b) It is used to boil 5 litres of water, (c) fire from paper briquette and small wood.

4. FUNDING POSSIBILITY FOR DESIGNED APPROACH OF DISSEMINATION

The first field testing was done in cooperation with Mahupala, Atmajaya University, 12 students were involved in introducing the green stoves to the villagers in Sumbungan Village, Dieng District, Wonosobo Regency. The villagers seem familiar with the operating process of the stove.

As funding so scare, the students do collect funding by singing (ngamen) in Kemang shopping area.

Previously, these students selected their first field work in West Kalimantan's Dayak tribe, but the money collected from 'ngamen' was not enough to buy the air tickets.

The Body Shop donates another 50 stoves for the next field testing.

Data from 2006 says about 45% of Indonesia primary energy need for household sector is from the firewood [14]. Trina Fizzanty et al.[15a] explained the classification of Indonesians income, those are:

- 45 million people having income > 9.8 USD/ capita/day (having a better standard of living)
- 152 million people having income between 1.25-9.8 USD/ capita/day (above the poverty line)
- 45 million people having income < 1,25USD/ capita/day (below the poverty line).

The people living below the poverty line face difficulties in getting their primary needs such as:

housing, energy, water and health. Therefore, a wider field testing is thought as a need.

Observing India effort in people economic development, Rishikesha T. Krishnan [15b] explains: "In many years of deprivation in India, frugal innovations emerged within the limited resources and constraints. Innovators are from diverse background. Technological advancement is not the main driver of the impactful frugal innovations that have emerged in India so far. Pillars of frugal engineering are: robustness, portability, simplicity, possibility for mega scale production, low cost service and support the ecosystem". The green stove fulfils all pillars of frugal engineering.

4.1. Dissemination Approach

For the 5-year project duration, the proposed locations can be:

• The first year in Kupang regency, East Nusa Tenggara for disseminating 7,000 stoves, while 3000 stoves are kept for selling investigation at various places. The trainings will be held consecutively:

1. In Kupang Regency, the capital city: Kupang, to disseminate 2500 stoves
2. In South Central Timor Regency (TTS), the capital city: SOE, to disseminate 1500 stoves
3. In North Central Timor Regency (TTU). The capital city: KEFA to disseminate 1500 stoves
4. In Belu Regency, the capital city: Atambua, to disseminate 1500 stoves.

Training location can be held in regency hall or in the local university hall. Manual is provided. Five hundred of these stoves will be distributed to the persons that help in project arrangement, this also for the purpose to get input on usage in a better educated people.

A hundred participants will join this training, so each participant has a task to distribute 15 stoves. Five hundred stoves will be sold via cooperative shop in the regency level to investigate the market. The stove will be shipping directly from Jakarta to the training location, see Table 4.

• The second year, trainings in different regency, NTT for disseminating 10,000 stoves.

The training will be done by the trained locals, in the following regencies:

- Rote Ndao Regency
- Sabu island or Sabu Regency
- Raijua island or Sarai Regency
- Sumba island

• The third year might be in West Nusa Tenggara to disseminate 10,000 stoves.

• The fourth year might be in East Java and West Java to disseminate 20,000 stoves.

• The fifth year will check the monitoring result for final report.

The project leader of Renewable Biomass Stove Application Group, a Non-Profit Organization, designs the field approach and makes coordination with local governments, community chiefs, local NGOs and local university. The targeted regency will be contacted to request participation into Renewable Biomass Stove Training. Information on the project will be given. They can decide the site of training and the number of participants. The participants have to show their address and their willingness to train their fellow community members. They need to inform how many stoves they need for their future training, and this should be reported to the Project Leader of Renewable Biomass Stove Application Group for fabrication purpose.

Fifty percent of the stoves requested should be paid by the local government /local stakeholders, the rest will be provided by the project. The training will be in 3 days, the schedule is:

Day 1: Teaching about the stove THE+S1 and its possibility to reduce the use of firewood plus lesson on global warming and climate change. Confirm the list of requested stove submitted by participants.

Day 2: To demonstrate the use of stove THE+S1 for cooking various dishes.

Thirty (30) stoves will be demonstrated at once. The participants cook various local dishes.

Thirty thermometers are provided to give them a scientific sense, to monitor the speed of cooking, the food temperature and the cooking process. One thermometer with data logger will be bought to be used for easier temperature monitoring.

The participants witness the firewood used that can be collected from the trees surrounding or waste wood. To experience less smoke compare to those come out from the 3-stone fireplace.

Any local cooking utensils can be applied, to demonstrate its size that fit to the stove.

Day 3: Questioning participant's opinion on the green stove and their idea on their further actions in the near future. Participants of the training in charge in distributing the stoves for their surrounding neighbours as to follow the list they submit to the Project Leader before the training.

4.2. Hypothesis for Carbon Emmission Reduction for Funding Possibilities

The estimated amount of anthropogenic greenhouse gas emission reductions per stove is 0.9297 tonnes CO2 equivalent per year, see session 5.4. So, the implementation of 50,000 stoves will give CO2 emission reduction of 46500 tCO2 eq./year, see Table 5. At CER price of 5 USD/tonne and 75% abated, the total CER that can be harvested will be 522,680 USD. This is enough to finance the project along the project duration. This is the hypothesis derived that will be monitored. The breakdown of the funds needed for the first year is given in **Table 6**.

Table 4: Time schedule of the first implementation year.

				Month of the first year													the second year			
No.	Descriptions	Submit the final proposal, August 7, 2012	Date of confirmation to support the first year project	1	2	3	4	5	6	7	8	9	10	11	12	Date of confirmation to support the second year project	1	2	3	4
1	Submit the final proposal, August 7 , 2012																			
2	Manufacturing																			
3	Communication with the local governments & local participants																			
4	Shipping																			
5	Training in Kupang and Kefa																			
6	Shipping																			
7	Training in SOE and Atambua																			
8	Monitoring																			
9	Verification																			
10	Preparation for the second year project																			
11	Submit the final proposal for the second year																			
12	Manufacturing																			
13	Communication with local government and local participants																			
14	Shipping																			
15	Training in Kupang and Kefa																			
16	Shipping																			
17	Training in SOE and Atambua																			
18	Monitoring																			
19	Verification																			
20	Preparation for the second year project																			

Table 5: The estimated amount of CO2 emission reductions and the possible CER harvested

year	Stoves implemented	Abatement success				Various CER price/tonne: 10 USD/t; 5 USD/t and 2 USD/t								
		100%	75%	50%	25%	10 USD/t	5 USD/t	2 USD/t	10 USD/t	5 USD/t	2 USD/t	10 USD/t	5 USD/t	2 USD/t
		tonnes of CO2 eg.				USD	USD	USD	USD	USD	USD	USD	USD	USD
						100% abated			75% abated			50% abated		
2012	2012: 10000	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	2013: 10000	9297 for 10000 stoves	6973	4638	2319	92970	46380	18594	69730	34865	13946	46380	23190	9276
2014	2014: 10000	18594 for 20000 stoves	13945	9297	4649	185940	92970	37100	139450	69725	27890	92970	46485	18594
2015	2015: 10000	27891 for 30000 stoves	20918	13945	6473	278910	139450	46500	209180	104590	41836	139450	69725	27890
2016	2016: 10000	37100 for 40000 stoves	27825	18594	9287	371000	185940	74200	278250	139125	55650	185940	92970	37188
2017		46500 for 50000 stoves	34875	23250	11625	465000	232500	93000	348750	174375	69750	232500	116250	46500
	Total 50000					1393820	**697240**	269394	**1045360**	**522680**	209072	**697240**	348620	139448
	Minimum capital need 5*100000 USD/year or 500,000 USD for the five project period. If the abetement success reach 100%, at CER price of 5 USD/t , the project has shown pay back. If the abatement success reach 75%, at CER price of 5 USD/t , the project still able to give pay back. If the abetement success reach 50%, the CER price should be 10 USD/t to make the project able to give pay back.													

5. CALCULATION OF CO2 EMISSION REDUCTION

5.1. Cross check on the assumption on Kerosene consumption

Data about energy end-use for cooking and for water heating in low income households is quoted from the publication of World Energy Council **[16]**: "...*daily cooking energy consumption per capita varied from 11.5 to 49 MJ, based on field measurements. Despite a wide range of locations and conditions the range of consumption is quite small. In all the cases food was cooked predominantly on an open fire. However, the lower figures are those applying to efficient wood or charcoal stoves and modern energy sources*." Thus, the lowest value of daily energy consumption per capita is:

E_{capita} = 11.5 MJ/capita/day

As most households have 4 to 6 members **[17]**, the mean number is 5 capita/household

Thus, the primary energy consumption per household (Ehousehold) is:

$E_{household}$ = E_{capita} * 5 capita/household

= 11.5 MJ/capita/day * 5 capita/household = 57.5 MJ/household/day

= 20.988 Giga Joules/household/year.

FAO **[18]**, stated the energy consumed per capita for cooking in developing countries is about E1 = 8.0 GJ/capita/year. So, the energy consumed per household having 5 members is 40 GJ/household/year

Kerosene consumption in East Nusa Tenggara is 1-1.5 litre/day. The low value is used in the calculation. This gives value of Ekerosene of 13.067 GJ/household/year , see equation (7) in section 5.2. This is smaller than FAO data and smaller than Ehousehold calculated above. It is deduced because of kerosene scarcity in East Nusa Tenggara that force people to use less, but people use firewood to fill their energy need.

Table 5: The estimated amount of CO_2 emission reductions and the possible CER harvested

No.	DESCRIPTION FOR FUNDING NEED FOR THE FIRST YEAR PROJECT	unit price IDR	total price IDR	per section IDR
1	Making this proposal, link to industry and production trial		**15,000,000**	15,000,000
2	The need of the stove THE+S1			
	1 Kupang regency 2500 stoves			
	2 TTU regency 1500 stoves			
	3 TTS regency 1500 stoves			
	4 Belu regency 1500 stoves			
	Total 7000 stoves	100,000	**700,000,000**	700,000,000
3	Transport pengiriman			
	1 to Kupang			
	2 to Kefa			
	3 to Soe			
	4 to Atambua			
	Total		**25,000,000**	25,000,000
4	Preparation for training			
	1 communication/mail/ administration need	1,000,000	**12,000,000**	12,000,000
	2 Trip of project leader to meet the Head of Regency to prepare the training			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	5 days — accomodation/day	500,000	2,500,000	
	5 days — meal/day	400,000	2,000,000	
	5 days car rent	150,000	750,000	
	Total		**8,850,000**	8,850,000
	3 Tool for cooking demonstration			
	30 Thermometer stick	100,000	3,000,000	
	A set thermometer and data logger		5,000,000	
	30 Pan	60,000	1.800,000	
	30 wok	60,000	1.800,000	
	30 wok feet	40,000	1,200,000	
	One Camera for documentation	4,000,000	4,000,000	
	Total		**13,200,000**	13,200,000
5	Training in Kupang and Kefa/TTU			
	1a Trip of project leader to Kupang and TTU for the training			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	10 days — accomodation/day	500,000	5,000,000	
	10 days — meal/day	400,000	4,000,000	
	1b Trip of one staff to Kupang and TTU for the training			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	10 days — accomodation/day	500,000	5,000,000	
	10 days — meal/day	400,000	4,000,000	
	1c 10 days Car rent	150,000	1,500,000	
	Total		**26,700,000**	26,700,000
	Training in SOE/TTS and Atambua/Belu			
	2a Trip of project leader to TTS and Belu for the training			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	10 days — accomodation/day	500,000	5,000,000	
	10 days — meal/day	400,000	4,000,000	
	2b Trip of one staff to TTS and Belu for the training			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	10 days — accomodation/day	500,000	5,000,000	
	10 days — meal/day	400,000	4,000,000	
	2c 10 days Car rent	150,000	1,500,000	
	Total		**26,700,000**	26,700,000
	3 Meal for 100 participants join in the training in Kupang			
	3 days morning snake and coffee	5,000	1,500,000	
	3 days lunch	15,000	4,500,000	
	3days after noon snake and coffee	5,000	500,000	
	3 days transport for 100 participants: 15,000/day	45,000	4,500,000	
	Total per training		*11,000,000*	
	Total for 4 trainings in 4 locations		**44,000,000**	44,000,000
	4 Fee Trainer for cooking local food			
	1x 2 days x 4 training	500,000	4,000,000	
	Local volunteers to assisst for preparing firewood/distribution			
	1x 3 days x 4 training	300,000	3,600,000	
	Total for 4 trainings in 4 locations		**7,600,000**	7,600,000
6	MONITORING by Renewable Biomass Stove Application Group			
	1 Making monitoring report		15,000,000	15,000,000
	2 Project Leader for a year	2,000,000	24,000,000	24,000,000
	3 Trip of project leader for monitoring			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	10 days — accomodation/day	500,000	5,000,000	
	10 days — meal/day	400,000	4,000,000	
	10 days car rent	150,000	1,500,000	
	Total		**14,100,000**	14,100,000
	4 Staff in the office 2,000,000/month for 6months	2,000,000	12,000,000	12,000,000
	5 Field staff in Kupang 2,000,000/month for 6 month	2,000,000	12,000,000	
	6 Field staff in TTU 2,000,000/month for 6 month	2,000,000	12,000,000	
	7 Field staff in TTS 2,000,000/month for 6 month	2,000,000	12,000,000	
	8 Field staff in Belu 2,000,000/month for 6 month	2,000,000	12,000,000	
	Total		**48,000,000**	48,000,000
7	Verivication by ICED			
	1 Verification report		**15,000,000**	15,000,000
	2 Trip of staf ICED to Kupang and TTU for verification			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	6 days — accomodation/day	500,000	3,000,000	
	6 days — meal/day	400,000	2,400,000	
	6 days Car rent	150,000	900,000	
	3 Trip of staf ICED to TTS and Belu for verification			
	1 return — air ticket, tax and taxi	3,600,000	3,600,000	
	6 days — accomodation/day	500,000	3,000,000	
	6 days — meal/day	400,000	2,400,000	
	6 days Car rent	150,000	900,000	
	Total		**19,800,000**	19,800,000
8	Trip for international publication by Project leader		**30,000,000**	30,000,000
9	Cost for Sanu Kaji Shrestha to join the training in Kupang		**30,000,000**	30,000,000
	GRAND TOTAL FOR THE FIRST YEAR in IDR			**1,086,950,000**
	currency conversion 1 USD = 9500 IDR			9500
	GRAND TOTAL FOR THE FIRST YEAR in USD			**114,416**

5.2. Details of the baseline to find the operating time of the stove THE+S1 in replacing the kerosene brazier that need 1 litre kerosene per day

The calculation below follows a base line described in "CDM Cook Stove Kupang 1" **[19]**. Title of the approved baseline methodology applied to the small-scale CDM project: Renewable Energy Projects. Reference: AMS I.C, Thermal Energy for the User Version 08, Scope 1, valid since 03 March 2006

The project category is I.C. The limit of thermal capacity for the small-scale CDM project is 45 MWthermal. For the proposed CDM project having capacity below this limit, the simplified methodology can be applied **[20]**.

The mean kerosene consumption ($V_{kerosene}$) is between 1-1.5 litre. The daily cooking is about 4 - 6 hours.

The baseline-calculation uses the low range:

$$V_{kerosene} = 1 \text{ litre/day} \quad (3)$$

Chemical Engineers' Handbook, McGraw-Hill Book Co., 4th ed., Table 3-137 **[21]** shows the specific density of kerosene ($\rho_{kerosene}$) is in the range of 0.78-0.82. A test on Indonesian kerosene gives:

$$\rho_{kerosene} = 0.80 \text{ kg /litre} \quad (4)$$

Mass of kerosene ($m_{kerosene}$) is:

$$m_{kerosene} = V_{kerosene} * \rho_{kerosene} = 0.8 \text{ kg /day} = 292 \text{ kg /year} \quad (5)$$

Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, page 1.23, Table 1-3 **[22]** give information about the net calorific value of kerosene:

$$NCV_{kerosene} = 44.75 \text{ Terra Joules} / 10^3 \text{ tonnes} = 44.75 \text{ MJ/kg} \quad (6)$$

Primary energy of kerosene ($E_{kerosene}$) is:

$$E_{kerosene} = m_{kerosene} * NCV_{kerosene} \quad (7)$$

$$= 0.8 \text{ kg kerosene/day} * 44.75 \text{ MJ/kg} = 35.8 \text{ MJ/day} = 13067 \text{ MJ/ year}$$

The energy used effectively by kerosene brazier ($E_{used\ effectively\ by\ KB}$) is written as

$$E_{used\ effectively\ by\ KB} = E_{kerosene} * \eta_{kerosene\ brazier} \quad (8)$$

$$= m_{kerosene} * NCV_{kerosene} * \eta_{kerosene\ brazier}$$

$$E_{kerosene} = (E_{used\ effectively\ by\ KB} / \eta_{kerosene\ brazier}) \quad (9)$$

The energy used effectively by kerosene brazier ($E_{used\ effectively\ by\ KB}$) to boil the load is the product of the effective power of kerosene brazier ($P_{kerosene}$) multiplied by operating time $t_{kerosene}$.

$$E_{used\ effectively\ by\ KB} = P_{kerosene} * t_{kerosene} \quad (10)$$

The equations (8) is equal to equation (10), then:

$$m_{kerosene} * NCV_{kerosene} * ?_{kerosene\ brazier} = P_{kerosene} * t_{kerosene}$$

$$m_{kerosene} = P_{kerosene} * t_{kerosene} / (NCV_{kerosene} * \eta_{kerosene\ brazier}) \quad (11)$$

This equation shows the relation between the mass of kerosene with the other kerosene parameters.

To find the operating time of the stove THE+S1 in replacing the kerosene brazier that need 1 litre kerosene /day, we should think that *"the energy used effectively by kerosene brazier in equation (10) is equal to the energy used effectively by the stove THE+S1"*, so:

$$E_{used\ effectively\ by\ KB} = E_{used\ effectively\ by\ THE+S1} = P_{stove} * t_{stove} \quad (12)$$

Substitute equation (8) to equation (12), then:

$$m_{kerosene} * NCV_{kerosene} * \eta_{kerosene\ brazier} = P_{stove} * t_{stove} \quad (13)$$

$$t_{stove} = m_{kerosene} * NCV_{kerosene} * \eta_{kerosene\ brazier} / P_{stove} \quad (14)$$

From equation (1):

$$P_{stove\ THE+S1} = 0.8476 \text{ kW} = 3.05136 \text{ MJ/hour} \quad (15)$$

The effective energy of the stove THE+S1 can be less than the effective energy of kerosene brazier. Therefore, a bigger load and a bigger temperature different are applied for kerosene brazier to make a balance comparison of capability.

Experiment with kerosene brazier to boil 6 litres of water from 20 C to boil needs 100 grams kerosene.

$$\eta_{kerosene\ brazier} = 6 \text{ kg} * 4.18 \text{ kJ/kg} * (100\text{-}20)/(0.1 \text{ kg} * 44750 \text{ kJ/kg}) = 0.45 \quad (16)$$

This high $?_{kerosene}$ brazier gives a higher operating time for the stove THE+S1 to be balance with the capability of the kerosene brazier.

$$t_{stove} = m_{kerosene} * NCV_{kerosene} * \eta_{kerosene\ brazier} / P_{stove}$$

$$= 0.8 \text{ kg/day} * 44.75 \text{ MJ/kg} * 0.45 / 3.05136 \text{ MJ/hour}$$

$$= 5.2796 \text{ hour/day} \quad (17)$$

The stove THE+S1 should be used 5.3 hours per day = 1927 hour/ year

5.3. Carbon (C) emission from using the kerosene brazier

For this calculation, the annual data is used. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, page 1.23, Table 1.4. **[23]** explain about the Carbon Emission Factor of kerosene:

$CEF_{kerosene}$ = 19.6 *103 kg C/TJ = 0.0196 kg C/MJ (18)

The annual amount of emitted carbon (mC) of using kerosene brazier is written as:

$$mC = E_{kerosene} * CEF_{kerosene} \quad (19)$$

Substitute $E_{kerosene}$ from equation (7):

$$mC = 13067 \text{ MJ/ year} * 0.0196 \text{ kg C/MJ}$$

$$= 256.11 \text{ kg C/year} \quad (20)$$

If the stove is used, value in equation (20) means the amount of saved carbon emission per stove.

mC can be written in term of nominal effective power of stove and its operating time.

By substituting equation (9) to equation (19):

$$mC = (E_{used\ effectively\ by\ KB} / \eta_{kerosene\ brazier}) * CEF_{kerosene} \quad (21)$$

Substitute equation (12) to equation (21), then:

$$mC = (P_{stove} * t_{stove} / \eta_{kerosene\ brazier}) * CEF_{kerosene} \quad (22)$$

$$= (3.05136 \text{ MJ/hour} * t_{stove} / 0.45) * 0.0196 \text{ kg C/MJ}$$

$$= 0.1329 \text{ kg C/hour} * t_{stove} \quad (23)$$

Substitute the value of tstove in equation (17) gives:

$$mC = 0.1329 \text{ kg C/h} * 1927 \text{ hour/ year}$$

$$= 256.1 \text{ kg C/ year} \quad (24)$$

5.4. CO2 emission reduction from replacement the kerosene brazier with the stove THE+S1

Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, page 1.29, Table 1-6 **[24]** recommend an "*Approaches for Estimating CO_2 Emissions*" accounting for not oxidised carbon during combustion. The default value of Fraction of Carbon Oxidised is shown in Table 1-6, for oil and oil products is 0.99. (25).

The emission of carbon (C) is converted to the emission of CO_2 equivalent by multiplying by the molecular weight ratio (see Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual, page 1.30) **[25]**. It is written as:

$$M_{CO2}/M_C = 44/12 \text{ kg } CO_2\text{/kg C} \quad (26).$$

Thus, the saved annually CO_2 emission (mCO_2) is :

$$m_{CO2} = m_C * \text{Fraction of Carbon Oxidised} * M_{CO2}/M_C \quad (27)$$

$$= m_C * 0.99 * 44/12 \text{ kg } CO_2\text{/kg C}$$

$$= m_C * 3.63 \text{ kg } CO_2\text{/kg C} \quad (28)$$

Substitute the result of equation (20), then we have:

$$m_{CO2} = 256.11 \text{ kg C/year} * 3.63 \text{ kg } CO_2\text{/kg C}$$

$$= 929.679 \text{ kg } CO_2 \text{ eq./year} = 0.9297 \text{ tonne } CO_2 \text{ eq./year} \quad (29)$$

This annually CO_2 emission reduction (mCO_2) is generated by one stove THE+S1 that has an effective power of 0.8476 kW and uses renewable harvested firewood and operated for 5.3 hours daily.

5.5. The stove THE+S1 versus the traditional 3-stone fireplace

Survey in 1998 to investigate the firewood demand **[3]** shows:

- For the families that buy firewood, the average buying is 300 kilograms/month.
- For the families that collect firewood from surrounding, they do this job 9 times per month, each collection is about 15-20 kilograms. This means 135 - 180 kg firewood collected per month.

This different demand is caused by different buying ability to buy raw cooking food and the luxurious need in bathing with warm water. The average firewood demand is 217.5 kg/month or 7 kg/day.

The stove THE+S1 can boil 5 litres of water from 27°C within 30 minutes and needs 350 grams of small pieces of dry wood mix with paper briquette, see equation (1).

The stove THE+S1 should be used 5.3 hours/day to replace the fungtion of kerosene brazier that need 1 litre kerosene/day. If this operating time is used to boil the water only, the need of small pieced firewood will be [(5.2796 * 60) /30 minutes *350 gram =] 3689 gram. In other words, the stove will save (3689/7000=) 52.7% of the total collection of firewood per day.

This means reduce a half of the environmental burden and reduce the wood smoke.

5.6. Emission reduction impact from the use of the stove THE+S1

The emission reduction per stoves is 0.93 tCO_2 eq./year.

The maximum use of the stove THE+S1 that give 100% of CO_2 reduction, monitoring takes place to reconfirm full usage that means:

- The household boils water for drinking with the stove THE+S1
- The household boils water for bathing with the stove THE+S1
- The household cooks rice with the stove THE+S1
- The household prepares fish/meat/vegetable/various porridge with the stove THE+S1

1. If the stove THE+S1 is used dominantly and the use of the traditional 3-stone fireplace less than 25 %. The firewood savings are accounted as 75% of CO_2 emission reduction (case 1).
2. If the traditional 3-stone fireplace is still in use between 25% to 50%, the firewood savings are accounted as 50 % of CO_2 emission reduction (case 2).
3. If the traditional 3-stone fireplace is still in use between 50% to 75 %, the firewood savings are accounted as 25 % of CO_2 emission reduction (case 3).
4. If the traditional 3-stone fireplace is still in use more that 75 % , the firewood savings are accounted as 0 % of CO_2 emission reduction (case 4).

To count case 1 until case 4 are assessed by the random visits and questioning of households during monitoring stage. It can be counted from the saving of the household energy expenditure allocated to buy firewood, kerosene and LPG, and to monitor their firewood stock. The longer way for rating is by observing the trees surround the site of implementation. This seems difficult to sense.

However we should find a way to encourage people to change and appreciate the motivation of change.

5.7. Monitoring, Reporting, Verification and Publication of The Result

The Monitoring by skilled personnel enables opportunities to correct mistakes and deficiencies. Random visits and regular meetings with the users of the stoves are intended to ensure the best use of the stoves and to give the utmost assistance to the users in changing their cooking habits and to find out any success story for possible income generation. Monitoring activities will be combined with an enduring educational program to show new recipes to rise income generating. Monitoring will collect the information about declining the health problem caused by the wood smoke. Gathering all positive thoughts, that might help to widen the project. Also, to identifying reasons for potential failure in switching from using a traditional 3-stone fireplace to the stove THE+S1.

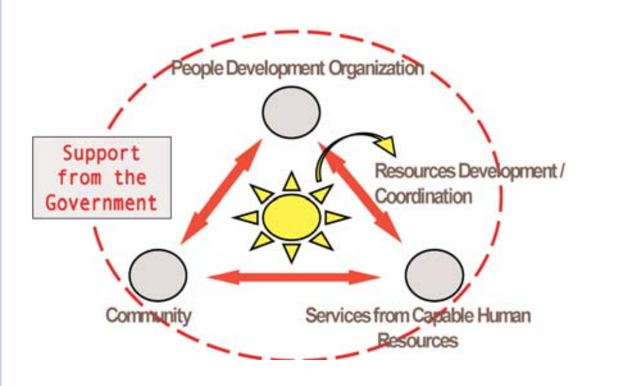
An annual report will cover the list of training, meeting and workshops; number of stove and receivers and their address, summaries of results of random checks according to case 1, case 2, case 3 and case 4 and number of damage stove THE+S1; estimated average usage hours taverage.

Verification of the data takes place through a regular visit to the users and regular meetings with the communities to obtain additional feedback about the actual usage and to find out reasons lead to un-use stoves. A national/ international publication will be exerted.

CONCLUSION

The green stove fulfils all pillars of frugal engineering: robustness, portability, simplicity, match to the local culture, gives a possibility of mega scale production, low cost service and support the ecosystem. Inovasi Kerakyatan is an appropriate terminology for all of actions described previously.

A simple scheme [26] of coordination among the government and other roles to improve people welfare is shown on your right.



The proposed actions described above cover field test in a wider dissemination. The use of Green Stoves certainly will reduce the CO2 emission. This gives a possibility to contribute to a policy to reduce Indonesian emission by 26% in the year 2020.

PerPres 05/2006 says that New and Renewable Energy target in the year 2025 is 17% of the total energy. However, this target is not covering the household energy need for cooking. If the use of Green Stoves that uses renewable source of firewood can be counted under biomass, this proposed actions will give a contribution to reach the 17% target on RE implementation and to raise people ability to solve their energy problem. Hopefully, a wider implementation of green stoves will give a wider impact to improve the living of firewood consumers and for those who live below the poverty line.

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