

FUELWOOD SAVING WITH IMPROVED COOK-STOVES IN CAMBODIA MONITORING REPORT 1ST JANUARY - 31ST DECEMBER 2012



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Project Title	Fuel-Wood Saving with Improved Cookstoves in Cambodia"
Version	5
Report ID	KBS_13Apr18_NLS_Monitoring Report.v5
Date of Issue	18 April 2013
Project ID	181
Monitoring Period	1 st January 2012 – 31st December 2012
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1 PROJECT DETAILS

1.1 Summary Description of Project

Currently, the majority of the Cambodian population relies on fuelwood for cooking. This situation is forecast to continue for the foreseeable future (World Bank, 2007). The project has evolved from the Cambodian Fuelwood Saving Project (CFSP), which was created to protect forest resources in Cambodia by reducing fuelwood consumption. It was a service project that converted traditional stove makers to improved stove manufacturers.

The improved stoves, called the New Lao Stove (NLS), are more expensive but individuals choose them because they last longer and reduce the amount of money spent on charcoal. As a competitive advantage exists, a commercialised approach is used to disseminate the improved stoves, or NLS, through existing market channels. The user pays the full cost of the stove and the project does not introduce any market distortion such as subsidies or free distribution.

Whilst at the producer/consumer level the stoves are commercially viable, the project implements initiatives at sectoral level to transform the existing private sector towards a cleaner technology. These externalities, which include R&D, training, technical follow-up, quality control, market development, structuring the supply chain with fair trade values, energy policy work and advertising, cannot be passed on to the consumer and are funded through carbon finance.

The project has proceeded in three distinct phases:

1. Phase I was primarily a set-up phase which elaborated stove design, trained producers and developed distribution networks.
2. Phase II focused on developing the commercialised distribution of the stove design.
3. The third (current) phase involves scaling-up of the project to achieve large-scale dissemination, and is distinguished from the first two phases by its funding source; carbon finance. The project had been co-financed by the EU and, following the end of start-up funding, additional capital was sought in the form of carbon financing to not only complete the financing of the first two phases but also increase market penetration.

The reduction in emissions of greenhouse gases (GHG), stemming from the replacement of inefficient stoves, combined with exceptionally high development dividends make the project an ideal candidate for carbon finance. The utilisation of this long term funding stream will ensure that further strides are taken towards transforming the household energy sector in Cambodia.

1.2 Sectoral Scope and Project Type

UNFCCC category: Type II [Energy Efficiency Improvement Projects]

VCS Sectoral Scope 3: Energy demand

1.3 Project Proponent

Groupe Energies Renouvelables, Environnement et Solidarités (GERES) – Cambodia
#350, Street 350, Boeung Keng Kang 3, Chamkarmorn,
Phnom Penh, Cambodia, P.O Box: 2528
Tel: +855-23-986-891
Fax: +855-23-221-314

1.4 Other Entities Involved in the Project

Improved Cooking Stove Producers Distributors Association of Cambodia (ICOPRODAC)

1.5 Project Start Date

1st January 2003

1.6 Project Crediting Period

10 years

10th May 2003 – 9th May 2013

1.7 Project Location

Producers included in the 2012 crediting period are located in five provinces: Kampong Chhnang, Battambang, Prey Veng, Phnom Penh and Takeo (see Figure 1 below).

Figure 1: Map of New Lao Stove Production in Cambodia, 2011



1.8 Title and Reference of Methodology

Title: “Fuel-Wood Saving with Improved Cookstoves in Cambodia”

Methodology: **Voluntary Emission Reductions – Improved Efficiency in Use of Non-Renewable Biomass** as issued by the Climate Care Trust, based on modifications of proposed methodology SSC.II.G. by the Joanneum Institute.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

This is the sixth verification of the project activity (see Table 1 below). This monitoring report covers the period 1st January 2011 – 31st December 2012.

Table 1: Summary of validation & verifications for NLS project

	Period Covered	Date Completed
Validation	2003 - 2012	07/06/07
1st Verification	May 10 th 2003 - Jan 9 th 2007	07/06/07
2nd Verification	Jan 10 th 2007 – Jan 9 th 2008	18/09/08
3th Verification	Jan 10 th 2008 – Dec 31 st 2008	20/08/09
4th Verification	Jan 1 st 2009 – Dec 31 st 2009	28/07/2010
5th Verification	Jan 1 st 2010 – Dec 31 st 2010	14/06/2011
6th Verification	Jan 1 st 2011 – Dec 31 st 2011	03/04/2012
7th Verification	Jan 1 st 2012 – Dec 31 st 2012	

The monitoring parameters that have been updated since the last verification are summarised in Table 2 below. Stove lifetime and equipment ratio were updated based on the findings of the biennial National User Survey¹, conducted in August 2011. Monthly NLS sales and units in use are summarised in Table 3.

The number of NLS in use is more than the number of NLS sold because the NLS is used for around 18 months. This means that, in 2012, the number of NLS in use at any one time included all those NLS sold within the past 18 months (including some stoves from 2011 and 2010) – not just the NLS sold during the year 2012.

Table 2: Updated parameters (compared to previous verification)

Number of NLS sold	411008
Total number of NLS in use	560431
Number of producers	32

¹ See Appendix 2 for more information on the National User Survey.

Table 3: Summary of stoves sold and in use, 1st January - 31st December 2011

Month #	Date		Number of NLS sold	Cumulative number of NLS in use
105	01-Jan-12	31-Jan-12	32764	491174
106	01-Feb-12	29-Feb-12	35255	502919
107	01-Mar-12	31-Mar-12	42096	502531
108	01-Apr-12	30-Apr-12	27171	512415
109	01-May-12	31-May-12	34130	532972
110	01-Jun-12	30-Jun-12	38865	529949
111	01-Jul-12	31-Jul-12	27164	537350
112	01-Aug-12	31-Aug-12	40727	542230
113	01-Sep-12	30-Sep-12	36597	540197
114	01-Oct-12	31-Oct-12	31613	548657
115	01-Nov-12	30-Nov-12	35310	555671
116	01-Dec-12	31-Dec-12	29316	560431
Total			411008	

2.2 Project Description Deviations

There were no deviations from the Monitoring Plan during the crediting period.

2.3 Grouped Project

Not applicable

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Not applicable.

3.2 Data and Parameters Monitored

Data Unit / Parameter:	Representative sample of mass of biomass used before and after installation of devices and efficiency measures.
Data unit:	kg/ month / Family

Description:	Bi-annual survey results will demonstrate the average consumption per family. These results will be combined with efficiency savings of NLS and monthly sales data to monitor mass of biomass used before and after installation of efficiency devices.
Source of data:	Household Fuel Consumption Test National Stove Users Survey Stove Producer Sales data
Description of measurement methods and procedures to be applied:	The monitoring will combine <i>ex-ante</i> calculations with the monitored stove sales and periodic verification of fuel savings. The GERES Cambodia Monitoring Unit will test producers to ensure compliance and efficiency standards are maintained.
Frequency of monitoring/recording:	Household Fuel Consumption Test data – twice per year National Stove Users Survey – once every two years (biennial) Stove Producer Sales data – monthly
Value monitored:	The data will be used to estimate the emissions reductions from utilisation of the NLS. The data will be used to gauge the effectiveness of the commercialised distribution, as well as the socio-economic benefits of the project activity.
Monitoring equipment:	N/A
QA/QC procedures to be applied:	GERES Cambodia Monitoring Unit will take samples from producers yearly to ensure production standards meet standardised dimensions.
Calculation method:	N/A
Any comment:	N/A

Data Unit / Parameter:	Representative samples of the moisture content of the biomass at the time it is burnt
Data unit:	%
Description:	Fuel savings are calculated using data from studies conducted in both rainy and dry season. Test are conducted under laboratory conditions but designed to replicate actual use.

Source of data:	Household Fuel Consumption Test
Description of measurement methods and procedures to be applied:	Humidity meter
Frequency of monitoring/recording:	Twice per year, as part of the Household Fuel Consumption Tests
Value monitored:	Ensure accurate reporting of fuel savings
Monitoring equipment:	Humidity meter
QA/QC procedures to be applied:	Standardised methodology and replicability of tests. Test are repeated frequently allowing results to be verified by the observable range of data.
Calculation method:	Humidity meter
Any comment:	Moisture content data is not required for calculations because the humidity of the fuel is automatically taken account of through the HFCT and uniformity of the fuel used for both NLS and TLS HFCTs. Only humidity of wood is checked and only for the purpose of ensuring the moisture content for NLS and TLS HFCTs is comparable. Moisture content for charcoal is usually more uniform – differences in wood species provides scopes for greater discrepancy in moisture content.

Data Unit / Parameter:	Annual check of representative samples to ensure that they are still operating or replaced by an equivalent in service appliance or measure
Data unit:	Stove lifetime years No of stoves sales per month
Description:	The project activity currently uses a conservative estimate of 1.5 lifespan per stove, based on survey data from households. After that period the stove is assumed to be replaced, these stoves are deducted from the monthly stove sales. These calculations are underpinned by the stove sales data which will demonstrate the increased market share of NLS. In addition survey data demonstrate user's preferences.

Source of data:	National Stove User Survey Stove Producer Sales data
Description of measurement methods and procedures to be applied:	Measurement method combines <i>ex-ante</i> and <i>ex-post</i> data. Conservative lifetime assumption of three years is determined by survey data. This figure is combined with sales figures collected by the monitoring unit every month from each stove producer.
Frequency of monitoring/recording:	National Stove User Survey – every two years (biennially) Stove Producer Sales data – monthly
Value monitored:	Ensure accuracy of emissions reductions
Monitoring equipment:	N/A
QA/QC procedures to be applied:	Internal validation of stove producer's sales data.
Calculation method:	N/A
Any comment:	N/A

Data Unit / Parameter:	Monitoring shall include the efficiency of the appliances
Data unit:	%
Description:	Monitoring Unit will test samples from stove producers to measure the efficiency of stoves constructed by producers.
Source of data:	Household Fuel Consumption Test (HFCT)
Description of measurement methods and procedures to be applied:	Field tests using the HFCT protocol, using both TLS and NLS. The HFCTs are conducted with both wood and charcoal during both rainy and dry seasons to provide real field data on fuel saving.
Frequency of monitoring/recording:	Twice per year
Value monitored:	Quality control of stove production
Monitoring equipment:	An accurate balance (simple 10 kg capacity and 10 g accuracy which is available in villages; Wood moisture meter if wood cannot be distributed.

	25 NLS and 25 TLS 5kg of charcoal and 5kg of fuelwood 10-litre containers (for water)
QA/QC procedures to be applied:	Training for technicians is provided and established methodology is used. Test are repeated frequently allowing results to be verified by the observable range of data
Calculation method:	$\text{FFS} = \frac{\text{FCTS} - \text{FCICS}}{\text{FCTS}}$ FFS Field Fuel Saving FCTS fuel consumption for cooking in traditional stove FCICS fuel consumption for cooking with improved cook stove. The FFS can be calculated for each family and then an average is calculated representing all the families.
Any comment:	N/A

Data Unit / Parameter:	Ensure replaced low efficiency appliances are not used within the boundary
Data unit:	N/A
Description:	Bi-annual survey data on user behaviour in addition the Stove sales data demonstrates the increasing market share of the NLS over time.
Source of data:	Stove sales data National Stove User Surveys
Description of measurement methods and procedures to be applied:	User surveys will establish the percentage of stove users using traditional and NLS simultaneously.
Frequency of monitoring/recording:	Stove sales data – monthly National Stove User Surveys – every two years (biennially)
Value monitored:	Ensure the accuracy of emissions reductions calculations
Monitoring equipment:	N/A
QA/QC procedures to be applied:	Statistical analysis

	External evaluation
Calculation method:	N/A
Any comment:	N/A

Data Unit / Parameter:	Quantity of alternative fuels used by project participants and assessment of aggregate biomass renewability in the region.
Data unit:	Deforestation rate Fuel mix
Description:	Establish that the trend of biomass use is unsustainable in the long term through independent literature and GIS data. Bi-annual survey data will monitor fuel mix being used.
Source of data:	Independent accredited literature National Stove User surveys
Description of measurement methods and procedures to be applied:	Literature review Survey of representative sample of stove users in Cambodia (National Stove User Survey)
Frequency of monitoring/recording:	Independent accredited literature – annually National Stove User surveys – every two years (biennially)
Value monitored:	Validity of emission reductions from non-renewable biomass
Monitoring equipment:	N/A
QA/QC procedures to be applied:	Peer reviewed published reports.
Calculation method:	N/A
Any comment:	N/A

Data Unit / Parameter:	Greater use of non-renewable biomass outside the project boundary does not exist
Data unit:	%
Description:	Default factor 15% as stipulated in the

	methodology
Source of data:	Methodology
Description of measurement methods and procedures to be applied:	N/A
Frequency of monitoring/recording:	N/A
Value monitored:	Conservative factor applied to take account of leakage
Monitoring equipment:	N/A
QA/QC procedures to be applied:	N/A
Calculation method:	N/A
Any comment:	N/A

Data Unit / Parameter:	Wider social and economic impact of the projects will be monitored; on-going analysis will be made of its contribution positive or otherwise to sustainable development in the area.
Data unit:	N/A
Description:	Survey data designed to assesses socio-economic impacts of the stove project. Furthermore the increasing market share is testament to the competitive advantages of the NLS and consequently the socio-economic benefits that are derived from them.
Source of data:	National Stove User Survey
Description of measurement methods and procedures to be applied:	Survey of representative sample of stove users in Cambodia (National Stove User Survey)
Frequency of monitoring/recording:	Every two years (biennially)
Value monitored:	Sustainable development benefits of Project Activity.
Monitoring equipment:	N/A
QA/QC procedures to be applied:	Statistical analysis External evaluation
Calculation method:	N/A

Any comment:	N/A
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3.3 Description of the Monitoring Plan

3.3.1 Ex-ante parameters

3.3.1.1 Fuel saving tests

Fuel saving is considered an ex-ante parameter because during validation (in 2007), the DOE (Det Norske Veritas) advised GERES to continue using the fuel saving figures in the PDD (in order to maintain consistency) and simply use subsequent fuel saving tests to verify that the PDD values are still valid.

Household Fuel Consumption Tests (HFCTs) are used to determine the fuel savings achieved through use of the NLS. The results for the tests conducted during 2012 are presented in Table 4 below.

Table 4: Fuel savings achieved during HFCTs in 2012²

Fuel type	Fuel saving		
	PDD (2003-2007)	2012 wet season	2012 dry season
Charcoal	21.20%	22.06%	22.01%
Wood	20.89%	23.75%	22.19%

3.3.1.2 Wood to charcoal conversion

The PDD uses IPCC (2006) default value for wood to charcoal conversion.

3.3.1.3 NCV of biomass;

The PDD uses Net Calorific Value (NCV) stipulated in the IPCC (2006) guidelines.

3.3.1.4 EF CO₂, biomass;

The PDD uses Emissions Factors stipulated in the IPCC (2006) guidelines.

3.3.2 Ex-post parameters

3.3.2.1 Stoves produced

The quantity of stoves produced is calculated on a monthly basis. Every month, Quality Control and Monitoring (QCM) staff of the NLS team visit each stove producer and collect the data from producer logbooks. The data is then entered into spreadsheets at the GERES office. The following data is collected:

- date on which the stoves were bought
- amount and type of stoves bought

² See Appendix 3 for more detailed results of 2012 HFCTs.

- buying price
- from which production centre or middleman the stoves were bought
- date on which the stoves were sold
- amount and kind of stoves sold
- selling price
- to whom they were sold (middleman or individual).

Table 5 below identifies the producers included in this verification.

Table 5: Producers included in verification

#	Name	Sex	Village	Commune	District	Province	Logo
1	Dul Sam Oun	Male	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Eagle
2	Ris Sarath	Male	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Gourd
3	Vann Tola	Female	Prey Moan	Srae Thmey	Rolear Bi'ear	KCN	Coconut Palm
4	Khin Pum	Male	Chamka Samrong1	Chamka Samrong	Battambang	BTB	Heart
5	Mok Soy	Male	Kandach	Chong Ampil	Kanh Chreach	PRV	Goat
6	Sim Seth	Male	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Rabbit
7	Phon Somen	Male	Banh Chhkol	Chreybak	Rolear Bi'ear	KCN	Apple
8	Mak Samith	Male	Tuol Rokar	Chak Angrekrom	Meanchey	PNH	Chicken
9	Leng Sophat	Male	Slaket	Slaket	Battambang	BTB	Tadombangkronhoung
10	Nhek Sakun	Male	Chamka Samrong2	Chamka Samrong	Battambang	BTB	Diamond
11	Sim Mom	Female	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Mouse
12	Sim Sour	Female	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Butterfly
13	Kong Sok	Male	Tadou	Rokar Knong	Dounkeo	TKO	Elephant
14	Sun Tha	Female	Andong Russey	Srae Thmey	Rolear Bi'ear	KCN	Dragon
15	Khoem Tim	Female	Andong Russey	Srae Thmey	Rolear Bi'ear	KCN	Deymeas Mountain
16	Phon Sopha	Male	Banh Chhkol	Chreybak	Rolear Bi'ear	KCN	Camel
17	Kong Sophear	Male	Chamkar Tamao	Srae Thmey	Rolear Bi'ear	KCN	Flower

18	Mom Samean	Male	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Kangaroo
19	Long Ty	Female	Trear Cherng	Srae Thmey	Rolear Bi'ear	KCN	Swan
20	Phun Sophal	Male	Andong Russey	Srae Thmey	Rolear Bi'ear	KCN	Cow
21	Keo Chanthear	Female	Andong Russey	Srae Thmey	Rolear Bi'ear	KCN	Lion
22	Thon Chamrem	Male	Andong Russey	Srae Thmey	Rolear Bi'ear	KCN	Monkey
23	Sor Phy	Female	Slaket	Slaket	Battambang	BTB	Kou Srov
24	Dourng Saronn	Male	Kdey Tnoat	Srae Thmey	Rolear Bi'ear	KCN	Fish
25	Ven Chomraeun	Male	Chamkar Tamao	Srae Thmey	Rolear Bi'ear	KCN	Dragonfly
26	Chourn Sopheak	Male	Andong Russey	Srae Thmey	Rolear Bi'ear	KCN	Rhinoceros
27	Han Sophal	Female	Khley	Chreybak	Rolear Bi'ear	KCN	Ka-orm
28	Khoem Chanthen	Female	Banh Chhkoi	Chreybak	Rolear Bi'ear	KCN	Horse
29	Thean Pov	Male	Banh Chhkoi	Chreybak	Rolear Bi'ear	KCN	Glass
30	Hun Sopheap	Male	Banh Chhkoi	Chreybak	Rolear Bi'ear	KCN	Scorpion
31	Boeun Sokhan	Female	Banh Chhkoi	Chreybak	Rolear Bi'ear	KCN	Cashew
32	Sim Pov	Female	Trear Cherng	Srae Thmey	Rolear Bi'ear	KCN	Star

3.3.2.2 *Sales of New Lao Stoves to users: POST*

Emission reductions from the NLS project are based on monthly sales of stoves sold by producers. Calculation of emissions reductions assumes that stoves are used immediately upon purchase by the end user and therefore start to generate emissions reductions at this point; however, it is important to account for the time lapse between the stoves' production and actual use (POST), during which no emissions reductions are generated.

The duration of the POST is defined by two points in the stove supply chain:

1. During distribution from producers to retailers, sometimes via middlemen.
2. The number of stove shelf days (SSD), which refers to the length of time stoves are held by the retailer before their eventual sale to the end user.

GERES' NLS labelling system assists in estimating the time lapse between stove production and stove use. The labels serve not only as a mark of quality control, but also provide a unique serial number. This number is recorded at three points in order to determine the POST:

1. When the label is issued to producers.
2. When the stove is sold by producers.
3. When the stove is sold to end users.

Using the figures of the QC labels, a survey was conducted in 2008, based on 535 stoves (out of a total of 244,102, providing a confidence level of 95.7%). Based on the data obtained, the average POST is 53.4 days³, which is a conservative estimate because:

- It includes the time lapse between the point at which the producers obtain the QC label and the point at which the producers label the produced stove. Producers generally apply labels in batches, rather than on a stove-by-stove basis, which means the delay between receiving and issuing the label could be in the order of weeks (since labels are issued monthly).
- Extreme POST data was included in the calculation. The extreme values may result from a number of situations, such as misplacement of the labels by producers, or using new batches of labels before using leftover labels from the previous month.
- It is not discounted for sales closer to the point of production.
- Revised calculations from 2012 data obtained from buying and selling books issued to producers, middlemen and retailers indicates that the POST is **19 days**, based on a sample of **8,618 NLS** sold in (see section 5.1.2 for further information). The lower POST time reflects improvement in distributors' transport systems (eg. fewer ox carts and more trucks and moto remorques); and improvements in GERES' monitoring system, which allows the POST to be tracked from the point at which the producers sell the NLS (rather than the point at which the QC label is issued to producers – see Figure 14 for further information) and provides more detailed and accurate data, encompassing larger sample sizes.

3.3.2.3 *Stove lifetime*

The lifespan adopted is 1.5 years or 18 months. GERES suspects the decrease in stove lifetime is due to scaling-back of GERES awareness-raising activities. It is very important that NLS users do not move the stove around too much, as this decreases stove lifetime. In the early stages of the project, GERES

³ See Appendix 4 for further detail on POST calculation

invested more time and effort in educating users about the appropriate operation of the NLS but in recent years, such activities have decreased.

3.3.2.4 *Equipment ratio: stoves per family.*

Equipment ratio refers to the number of stoves used per family. Results from the National User Survey (2011) identified an equipment ratio of 1.23 (see Table 6). This ratio is lower than the previously calculated ratio of 1.6, probably due to the fact that LPG is becoming more common as a cooking fuel in urban and peri-urban areas.

Table 6: Equipment ratio calculation

Number of stoves	Frequency	Total Stoves	Equipment Ratio
1	565	565	
2	137	274	
3	12	36	
Total	714	875	1.23

3.3.2.5 *Transport Emissions*

Transportation emissions are generated from collecting producer and retailer data, quality control activities and conducting household fuel consumption tests. The emissions would not have occurred in the absence of the project activity and are calculated as project emissions and deducted from total emissions reductions.

The transport emissions are calculated based on the consumption of fossil fuel associated with the monitoring activities. The fuel consumption is derived from GERES' accounting records for the period 1st January – 31st December 2012. Receipts to cover travel expenses are submitted to the Finance Unit of GERES Cambodia. In its records, the Finance Unit ensures that travel for monitoring activities of the NLS project are distinguishable from travel associated with other projects.

Transport emissions were determined according to fuel consumption, which was calculated based on monthly prices for gasoline and diesel in 2012 (obtained from random selection of fuel receipts from GERES' records – see Appendix 4 for further information). **In this crediting period, 23tCO₂e were emitted from transport associated with monitoring of the NLS project.**

3.3.3 **Quality Assurance Measures**

Samples of NLS (sizes A1, A2 and A3) are collected every four months from producers. The samples are measured to check whether they conform to standardised stove dimensions – this is a **largely cosmetic check**, as stove dimensions have limited influence on the efficiency of the stoves⁴. Adapted Water Boiling Tests (AWBTs) are conducted to determine the NLS' efficiency, power input, burning rate and useful heat input. Performance should be within pre-determined thresholds. Finally, a system of labelling has been initiated for quality assurance of NLS. Producers whose construction standards have consistently achieved adequate results in the AWBTs are provided with labels to attach to the finished product.

⁴ This was proven during the 2009 testing of stoves that scored poorly in stove dimension tests. The average efficiency of the tested stoves was 31.1% in spite of their "poor" performance in the stove dimension tests.

3.3.4 Organisational structure and responsibilities

The structure of the NLS team is divided into three fields:

1. Performance QC
2. Physical QC
3. Monitoring

In 2012, the department was managed by the NLS Project Manager (Mr. Sokhannaro HEP). Three team leaders represent the three areas of the NLS project's operation. The members of the team perform tasks for each of the three work areas on a rotational basis, in order to diversify the staff's skills and provide variety in their work tasks. Table 7 identifies all staff involved in monitoring/ quality control of the NLS project in 2012.

Table 7: NLS Project staffing, 2012

Position	Acronym	Name
NLS Project Manager	HSO	HEP Sokhannaro
NLS Project Assistant	HSN	HENG Samnang
Quality Control Coordinator	SRA	SIN Rotha
ICS Field Testing Coordinator	LNR	LAY Narith
NLS Monitoring Team Leader	SSL	SAN Saly
NLS Monitoring Staff	NVN	NEANG Vanna
NLS Monitoring Staff	DMH	DEM Hoeung
NLS Monitoring Staff	LMH	LY Math
NLS Monitoring Staff	VAT	VANN Tin
NLS Monitoring Staff	KSP	KHIN Sophan
NLS Monitoring Staff	NSA	NGET Sereiratana
NLS Monitoring Staff	CCY	CHY Chanthy
NLS Monitoring Staff	SSM	SA Sreymom
NLS Monitoring Staff	SOP	SAING Sophear
NLS Monitoring Staff	TSL	TEM Soleang
NLS Quality Control (Physical) Team Leader	SMR	SREY Makara
Quality Control (Physical) Staff	MBA	MEAS Bona
Quality Control (Physical) Staff	BCN	BOUEN Chansarin

Quality Control (Physical) Staff	LST	LY Sou Ty
Quality Control (Physical) Staff	YOY	YOUS Yim
NLS Testing (Performance Quality Control) Team Leader	CTL	CHHEANG ToI
Quality Control (Physical) Staff	THA	TU Tha
Testing (Performance Quality Control) Staff	KSA	KONG Samath
Testing (Performance Quality Control) Staff	DET	KEM Tim
Testing (Performance Quality Control) Staff	TSN	TEY Sarin

3.3.5 Data collection

3.3.5.1 Monitoring

Frequency	- At least once per month (at the end of the month) for all producers and retailers. - For middlemen, may be less frequent because they spend a lot of time travelling and it can be difficult to know when they will be home.
Sample size	Every accredited NLS producer
Tools/ equipment	- Date stamp - QC labels - Log sheets - Receipt book - Buying book - Selling book
Procedure	- Visiting the producer: - Make a copy of the stove log book. - Collect the hard copies of the buying and selling books - Cross check the stove producer's log book with the QC label logsheet. - Exchange current date stamp with previous month's date stamp. - Issue new batch of QC labels. - Receive 20,000 Riel payment for ICOPRODAC membership and issue receipt. - Visiting middlemen and retailers: - Make a copy of the logbook - Collect the hard copies of the buying and selling books

	- Managing the data: - Enter the following data into the corresponding spreadsheets/ databases: - stove sales data - buying and selling book data - financial incentive payment records - QC label issuance - ICOPRODAC contribution - Place hard copies of producer logbooks in relevant folders and file in the NLS room in the GERES Cambodia office.
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3.3.5.2 Adapted Water Boiling Test (AWBT)

Frequency	Once every 4 months for each producer
Sample size	3 stoves for NLS A1 tests 2 stoves for NLS A2 tests 2 stoves for NLS A3 tests
Tools and equipment	- A digital watch with second precision; - An accurate platform scale (ratio between precision of the measure and maximum weight lower or equal at 1%), a simple balance almost available in all villages; - Digital thermometer with thermocouple probes if possible or other type of mercury glass thermometer able to indicate temperature in water until 100°C (accuracy of 1 °C); - A form for recording data (see annex I for record sheet form); - Cylindrical aluminum pots/pans with flat/round bottom; diameter of the pot rim and bottom part 23,8 cm, height: 11 cm and thickness of pot: 2 mm for 3 liters water Two frame supports with thermocouple probes to permit measurement of water temperature, 1 cm above the internal bottom of pot; - Around 15 grams of local resin (from <i>Dipterocarpus alatus</i>) is used traditionally as fire starter and let it burn for 3 minutes ignition; - For charcoal stove we use 400 g of charcoal for the above cooking pots and let combustion process maintain high power phase without intervention.
Procedure	- Weigh the recommended amount of charcoal (400 grams) for 23.8 cm diameter pot. - Note the room temperature for comparative information. - Install the cold and clean stove in a room and protect it from the wind in the direction to the fire door. - Place two similar pots above potholes of two comparing stoves with probe instrumented pot lids 1 cm above the internal bottom of the pot.

	• Ignite the charcoal with a fixed quantity of resin (15g); • Manage charcoal in the stove in such manner to obtain the maximal power output as possible during the high power phase, to reach as quickly as possible the boiling point. Boiling point is reached when temperature is stabilized, around 99 °C, after 10 seconds. • Record the Time to Boil • Maintain the high power phase after reaching the water boiling point in pot for 5 minutes to respect traditional way of cooking. • Maintain water simmering in the pot in a range of two degrees around boiling point (97-99 °C), avoiding flames to extinguish. • Temperature is recorded at every 3 minutes interval. When all the remaining charcoal is burned and the temperature drop below 97 °C, Total Time Test is recorded. If the range of five degrees is over passed during the simmering period, the test should be rejected. • Weigh the remaining charcoal and water in the pot. • At the end of the test, the maximum charcoal weight has to be less than 20 grams to accept the test. • Using the calculation spreadsheets, calculate Total Time Test (TTT), Useful Power, Useful Energy, Efficiency.
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3.3.5.3 Household Fuel Consumption Test (HFCT)

Frequency	• Twice per year (once in rainy season and once in dry season)
Sample size	• 25 households per test
Tools/ equipment	• an accurate balance (simple 10 kg capacity and 10 g accuracy which is available in villages; • wood moisture meter if wood cannot be distributed. • 25 NLS and 25 TLS • 5kg of charcoal and 5kg of fuelwood • 10-litre containers (for water)
Procedure	<i>Day 0</i> • The day before testing commences, provide each household with: - o an NLS (or TLS) - o sufficient fuel for 1 day of cooking (5kg kg for wood testing and 5kg for charcoal testing). - o 40 litres of water in a container. - o a log sheet for the family to record its menu • Explain the test to the family, especially: - o That they must only use the water and fuel supplied for cooking

	food - o That they must only use the stoves provided for cooking their food - o How to fill out the log form for recording the meals cooked during the test <i>Day 2 – 7</i> • Visit each household daily. • Note/ measure: - o The remaining wood/ charcoal - o The remaining water. • Take away the remaining fuel and replace with a fresh 5kg batch • Top-up the water to 40 litres. • Using the calculation spreadsheets, calculate Field Fuel Saving (FFS) and Specific Fuel Consumption (SFC)
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3.3.6 Document storage and control

Clear and appropriate document labelling and storage systems are necessary to preserve the audit trail for verification of the NLS project and to track the project's evolution and monitor its success. The file labelling and storage system outlined in Table 8 below is adhered to. There is also a MS Excel spreadsheet that enables users to search the location of hard copies in the office.

Table 8: Data storage and control

Record name	Format	Location	Duration	Person in charge	
				Directly	Verifier
Data					
Stove sales data	MS Access database	\\192.168.0.2\proj\ICS\NLS\MONITORING TEAM\	Indefinitely	SANN Saly	HEP Sokhanaro
	Photocopies of producer log books	Filing cabinet	2 years after project end date (9th May 2015)		
	Old producer log books	Filing cabinet	2 years after project end date (9th May 2015)		
QC label distribution	Log sheet filled in by producers	Filing cabinet	2 years after project end date (9th May 2015)	SANN Saly	HEP Sokhanaro
	MS Excel spreadsheet	\\192.168.0.2\proj\ICS\NLS\MONITORING TEAM\	Indefinitely		
Water boiling test data	Handwritten log sheets	Filing cabinet	2 years after project end date (9th May 2015)	Tol CHHEANG	HEP Sokhanaro
	MS Excel calculation database	\\192.168.0.2\proj\ICS\NLS\PERFORMANCE QC	Indefinitely		
Household fuel consumption test	Handwritten log sheets	Filing cabinet	2 years after project end date (9th May 2015)	Tol CHHEANG	HEP Sokhanaro
	MS Excel calculation spreadsheet	\\192.168.0.2\proj\ICS\NLS\PERFORMANCE QC	Indefinitely		
Stove	Handwritten log	Filing cabinet	2 years after project end	SREY	HEP Sokhanaro

Dimension Test (shrinkage factor)	sheets		date (9th May 2015)	Makara	
	MS Excel calculation spreadsheet	\\192.168.0.2\proj\ICS\NLS\PHYSICAL QC\	Indefinitely		
Stove Dimension Test (for AWBT)	Handwritten log sheet stickers		Not retained (placed on stoves)	SREY Makara	HEP Sokhanaro
	MS Excel calculation spreadsheet	\\192.168.0.2\proj\ICS\NLS\PHYSICAL QC\	Indefinitely		
SD test sheets for 5-stage QC procedure for new producers	Handwritten log sheets	Filing cabinet	2 years after project end date (9th May 2015)	SREY Makara	HEP Sokhanaro
Copies of fuel receipts for travel associated with QCM for NLS	Paper photocopies	Filing cabinet	2 years after project end date (9th May 2015)	HENG Samnang	HEP Sokhanaro
Logsheet for final approval of new producers	MS Excel spreadsheet	\\192.168.0.2\proj\ICS\NLS\PHYSICAL QC\	Indefinitely	HEP Sokhanaro	HEP Sokhanaro
Forms					
Water boiling test form	MS Excel spreadsheet	\\192.168.0.2\proj\ICS\NLS\PERFORMANCE QC	End of project lifetime (9th May 2013)	CHHEANG Tol	HEP Sokhanaro
SD test form (for AWBT)	MS Excel spreadsheet	\\192.168.0.2\proj\ICS\NLS\PHYSICAL QC\	End of project lifetime (9th May 2013)	CHHEANG Tol	HEP Sokhanaro
SD test form (shrinkage factor)	MS Excel spreadsheet	\\192.168.0.2\proj\ICS\NLS\PHYSICAL QC\	End of project lifetime (9th May 2013)	SREY Makara	HEP Sokhanaro

HFCT forms	MS Excel spreadsheet	\\192.168.0.2\proj\ICS\NLS\PERFORMANCE QC	End of project lifetime (9th May 2013)	CHHEANG Tol	HEP Sokhanaro
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4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

		No of units sold	Number of units retired	Number of units in use	Biomass wood (t)	Biomass charcoal (t)	Total biomass cons. (t)	Total baseline emissions (tCO ₂)
01-Jan-12	31-Jan-12	32764	22627	491174	14998.8	76959	91957	160668
01-Feb-12	29-Feb-12	35255	33761	502919	15357.4	78799	94156	164510
01-Mar-12	31-Mar-12	42096	27043	502531	15345.6	78738	94084	164383
01-Apr-12	30-Apr-12	27171	17891	512415	15647.4	80287	95934	167616
01-May-12	31-May-12	34130	31895	532972	16275.1	83508	99783	174340
01-Jun-12	30-Jun-12	38865	27886	529949	16182.8	83034	99217	173352
01-Jul-12	31-Jul-12	27164	31125	537350	16408.8	84194	100602	175773
01-Aug-12	31-Aug-12	40727	32512	542230	16557.9	84958	101516	177369
01-Sep-12	30-Sep-12	36597	31258	540197	16495.8	84640	101135	176704
01-Oct-12	31-Oct-12	31613	28365	548657	16754.1	85965	102719	179471
01-Nov-12	30-Nov-12	35310	27756	555671	16968.3	87064	104032	181765
01-Dec-12	31-Dec-12	29316	28171	560431	17113.7	87810	104924	183323

		411008	340290		194106	995954	1190060	2079273
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4.2 Project Emissions

		No of units sold	Number of units retired	Number of units in use	Biomass wood (t)	Biomass charcoal (t)	Total biomass cons. (t)	Project emissions (biomass cons.) (tCO ₂)	Transport emissions (tCO ₂)	Total project emissions (tCO ₂)
01-Jan-12	31-Jan-12	32764	22627	491174	11866	60643	72509	126688	1.61	126689
01-Feb-12	29-Feb-12	35255	33761	502919	12149	62093	74243	129717	2.05	129719
01-Mar-12	31-Mar-12	42096	27043	502531	12140	62046	74185	129617	2.60	129619
01-Apr-12	30-Apr-12	27171	17891	512415	12379	63266	75645	132166	1.55	132168
01-May-12	31-May-12	34130	31895	532972	12875	65804	78679	137468	1.34	137470
01-Jun-12	30-Jun-12	38865	27886	529949	12802	65431	78233	136689	2.18	136691
01-Jul-12	31-Jul-12	27164	31125	537350	12981	66345	79326	138598	2.69	138600
01-Aug-12	31-Aug-12	40727	32512	542230	13099	66947	80046	139856	2.22	139859
01-Sep-12	30-Sep-12	36597	31258	540197	13050	66696	79746	139332	2.15	139334
01-Oct-12	31-Oct-12	31613	28365	548657	13254	67741	80995	141514	1.66	141516
01-Nov-12	30-Nov-12	35310	27756	555671	13424	68607	82030	143323	1.36	143324
01-Dec-12	31-Dec-12	29316	28171	560431	13539	69194	82733	144551	1.39	144552
		411008	340290		153557	784812	938369	1639518	23	1639541

4.3 Leakage

		ERs (biomass) (tCO ₂)	Leakage (15%) (tCO ₂)
01-Jan-12	31-Jan-12	33980	5097
01-Feb-12	29-Feb-12	34793	5219
01-Mar-12	31-Mar-12	34766	5215
01-Apr-12	30-Apr-12	35450	5317
01-May-12	31-May-12	36872	5531
01-Jun-12	30-Jun-12	36663	5499
01-Jul-12	31-Jul-12	37175	5576
01-Aug-12	31-Aug-12	37513	5627
01-Sep-12	30-Sep-12	37372	5606
01-Oct-12	31-Oct-12	37957	5694
01-Nov-12	30-Nov-12	38442	5766
01-Dec-12	31-Dec-12	38772	5816
		439754	65963

4.4 Summary of GHG Emission Reductions and Removals

		Total baseline emissions (tCO ₂)	Project emissions (biomass) (tCO ₂)	ERs (biomass) (tCO ₂)	Leakage (15%) (tCO ₂)	Project emissions (transport) (tCO ₂)	Total ERs (tCO ₂)
01-Jan-12	31-Jan-12	160668	126688	33980	5097	1.61	28882
01-Feb-12	29-Feb-12	164510	129717	34793	5219	2.05	29572
01-Mar-12	31-Mar-12	164383	129617	34766	5215	2.60	29549
01-Apr-12	30-Apr-12	167616	132166	35450	5317	1.55	30131
01-May-12	31-May-12	174340	137468	36872	5531	1.34	31340
01-Jun-12	30-Jun-12	173352	136689	36663	5499	2.18	31161
01-Jul-12	31-Jul-12	175773	138598	37175	5576	2.69	31596
01-Aug-12	31-Aug-12	177369	139856	37513	5627	2.22	31883
01-Sep-12	30-Sep-12	176704	139332	37372	5606	2.15	31764
01-Oct-12	31-Oct-12	179471	141514	37957	5694	1.66	32262
01-Nov-12	30-Nov-12	181765	143323	38442	5766	1.36	32675
01-Dec-12	31-Dec-12	183323	144551	38772	5816	1.39	32955
		2079273	1639518	439754	65963	23	373769

5 ADDITIONAL INFORMATION

5.1 Forward Action Requests (FARs)

During the last verification, two Forward Action Requests (FARs) were issued:

FAR1:

The boiling test in year 2012 should be conducted in size A0 and A4 for some producers who have the 1st and 2nd rank in sold record in each size.

FAR 2:

2.1 The retailer's record of NLS purchased and sold should be more implemented as possible. The retailer's competency and awareness should be improved to ensure that the NLS purchased and sold will be recorded correctly and continuously.

2.2 The retailer's record of NLS purchased and sold in year 2012 should be interpreted and cross checked with "53.4 days of Stove Shelf Life" to ensure that it is still valid and conservative to calculate the Emission Reduction in Year 2012.

5.1.1 FAR 1

The Adapted Water Boiling Test (AWBT) was conducted on twelve A0 stoves and twelve A4 stoves in 2012, for producers who have the 1st and 2nd ranking in sales records for each stove type (plus one other top producer for each of the two stove sizes). All tested stoves achieved more than 27% efficiency in the AWBTs, indicating that they meet GERES' quality standards (see Tables 9-12 below).

Table 9: AWBT results for A0 NLS

Producer name	% total A0 produced 2012	Date of AWBT	Efficiency	
			Stove 1	Stove 2
Khoem Tim	21.66%	29-30 Aug 2012	36.32%	30.99%
		17-18 Dec 2012	29.75%	28.98%
Nhek Sakun	17.08%	13-14 Nov 2012	28.32%	29.09%
		19-20 Dec 2012	30.14%	28.54%
Sim Sour	47.15%	8-10 August 2012	33.07%	32.73%
		18-20 Dec 2012	29.35%	30.84%

Table 10: A0 producers and the number of A0 produced in 2012

Ranking	Producer name	Total A0 produced 2012	% total A0 produced 2012
1	Sim Sour	381	47.15%
2	Khoem Tim	175	21.66%
3	Nhek Sakun	138	17.08%
4	Vann Tola	54	6.68%
5	Sim Mom	35	4.33%

6	Phon Somen	17	2.10%
7	Boeun Sokhan	6	0.74%
8	Ris Sarath	2	0.25%

Table 11: AWBT results for A4 NLS

Producer name	% total A4 produced 2012	Date of AWBT	Efficiency	
			Stove 1	Stove 2
Dul Sam Oun	22.49%	12-15 Dec 2012	27.89%	28.25%
		19-20 Dec 2012	27.51%	27.80%
Khoem Tim	11.09%	16-17 Dec 2012	27.47%	28.20%
		17-19 Dec 2012	27.75%	27.67%
Vann Tola	31.29%	18-20 Dec 2012	27.60%	27.82%
		19-20 Dec 2012	27.81%	28.17%

Table 12: A4 producers and the number of A4 produced in 2012

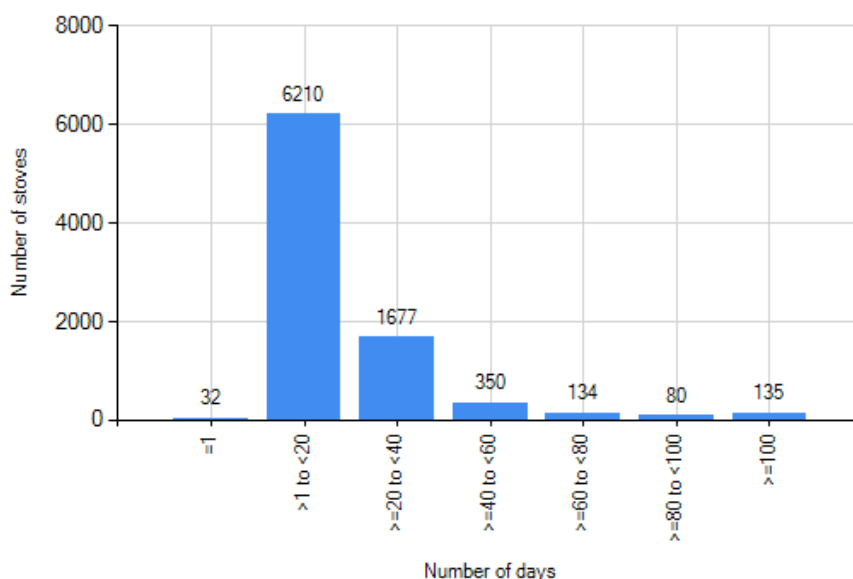
Ranking	Producer name	Total A4 produced 2012	% total A4 produced 2012
1	Vann Tola	4897	31.29%
2	Dul Sam Oun	3519	22.49%
3	Chourn Sopheak	1905	12.17%
4	Khoem Tim	1735	11.09%
5	Keo Chanthear	1575	10.06%
6	Sim Sour	735	4.70%
7	Han Sophal	636	4.06%
8	Khin Pum	183	1.17%
9	Sim Seth	177	1.13%
10	Ven Chomraeun	116	0.74%
11	Sun Tha	98	0.63%
12	Phun Sophal	73	0.47%

5.1.2 FAR 2

Difficulties in attaining detailed records from retailers in the NLS supply chain are more a matter of incentive, rather than lack of competency or awareness among retailers. GERES provides small financial incentives for retailers who cooperate and fill-in the logsheets.

In terms of the conservativeness of the POST calculation, further cross-checking was conducted in 2012 to verify that the POST is no more than 53.4 days. GERES hired a GIS & Database Specialist, Mr. PREY Sovann, who developed a database using SQL software, linked to a MS Access database, in order to track the amount of time it takes for NLS to go from the producer to the end user. The database uses data obtained from buying and selling books provided to all NLS producers and cooperating middlemen and retailers. Based on data gathered from 2012 (from January until October⁵) and a sample size of 8,618⁶ NLS, the average POST time is 19 days (see Figure 2 below). The lower POST time reflects improvement in distributors' transport systems (eg. fewer oxcarts and more trucks and moto remorques); and improvements in GERES' monitoring system, which allows the POST to be tracked from the point at which the producers sell the NLS (rather than the point at which the QC label is issued to producers – see Figure 14 for further information) and provides more detailed and accurate data, encompassing larger sample sizes. **Nevertheless, in order to maintain a conservative approach, 53.4 days is used as the POST time in the emissions reduction calculations.**

Figure 2: POSTs for sample of NLS sold 2012 (December until October)



5.2 Sustainability of the project

Data from the biennial National User Surveys (2007, 2009 and 2011) and NLS sales data indicate that the NLS is substituting traditional stoves (TLS) in the market place. This indicates that the emissions reductions from the project activities are permanent.

The most recent National User Survey (NUS), conducted in August 2011, found that 44% of the urban/peri-urban population use NLS (compared to 41.7% in the 2009 NUS and 31.3% in the 2007 NUS). Furthermore, the percentage of people using TLS decreased from 68.8% in 2007 and 67.9% in 2009, to 63% in 2011. This indicates that users are not switching back to inefficient stove technologies.

⁵ Due to staff shortages, the data from the buying and selling books for 2012 has only been entered up until October 2012.

⁶ Unfortunately every single NLS cannot be tracked along the supply chain; however, 8,618 NLS is a representative sample, based on the sampling approach illustrated in Table 18.

Table 13: National User Survey data on number/ proportion of respondents using NLS (2011)

	Frequency	Percent
Yes	731	43.9
No	933	56.1
Total	1,664	100

Stove sales data indicate that the NLS is accounting for an increasing proportion of total stoves produced (by production centres that make both TLS and NLS), with a corresponding decrease in the proportion of TLS produced. This reflects increasing demand for NLS among consumers and provides further proof of the sustainability of the NLS project. Figures 3 and 4 below illustrate this trend.

Figure 3: Number of NLS and TLS produced by NLS producers, 2003-2012

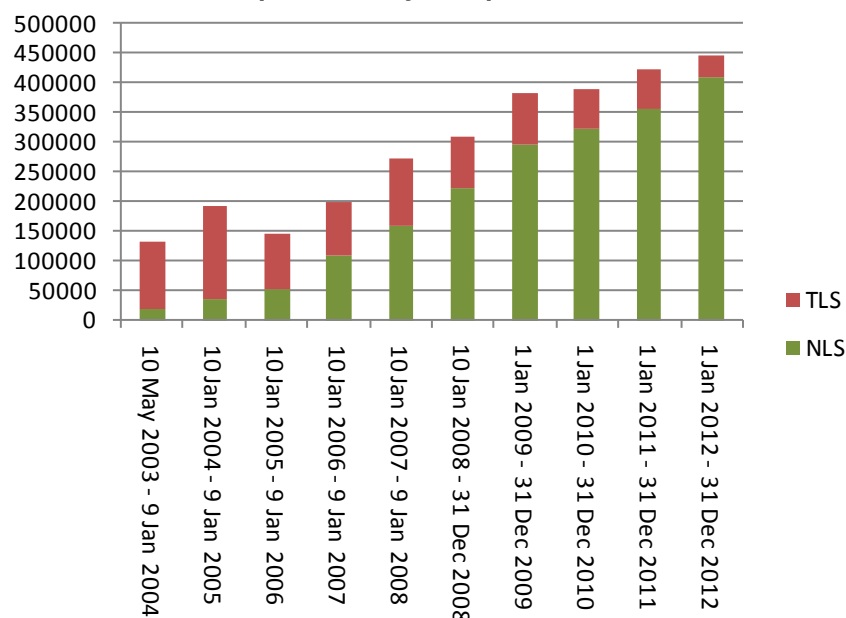
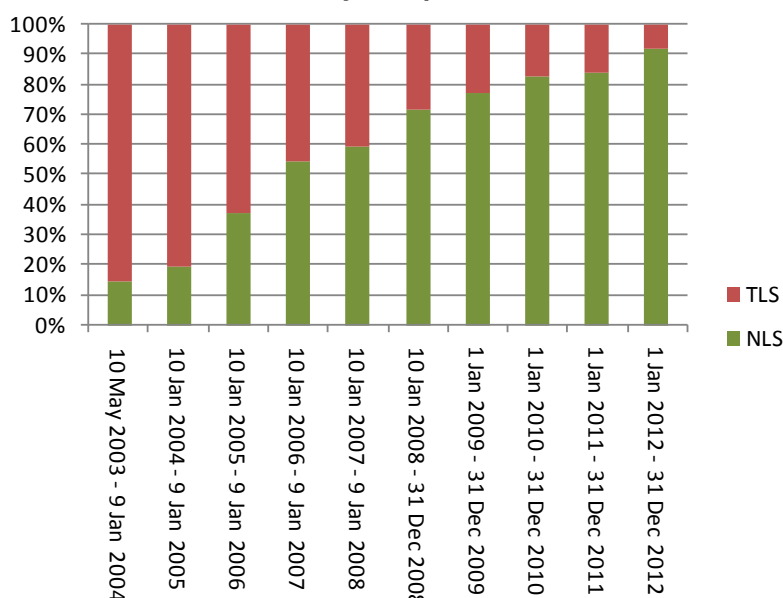


Figure 4: Proportion of NLS and TLS sold by NLS producers, 2003-2012



5.3 Environmental impacts

Aside from the environmental benefits of GHG emission mitigation, the project activity directly contributes to efforts to reduce unsustainable fuel wood consumption. Based on the total amount of wood and charcoal saved by the NLS project, it is estimated that during the 2012 monitoring period, the project saved the equivalent of 1,824 ha of forest⁷ (see Table 14).

Table 14: Biomass saved by NLS project, 1st January - 31st December 2012

Date		Number of units in use	Biomass saving wood (t)	Biomass saving charcoal (t)	Total Biomass saving (t)	Total Biomass saving (m ³)	Total Biomass saving (ha)
01-Jan-12	31-Jan-12	491174	3133	16315	19448	32421	141
01-Feb-12	29-Feb-12	502919	3208	16705	19914	33196	144
01-Mar-12	31-Mar-12	502531	3206	16692	19898	33170	144
01-Apr-12	30-Apr-12	512415	3269	17021	20290	33823	147
01-May-12	31-May-12	532972	3400	17704	21103	35180	153
01-Jun-12	30-Jun-12	529949	3381	17603	20984	34980	152
01-Jul-12	31-Jul-12	537350	3428	17849	21277	35468	154
01-Aug-12	31-Aug-12	542230	3459	18011	21470	35791	156
01-Sep-12	30-Sep-12	540197	3446	17944	21390	35656	155
01-Oct-12	31-Oct-12	548657	3500	18225	21725	36215	157
01-Nov-12	30-Nov-12	555671	3545	18458	22002	36678	159
01-Dec-12	31-Dec-12	560431	3575	18616	22191	36992	161
			40549	211142	251691	419569	1824

5.3.1 Non-Renewability

Cambodia's forest resources are rapidly being depleted. Biomass is considered non-renewable as the current trend of regional use is unsustainable in the long term.

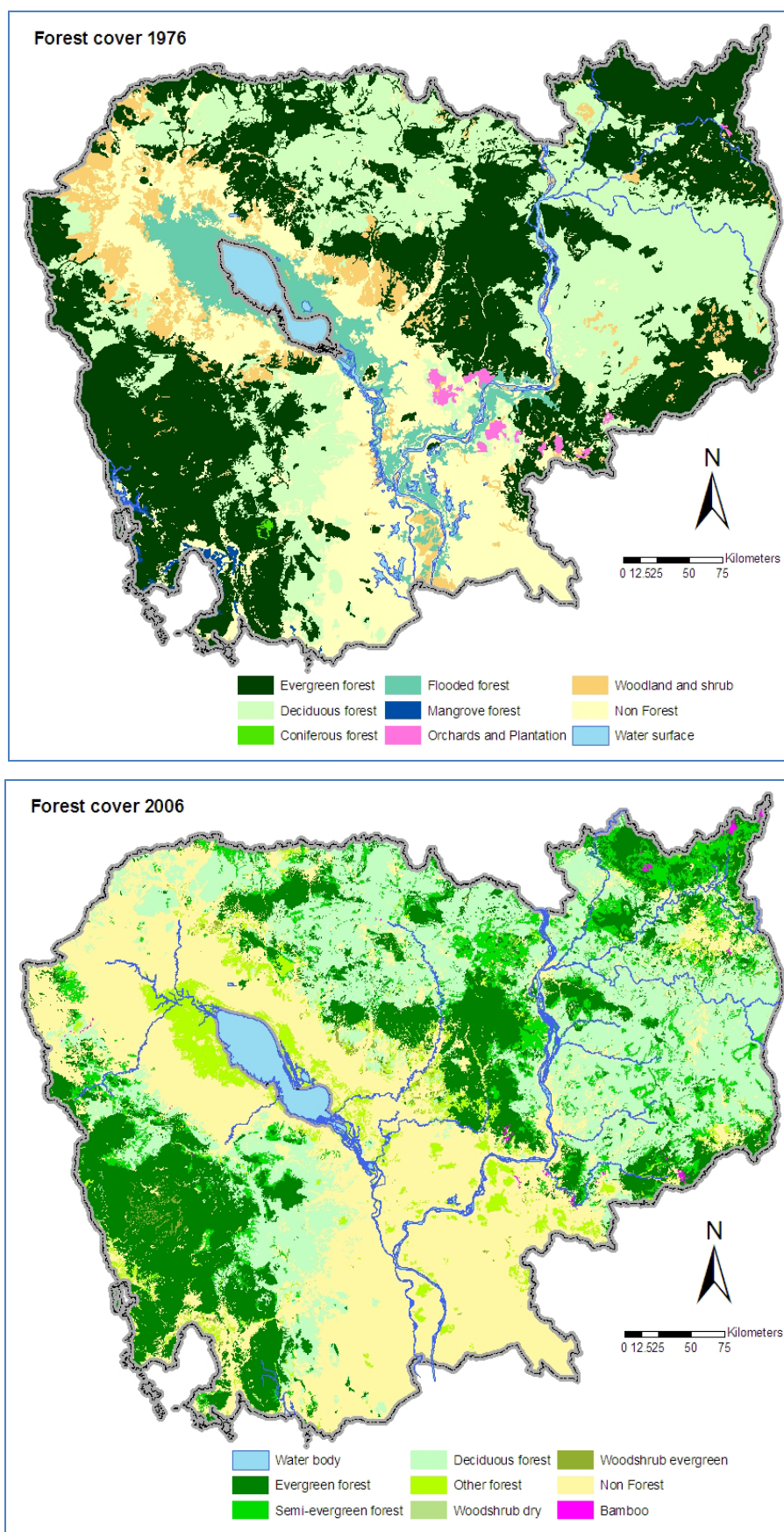
The main forested areas are located in the north and south of the country. The maps⁸ below illustrate the depleting carbon stocks in Cambodian forests, as certain changes in forest cover can indicate a reduction in carbon stocks (for example, evergreen forest contains a higher amount of carbon sequestered than semi-evergreen forest⁹).

⁷ 1 ton = 1.667 m³ and 1 ha = 230 m³ (GERES, 2005)

⁸ SCW (Save Cambodia's Wildlife) 2006

⁹ Top N., Mizoue N., Kai S., 2004; Kapos *et al.* 2010.

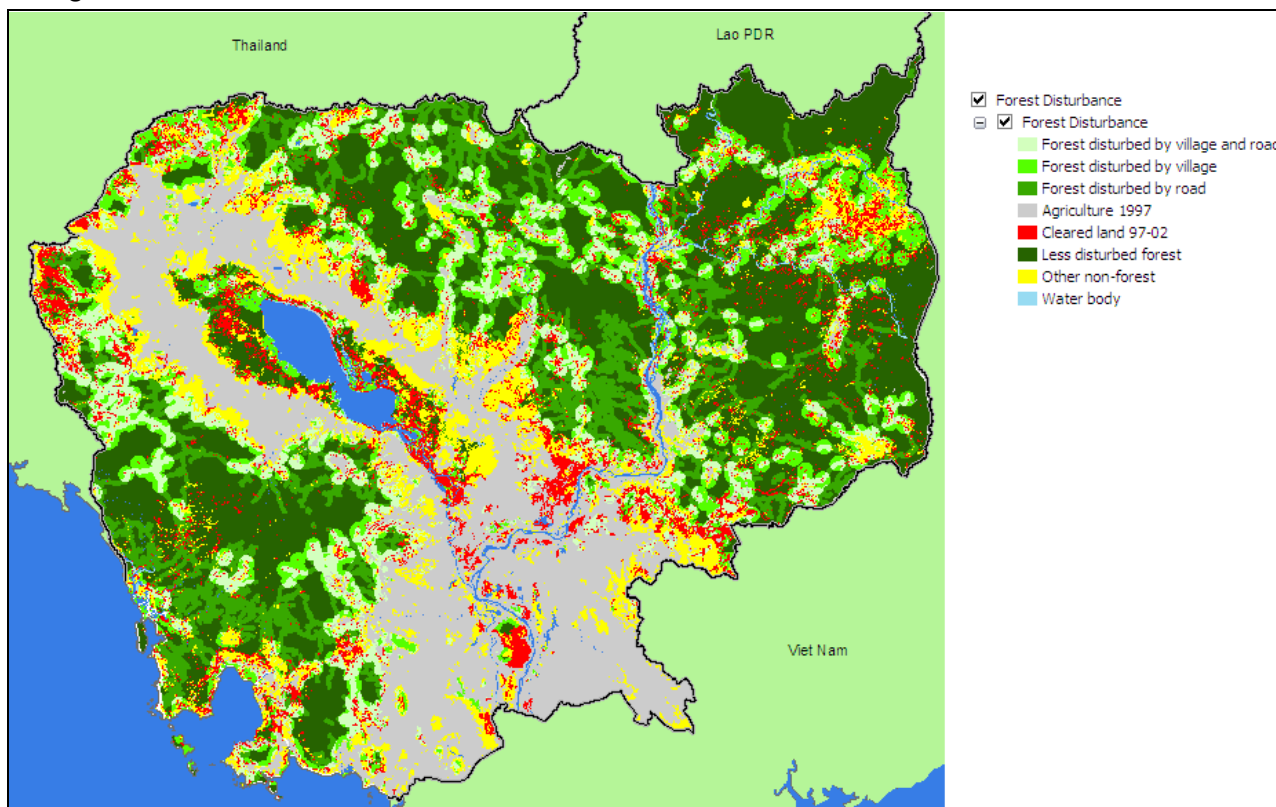
Figure 5: Distribution of forest cover in Cambodia in 1976 and 2006¹⁰



¹⁰ SCW (Save Cambodia's Wildlife) 2006; FAO 2010 v3.2

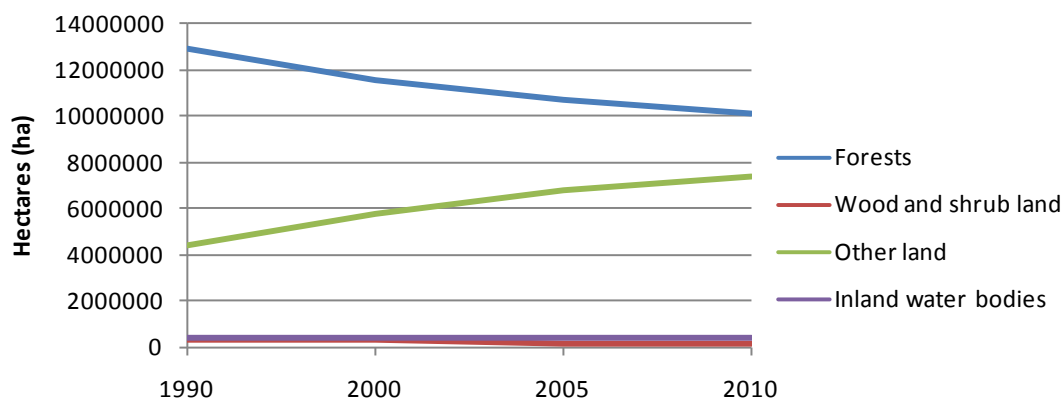
GIS mapping allows the overlay of different themes of data and a spatially explicit representation of the “woodfuel frontier” (where woodfuel is being produced); deforestation and forest degradation areas; and areas where the forest is being disturbed. The map below¹¹ represents a GIS map of forest disturbance in Cambodia from 2002. The red colour on the map is the forest cleared over 1997-2002. It clearly shows the fragmentation of primary and less disturbed forest by roads, logging, woodfuel production and land conversion to agriculture and human settlements.

Figure 6: Forest disturbance 1997-2002



Other recent evidence available to demonstrate non-renewability of biomass resources is provided by national forestry statistics. The latest Forest Resource Assessment¹² for Cambodia, released in 2010, revealed that Cambodia's deforestation rate is 1.22% per year. Forested area in the country decreased by 22% (2,850,430 ha) during 1990-2010 and wood/ shrub land area decreased by more than 60% (more than 200,000 ha) during the same period. Indeed, in recent years, deforestation rates in Cambodia being among the highest in the world¹³.

Figure 7: Decrease in forested area in Cambodia, 1990-2010¹⁴



¹¹ SCW (Save Cambodia's Wildlife) 2006

¹² FAO, 2010.

¹³ Kapos *et al.*, 2010.

¹⁴ FAO, 2010.

Evidence from GERES' National User Survey conducted in August 2011 also reflects the impacts of deforestation on wood fuel availability. Wood fuel costs can serve as a proxy indicator for wood fuel availability; the survey found that on average, households estimate that the price of fuelwood increased by 61 riel/kg (14%) compared to 2010 and the price of charcoal increased by 152 riel/ kg (22%).

Causes

The principle causes of deforestation in Cambodia are agriculture, shifting cultivation, fuelwood harvesting and logging¹⁵. In particular logging in Cambodia has been a source of international concern. Rival factions in the civil war funded themselves through logging and the practice has continued largely unabated ever since.

Despite public commitments to reform, Cambodia's shadow state has continued to generate money from the timber sector. Officials charged with implementing reforms have instead subverted them; with the result that illegal logging has continued in a variety of forms and is still causing severe damage to Cambodia's remaining forests (Global Witness, 2008).

Domestic fuel use also exerts pressure on environmental resources. Cambodia's increasing population relies heavily on fuel-wood as their main energy source. Indeed 91% of the households use firewood or charcoal for cooking.¹⁶ In addition, more than 70% of Cambodians live in areas that cannot sustainably secure sufficient wood for fuel, so the flow of wood into urban areas places increased pressure on easily accessed forest areas along roads and rivers¹⁷.

Charcoal is produced illegally and unsustainably, mostly for household and light industrial consumption:

Charcoal-making is not well managed, reflecting short term thinking without a long term planning horizon within an environment of highly insecure rights.¹⁸

Charcoal production in the Kampong Speu Province west of Phnom Penh (its main supply area) is evidently causing deforestation, converting primary forests into low-productivity degraded shrub-land. Charcoal, produced in traditional earth mound kilns, is mostly obtained from wood collected from the natural forest owned by the government.¹⁹

A wood energy baseline study conducted by GERES in 2006²⁰ found that the annual wood demand for Phnom Penh was 369,000 tonnes, or approximately 4,500 hectares per year. Harvesting the same yield sustainably would require the maintenance of a tree plantation of some 30,750 hectares – a proposition which is unfeasible in present day Cambodia.

5.4 Economic impacts

An advantage of the commercialised dissemination of the NLS is that the project is able to offer economic benefits throughout the stove distribution network of producers, retailers and end users. The stove distribution network in Cambodia is illustrated in Figure 8.

¹⁵ Ministry of Environment, 2010.

¹⁶ National Institute of Statistics, 2008

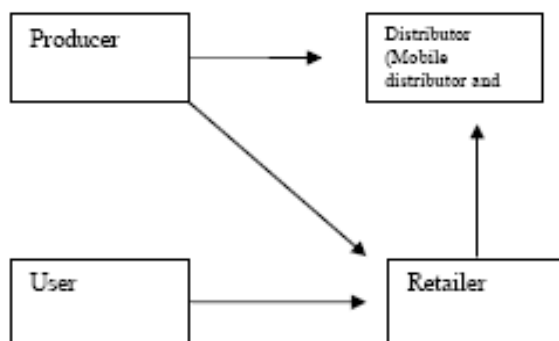
¹⁷ MOE, 2010.

¹⁸ World Bank, 2004.

¹⁹ Van Mansvelt et al., 2006b

²⁰ Van Mansvelt et al., 2006b

Figure 8: Stove distribution network²¹



The stove producers and retailers make a profit of US\$0.50 from each NLS. This compares favourably with profit from traditional stoves which is approximately US\$0.12 per stove²². Indeed, a study conducted in 2009 found that NLS production generates income per producer almost four times higher than TLS production²³.

The number of stoves sold throughout the monitoring period is 411,008, which means producers made an additional²⁴ \$156183 during the period. So far, during the lifetime of the project, producers have made an additional \$ 757,701 through the sale of NLS.

The profits are ultimately provided by the end users, who pay more per unit (around \$3 compared to \$1 for a TLS); however, reductions in charcoal and fuelwood use and the increased durability of the NLS extend economic benefits of the stove to end users²⁵.

Finally, NLS production is more labour-intensive and consequently requires more workers and generates employment; NLS producers employ between 10 and 14 workers, as opposed to just three for TLS producers²⁶.

5.5 Social impacts

5.5.1 Health & lifestyle

The NLS does not fully alleviate the problems associated with the inhalation of cooking smoke and although the reduction in health damaging pollutants has not been directly monitored, the greater combustion efficiency and reduced exposure time is expected to mitigate the health impacts of cooking with charcoal. Furthermore, as demonstrated in Figures 9 and 10 below, during the 2011 National User Survey, the majority of households reported positive impacts from the NLS in terms of cooking time and fuel consumption. On average, respondents reported that cooking time was reduced by 9 hours per month.

²¹ Atukorala, 2006.

²² Winrock, 2006.

²³ Agence Francaise de Developpement (AFD) and GERES, 2009.

²⁴ Compared to exclusive sale of TLS.

²⁵ Winrock, 2006.

²⁶ Agence Francaise de Developpement (AFD) and GERES, 2009

Figure 9: NLS users' satisfaction with NLS performance in terms of cooking time

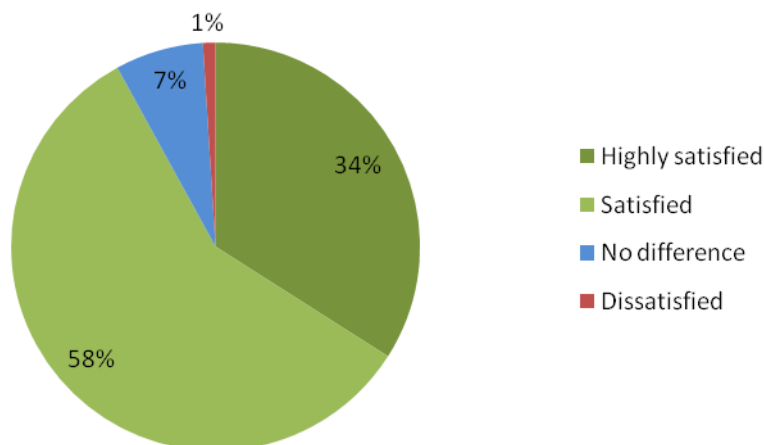
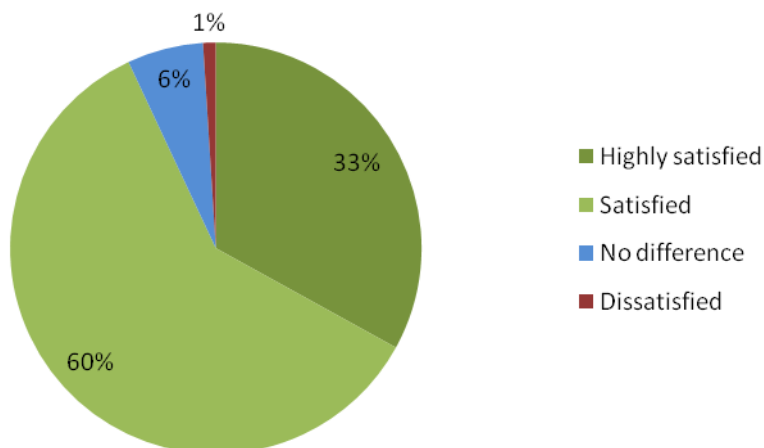


Figure 10: NLS users' satisfaction with NLS performance in terms of fuel consumption



5.5.2 Energy access & food security

The dissemination of more efficient cook stoves reduces the gap between rising fuel wood demands and diminishing forest resources. In the wider context of energy use, this means there is less competition for the same resources with the result that energy access and food security is improved, especially for the less wealthy in Cambodian society. The adoption of the NLS reduces the cost of meeting energy requirements due to its improved efficiency and allows the financial savings to be spent elsewhere.

To date, these benefits are primarily confined to urban and semi-urban areas where charcoal is used in larger quantities. It is estimated that 75% of stoves are destined for urban and semi-urban areas²⁷. In rural areas, fuel is often free to collect and home-made three stone fires are used to burn it.

5.5.3 Gender implications

Almost all (around 98%) of stove users are female, thus the adoption and use of the NLS has strong gender implications. Whilst the time saving from using the NLS is not enough for users to engage in additional income generating activities, it does free up time that can be used for other vital activities, such as water boiling, childcare and socializing²⁸.

²⁷ Atukorala, 2006.

²⁸ See National User Survey, 2007.

In addition, the cash savings, although relatively small, take place in an essential area of the family that is managed by women and deals with food nutrition and childcare. The money saved on charcoal purchases is mostly used to buy both durable and consumable goods for the household²⁹.

The production process also has a strong gender dimension as a significant number of women participate in the stove business and in fact, nearly one quarter of NLS producers are women. In case studies of the production process, there is only one task (insulation and cementing) which is done solely by men and all other activities are done by both male and female. Skilled work like trimming is done mostly by women³⁰.

5.5.4 Civil society

The development of civil society is encouraged by a strong emphasis on the development of local capacity and expertise. A good example of this is the establishment of the Improved Cooking Stove Producers Distributors Association of Cambodia (ICOPRODAC) which is the professional association of stakeholders along the ICS supply chain.

In the past, stove producers have been reluctant to cooperate and share information which resulted in some unhealthy competition and a lack of accountability. In response, ICOPRODAC was formed to facilitate sectoral development, quality assurance, and the long-term sustainability of ICS dissemination without external assistance. The association supports the producers with new data, coordinates dissemination, allows the stakeholders to assert ownership of the project process and provides a forum to raise issues.

GERES facilitates regular meetings between stove producers and stove distributors, through a stove producers and retailers association, known as ICOPRODAC. During the meetings members discuss pricing issues and share information to produce better quality stoves. The quality control and assurance of the stoves is also coordinated through ICOPRODAC; the organisation issues stickers to the NLS producers who qualify for the hallmark of quality.

A finance facility, known as the Economic Pillar, has also been established to serve as a savings and credit association. Members contribute 20,000 riel (around \$5) per month to fund the association.

²⁹ Winrock, 2006.

³⁰ GERES, 2005.

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7 APPENDIX 1: NATIONAL USER SURVEY –OBJECTIVES AND METHODOLOGY

7.1 Background & objectives

The National Stove Users Survey is conducted every two years to monitor the social impacts of the NLS and several parameters relevant to the NLS project:

- Equipment ratio
- Stove lifetime
- NLS usage
- TLS usage
- User satisfaction
- Social/ economic impacts on families

7.2 Methodology

7.2.1 Site Selection

The National User Survey focuses on urban and peri-urban areas of Cambodia, which reflects the main market for NLS. The 2011 NUS focused on the same provinces as earlier NUS (from 2007 and 2009).

The selected provinces are:

- Preah Sihanouk
- Kampot
- Kampong Speu
- Kampong Chhnang
- Phnom Penh
- Kampong Cham
- Kampong Thom
- Siem Reap
- Battambang

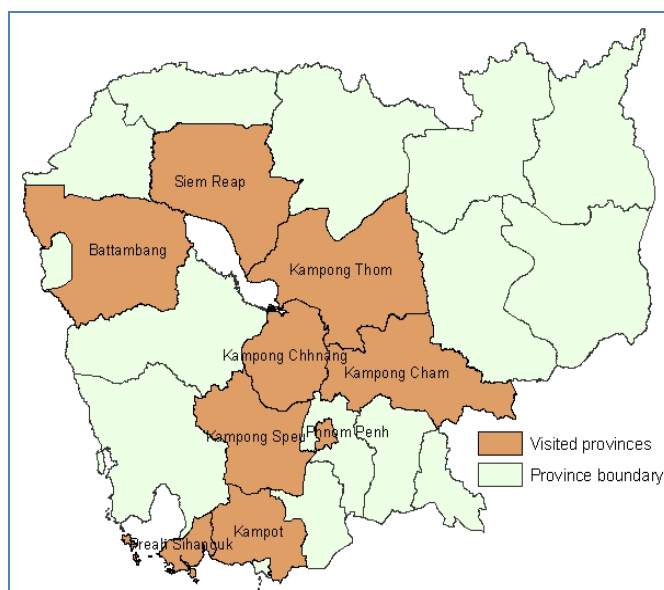


Figure 11: Map of selected provinces

In line with the 2009 National User Survey, within these provinces, “urban” and “peri-urban”³¹ areas were identified and then the main roads of each area were identified. After the roads were identified, preliminary field assessments were conducted in order to ensure residential areas were selected, as opposed to areas with a large concentration of businesses/ offices. Houses were then randomly selected in these areas.

³¹ Phnom Penh Municipality report in 2003 and 2006 defines urban and suburban Phnom Penh by population density, in which 500 inhabitants per hectare is counted in urban Phnom Penh and 50 inhabitants per hectare in peri-urban areas

7.2.2 Sampling

Researchers interviewed members of 1,664 families; the calculated minimum sample size was 1,594 and an additional 70 households were interviewed to compensate for any invalid surveys. Sample size was calculated through the Yamane equation (because the population was known) and with a confidence level (c) of 97.5%. The calculation is outlined below.

$$n = \frac{N}{1 + N(e)^2}$$

Where:

N = total population = 421,191 households

e = 0.025 (confidence level = 97.5%)

Sample sizes for each target area (province/city) were calculated based on demographic distribution of Cambodia's population (see Table 15).

Table 15 Sample sizes by province/city

Province	Provincial town	Households 2008 ³²	Pop. growth rates (%) ³³	Pop. growth/year	Households 2010	% of sample	Samples
Phnom Penh	Krong Phnom Penh	260,468	2.83%	7,371	275,210	65.3%	1,042
Kampong Speu	Krong Chbarmon	9,139	1.26%	115	9,369	2.2%	35
Kampong Chhnang	Krong Kampong Chhnang	8,411	0.33%	28	8,467	2.0%	32
Preah Sihanouk	Krong Preahsihanouk	19,157	2.93%	561	20,280	4.8%	77
Kampot	Krong Kampot	7,358	0.64%	47	7,452	1.8%	28
Kampong Thom	Krong Stueng Sen	11,510	0.15%	17	11,545	2.7%	44
Kampong Cham	Krong Kampong Cham	9,726	0.05%	5	9,736	2.3%	37
Siem Reap	Krong Siem Reap	45,717	5.28%	2,414	50,545	12.0%	191

³² National Institute of Statistics, 2008.

³³ Annual growth rate in urban areas, from National Institute of Statistics (2008).

Battambang	Krong Battambang	28,468	0.21%	60	28,588	6.8%	108
		399,954			421,191	100.0%	1,594

7.2.3 Data gathering

Data was gathered through face-to-face interviews using a structured questionnaire. During the field survey, four research teams consisting of five researchers and a team leader were deployed. Surveyors underwent one day of training and were provided with survey guidelines written in Khmer. Essentially, the guidelines advised surveyors to (1) follow the junction road identified for the survey, (2) survey every third household in the preselected area, and (3) interview households that use biomass fuel (do not continue the questionnaire if biomass fuel is not used in the household). All data existing in the questionnaire was entered into an SPSS file. Data was checked for consistency, reliability and input error.

8 APPENDIX 2: HFCT RESULTS 2012

8.1 Wet season

8.1.1 Wood

Testing was conducted 16-29 July 2012 in Prek Samrong Village, Ta Khmao.

For NLS (25 families), 7 days			
Average	Rice	Water	Wood
Consumption/week for the family(kg)	396.70	3719.20	780.90
Consumption/day for the family(kg)	57.53	531.31	111.56
Consumption/week/eq.adult	69.42	641.34	134.14
Consumption/day/eq.adult	9.92	91.62	19.16

For TLS (25 families) 7 days			
Average	Rice	Water	Wood
Consumption/week for the family(kg)	395.96	3998.00	1044.20
Consumption/day for the family(kg)	56.57	571.14	149.17
Consumption/week/eq.adult	67.03	674.28	175.92
Consumption/day/eq.adult	9.58	96.33	25.13

For an average of 1 family		
Rice	Water	Wood
15.87	148.77	31.24
2.30	21.25	4.46
2.78	25.65	5.37
0.40	3.66	0.77

For an average of 1 family		
Rice	Water	Wood
15.84	159.92	41.77
2.26	22.85	5.97
2.68	26.97	7.04
0.38	3.85	1.01

Real Fuel Saving % 23.75

8.1.2 Charcoal

Testing was conducted 11-24 June 2012 in Boeung Tumpun.

For NLS (25 families), 7 days			
Average	Rice	Water	Charcoal
Consumption/week for the family(kg)	355.14	3673.70	462.30
Consumption/day for the family(kg)	50.73	524.81	66.04
Consumption/week/eq.adult	57.96	608.94	76.36
Consumption/day/eq.adult	8.28	86.99	10.91

For TLS (25 families) 7 days			
Average	Rice	Water	Charcoal

For an average of 1 family		
Rice	Water	Charcoal
14.21	146.95	18.49
2.03	20.99	2.64
2.32	24.36	3.05
0.33	3.48	0.44

For an average of 1 family		
Rice	Water	Charcoal

Consumption/week for the family(kg)	355.01	3566.70	600.70
Consumption/day for the family(kg)	50.72	509.53	85.81
Consumption/week/eq.adult	56.94	581.54	97.98
Consumption/day/eq.adult	8.13	83.08	14.00

14.20	142.67	24.03
2.03	20.38	3.43
2.28	23.26	3.92
0.33	3.32	0.56

Real Fuel Saving % 22.06

8.2 Dry season

8.2.1 Wood

For NLS (25 families), 7 days			
Average	Rice	Water	Wood
Consumption/week for the family(kg)	423.35	3924.50	938.50
Consumption/day for the family(kg)	60.48	560.64	134.07
Consumption/week/eq.adult	72.38	672.18	159.62
Consumption/day/eq.adult	10.34	96.03	22.80

For TLS (25 families) 7 days			
Average	Rice	Water	Wood
Consumption/week for the family(kg)	413.61	4159.80	1235.70
Consumption/day for the family(kg)	59.09	594.26	176.53
Consumption/week/eq.adult	69.23	698.04	205.15
Consumption/day/eq.adult	9.89	99.72	29.31

For an average of 1 family		
Rice	Water	Wood
16.93	156.98	37.54
2.42	22.43	5.36
2.90	26.89	6.38
0.41	3.84	0.91

For an average of 1 family		
Rice	Water	Wood
16.54	166.39	49.43
2.36	23.77	7.06
2.77	27.92	8.21
0.40	3.99	1.17

Real Fuel Saving % 22.19

8.2.2 Charcoal

For NLS (25 families), 7 days			
Average	Rice	Water	Charcoal
Consumption/week for the family(kg)	349.41	3665.60	431.60
Consumption/day for the family(kg)	49.92	523.66	61.66
Consumption/week/eq.adult	58.35	614.93	72.84
Consumption/day/eq.adult	8.34	87.85	10.41

For an average of 1 family		
Rice	Water	Charcoal
13.98	146.62	17.26
2.00	20.95	2.47
2.33	24.60	2.91
0.33	3.51	0.42

For TLS (25 families) 7 days			
Average	Rice	Water	Charcoal
Consumption/week for the family(kg)	338.80	3696.70	563.20
Consumption/day for the family(kg)	48.40	528.10	80.46
Consumption/week/eq.adult	55.68	611.65	93.39
Consumption/day/eq.adult	7.95	87.38	13.34

For an average of 1 family		
Rice	Water	Charcoal
13.55	147.87	22.53
1.94	21.12	3.22
2.23	24.47	3.74
0.32	3.50	0.53

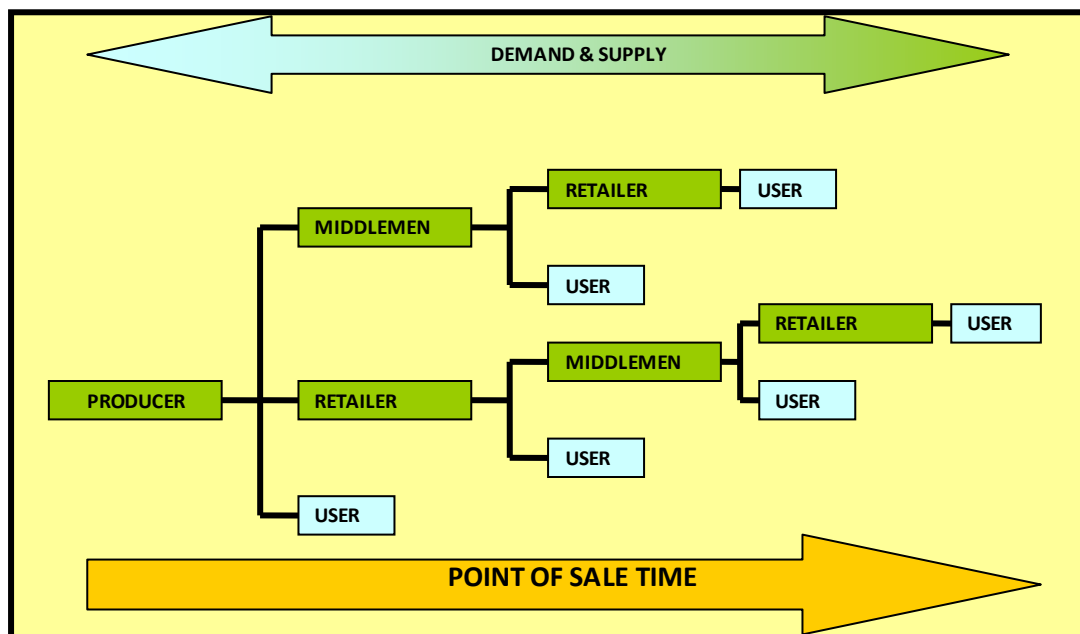
Real Fuel Saving % 22.01

9 APPENDIX 3: POST TIME CALCULATION

9.1 Background: Supply chain of NLS

Figure 12 below illustrates that the supply chain of the NLS consists of stove producers, middlemen, retailers and end users.

Figure 12: Supply chain of NLS



Stove units are moved through the chain by user demand and by the need to turn over stock in order to generate revenue. Evidence of such demand is reflected in the the longevity of the NLS project (which began in 1997) and the observable growth in market share (see Figures 3 and 4). Stove production is determined by market signals from distributors and, in turn, end users. If there was no demand or stock could not be regularly turned over then the NLS would no longer be available, as production would cease.

There are multiple paths stoves can take before they reach they are sold to the end user. Two generalisations can be made about the supply chain:

1. the further along the supply chain the stoves travel, the greater the time lapse between production and use
2. the further down the supply chain the stove is purchased, the higher the cost of the stove.

There is a vested interest for all links in the supply chain to minimise the time lapse from production to end use (POST); in the case of producers and distributors, to realise a return on their initial investment and for end users, to minimise the price paid for a stove.

Therefore, the POST is not an open-ended time period but is necessarily limited by constraining factors. Of the whole NLS supply chain, the majority of stoves are moved from the retailers to the users. Consequently, the time lapse between production and final use is a good estimate for the POST. The methodology is outlined in the next paragraph.

9.2 Research Methodology

One aspect of GERES' quality control system for the NLS is the quality control labels ("QC labels") that are provided to certified NLS stove producers. The QC label has two primary purposes:

1. To inform potential buyers that the product meets the quality standards of the stove as set by GERES.

2. To trace the stove back to the producers.

The QC label contains a unique number, which is linked to the date on which the producer obtained the label. This means that the POST time can be determined by visiting retailers and recording the point of sale (the moment the stove is bought by the end-user). This was achieved through the following strategy:

1. The monitoring team visited 44 shops in five provinces throughout 2008 and recorded the unique number of the QC labels of the NLS sold.
2. The QC label numbers of the sold NLS stoves were traced back to the moment the labels were obtained by the producers.

The eventual sample size was 535 stoves (out of a total of 244,102). This sample size returns a confidence level of 95.7%. The distribution of the sample throughout the provinces is outlined in Table 16.

Table 16: Distribution of sample used to calculate POST time

Province	Survey period in 2008	Number of retailers surveyed	Sample size (number of NLS)
Kampong Chnang	17-29 May	12	104
Siem Reap	17-22 August	11	128
Kandal	10 March -25 April	5	103
Battambang	16-27 May	14	100
Phnom Penh	7-26 March	2	95
Total		44	535

The representativeness of the chosen sample size for the total population of NLS disseminated in 2008 is ensured by the application of the Yamane formula (Yamane, 1963).

$$n = \frac{N}{1+N(e)^2}$$

Where:

N = total population

E = desired level of precision

Monitoring of stove production for 2008 gave a total population of stove units sold of 244,102. The sample size necessary for a range of confidence levels are illustrated in Table 17 below.

Table 17: Sample sizes and corresponding precision and confidence levels

Sample size	Precision level	Confidence %
100	0.1	90

123	0.09	91
156	0.08	92
204	0.07	93
277	0.06	94
399	0.05	95
623	0.04	96
1103	0.03	97
2462	0.02	98
9415	0.01	99
244102	0	100

Table 18 below indicates that a precision of 95% can be obtained with a sample size of 400. These figures correspond to published tables which give generic samples sizes needed when the size of population being studied is known. The table shows that for any population size 400 samples are required for any population over 100,000.

Table 18³⁴: Sample sizes and corresponding precision levels

Size of population	Sample Size (n) for Precision (e) of:			
	±3%	±5%	±7%	±10%
1,000	a	286	169	91
5,000	909	370	196	98
10,000	1,000	385	200	99
20,000	1,053	392	204	100
50,000	1,087	397	204	100
100,000	1,099	398	204	100
>100,000	1,111	400	204	100

In the case of the NLS project, a sample size of 535 was collected from a total population of 224,102. According to the Yamane formula this will give confidence level of 95.7% for the results contained within the sample size.

³⁴ University of Florida, 2007

9.3 Results

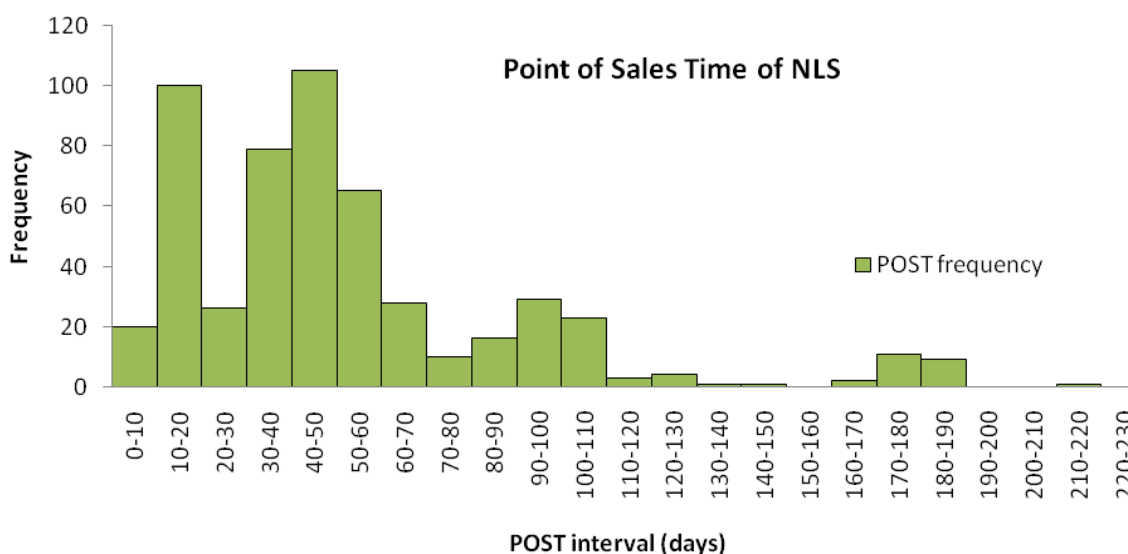
The average POST in the 5 provinces is 53.4 days with a standard deviation (SD) of 40.7 days. Table 19 below lists the average POSTs per province.

Table 19: Sample sizes and average POSTs in surveyed provinces

Province	Average POST (days) ³⁵	Sample size
Kampong Chhnang	34.5 (18.6)	104
Siem Reap	60.7 (41.3)	128
Kandal	60.2 (40.7)	103
Battambang	65.0 (62.6)	100
Phnom Penh	45.4 (7.0)	95
Average	53.4 (40.7)	535

The results show that in most provinces, the SD is very large. The SD is directly influenced by both the frequency of each quoted POST and the actual POST in days. To understand the effect of both influences on the SD, a histogram is depicted showing the POST frequency distribution (see Figure 13 below). The large value of the SDs can be explained by the occurrence of extreme values in the number of POST days.

Figure 13: Point of Sales Time of NLS

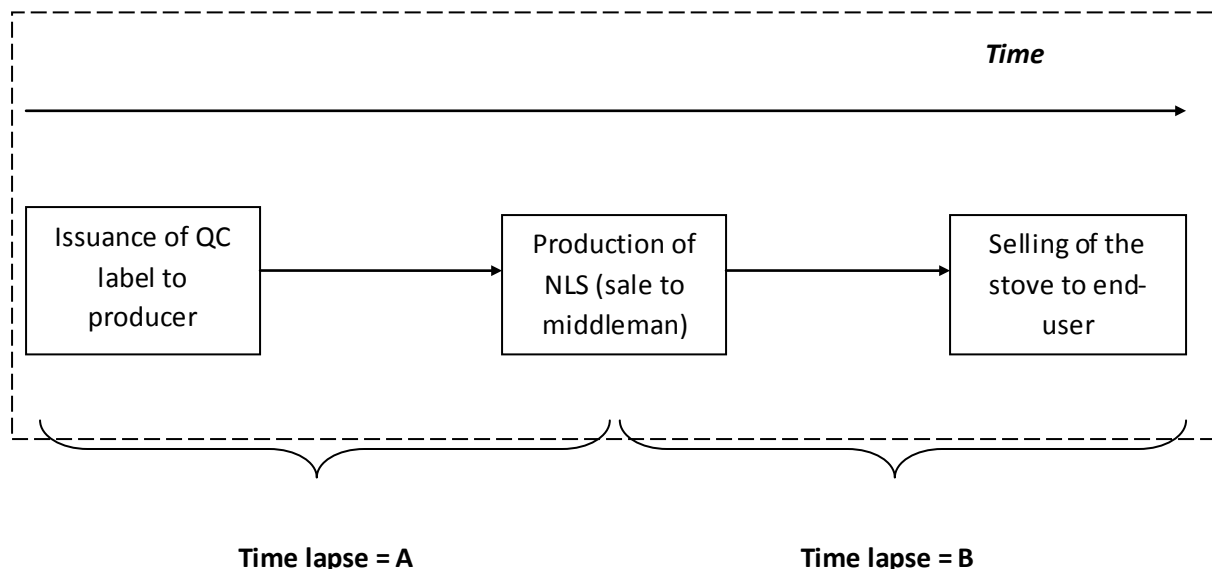


The average POST of 53.4 days is a conservative estimation because the average POST reflects the time lapse between the issuance of the QC label to the producer and the point of sale to the end-user,

³⁵ Standard deviation is in parenthesis

rather than the time lapse between the **actual point of production** and the point of sale to the end-user. Figure 14 below illustrates the time expenditure between the label issuance, label application and point of sale.

Figure 14: Time lapse between label issuance, application and POST



Total time (C) = A + B

Actual POST = B (time lapse between NLS production and point of sale)

Hence:

Actual POST = C – A, where C is the obtained average POST value of 53.4 days.

9.4 Maintaining a conservative approach

The obtained POST value is conservative, since it included the time lapse between the point at which the producers obtain the QC label and the point at which the producers label the produced stove. Producers generally apply labels in batches, rather than on a stove-by-stove basis, which means the delay between receiving and issuing the label could be in the order of weeks (since labels are issued monthly).

The assumption that the time lapse is in the order of weeks is further supported by the occurrence of extreme POST values, as shown in Figure 13. The extreme POST times, which skew the calculation of average POST, number 100 days or more and likely to reflect a very long time lapse between the obtainment of the QC labels and the labeling of the NLS. This could result from a number of situations, such as misplacement of the labels by producers, or using new batches of labels before using leftover labels from the previous month.

In addition, a proportion of the stoves are not sold by retailers; rather they are sold closer to the point of production, i.e. directly from the producers or a middleman. These cases were not incorporated in the calculations due to monitoring limitations.

Finally, in 2012, GERES' GIS & Database Specialist, Mr. PREY Sovann, developed a new data management system for tracking stoves, using SQL software, linked to a MS Access database. The database tracks stoves from the time that they leave the producer (sold by the producer to a middleman or end user) to the time they are sold to an end user. This data is gathered through the use of buying and

selling books, which are provided to all producers and certain middlemen and retailers. As demonstrated in Figure 2 (section 5.1.2), based on 2012 data, 92% of these stoves reached end users less than 40 days after they left the producer and the average POST time was 19 days. The lower POST time reflects improvement in distributors' transport systems (eg. fewer ox carts and more trucks and moto remorques); and improvements in GERES' monitoring system, which allows the POST to be tracked from the point at which the producers sell the NLS (rather than the point at which the QC label is issued to producers – see Figure 14 for further information) and provides more detailed and accurate data, encompassing larger sample sizes. **In spite of this evidence that the POST is considerably less than 53.4 days, in order to preserve a conservative approach, a POST of 53.4 days is used in the emissions reduction calculations.**

10 APPENDIX 4: TRANSPORT EMISSIONS

Monthly fuel prices were obtained through the random selection of fuel (gasoline and diesel) receipts from NLS activities during 2012, because publicly-available data on monthly fuel prices in Cambodia could not be located.

Tables 20 and 21 below summarise the details of the randomly-selected receipts. Total emissions from transport for 2012 is 23tCO₂e.

Table 20: Randomly selected gasoline receipts

Month	Staff	Description	Period Debit	Price (US\$/litre)
Jan	CTL	G M#CTL 12058 HFCT PNH	\$3.91	\$1.27
Feb	SMR	G M#2 90455 QC KCN	\$10.00	\$1.29
Mar	MBA	G M#16 39120 QC KCN	\$3.74	\$1.24
Apr	KSN	G M#4 10902 ICS MS KCN	\$5.48	\$1.37
May	DMH	G M#17 14509 ICS MS KCN	\$4.13	\$1.38
Jun	TSL	G M#14 68513 ICS MS KCN	\$3.59	\$1.32
Jul	SOP	G M#06 33625 ICS MS KCN	\$2.46	\$1.20
Aug	LST	G M#12 68078 QC KCN	\$2.86	\$1.18
Sep	SOP	G M#4 13105 ICS MS KCN	\$2.47	\$1.20
Oct	DMH	G M#18 13067 ICS MS Z4	\$3.98	\$1.31
Nov	MBA	G M#20 11649 QC KCN	\$3.64	\$1.21
Dec	SSL	G M#14 69401 ICS MS KCN	\$3.85	\$1.26

Table 21: Randomly selected diesel receipts

Month	Staff	Description	Period Debit	Price (US\$/litre)
Jan	NVN	D C#1 393059 ICS MS TKO	\$40	\$1.26
Feb	SSL	D C#3 329917 ICS MS BTB	\$56.25	\$1.25
Mar	SMR	D C#1 400151 QC KCN	\$55	\$1.32
Apr	NVN	D C#3 337163 ICS MS BTB	\$69	\$1.32
May	DMH	D C#3 339605 ICS MS BTB	\$65	\$1.29

Jun	NVN	D C#1 406424 ICS MS KPT	\$27	\$1.14
Jul	DMH	D C#1 407147 ICS MS PRV	\$45	\$1.15
Aug	NVN	D C#1 410144 ICS MS KCM	\$52	\$1.03
Sep	LMH	D C#1 44.88L ICS MS SRP	\$57	\$1.27
Oct	SMR	D C#2 55L QC BTB	\$58.50	\$1.05
Nov	DMH	D C#3 358374 ICS MS PST	\$57	\$1.27
Dec	KSN	D C#1 417186 ICS MS PRV	\$40	\$1.12

To calculate total consumption of each fuel, the equation below is applied. Table 22 outlines the sources of data used in the equation and Tables 23 and 24 outline the findings of the calculation.

$$E = C / F * NCV * EF$$

Where:

E = Total annual CO₂ emissions from transportation

C = Annual fuel consumption in litres (diesel or gasoline)

F = Factor to convert litres of fuel to tonnes of fuel (diesel or gasoline)

NCV = Net Calorific Value in TJ/t (diesel or gasoline)

EF = Emissions Factor in t/TJ (diesel or gasoline)

Table 22: Sources of data for transportation emissions calculation

	Value		Source
	Diesel	Gasoline	
C	4279	5229	GERES Cambodia Finance Department records
F	1185 litres/ tonne	1350 litres/ tonne	IEA/ OECD, 2004, <i>Energy Statistics Manual</i> .
NCV	0.043 TJ/t	0.0443 TJ/t	IPCC, 2006, <i>2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 1: Introduction</i> .
EF	69.3 t/TJ	74.1 t/TJ	IPCC, 2006, <i>2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 3: Mobile Combustion</i> .

Table 23: Gasoline emissions from NLS monitoring/ quality control, 2012

Month	Gasoline price (US\$/L)	Consumption (US\$)	Consumption (litres)	Consumption (tonnes)	Consumption (TJ)	tCO ₂ e
Jan	1.27	511.25	402.49	0.30	0.01	0.98
Feb	1.29	521.23	404.05	0.30	0.01	0.98
Mar	1.24	621.26	499.66	0.37	0.02	1.21
Apr	1.37	417.6	304.82	0.23	0.01	0.74
May	1.38	373.29	271.14	0.20	0.01	0.66
Jun	1.32	616.47	467.02	0.35	0.02	1.14
Jul	1.20	831.27	694.29	0.51	0.02	1.69
Aug	1.18	581.17	492.52	0.36	0.02	1.20
Sep	1.20	578.36	480.56	0.36	0.02	1.17
Oct	1.31	383.62	293.84	0.22	0.01	0.71
Nov	1.21	363.54	300.31	0.22	0.01	0.73
Dec	1.26	325.26	257.78	0.19	0.01	0.63
		6124.32	4868.48	3.61	0.16	11.84

Table 24: Diesel emissions from NLS monitoring/ quality control, 2012

Month	Diesel price (US\$/L)	Consumption (US\$)	Consumption (litres)	Consumption (tonnes)t	Consumption (TJ)	tCO ₂ e
Jan	1.26	317.18	251.73	0.21	0.01	0.63
Feb	1.25	530.79	424.63	0.36	0.02	1.07
Mar	1.32	725.50	549.62	0.46	0.02	1.38
Apr	1.32	427.00	323.48	0.27	0.01	0.81
May	1.29	347.00	268.99	0.23	0.01	0.68
Jun	1.14	471.50	413.60	0.35	0.02	1.04
Jul	1.15	457.00	397.39	0.34	0.01	1.00
Aug	1.03	420.00	407.77	0.34	0.01	1.03

Sep	1.27	498.00	392.13	0.33	0.01	0.99
Oct	1.05	396.50	377.87	0.32	0.01	0.95
Nov	1.27	318.00	250.39	0.21	0.01	0.63
Dec	1.12	340.00	303.57	0.26	0.01	0.76
		5248.47	4361.17	3.68	0.16	10.97