Ministry of Industry and Trade
General Directorate of Energy

LCEE LOW CARBON TRANSITION IN THE ENERGY EFFICIENCY
Vietnam-Denmark government cooperation in the energy sector

Embassy of Denmark

GREEN INVESTMENT FACILITY (GIF)

TSP Guideline

Production technology for non-fired brick

Approved Date: 25th April 2016

ENERGI STYRELSEN

VNEEP

Contents

Abbreviation

AMU	Administrative and Management Unit of GIF
EDK	Embassy of Denmark in Vietnam
EE	Energy Efficiency
ESA	Energy Saving Award
GIF	Green Investment Facility
LCEE	Low Carbon Transition in Energy Efficiency
DEA	Danish Energy Agency
CLC	Cellular Light Concrete
NFB	Non fired bricks
PMU	Project Management Unit
SBU	Standard Brick Unit
SEC	Specific Energy Consumption
TCVN	Vietnam Standards
SMEs	Small and Medium Enterprises
TSP	Technical Service Providers
VNEEP	Vietnam National Energy Efficiency Programme

1 Introduction

Green Investment Facility (GIF) is LCEE project's financial mechanism for promoting energy efficiency solutions for SMEs in brick, ceramic and food processing industries.

The guideline for EE solutions is mainly in technical point of view so that the TSP can use this guideline for their work in producing Pre-check and Post-check Reports following GIF requirements. In addition, the guideline sometimes provides information for SMEs to understand the specific requirements of the project in order to be eligible for GIF support.

TSP should use Application, Pre-check and Post-check Forms when following this Guideline.

In order to apply for GIF, the following steps need to be done by involving stakeholders:

The First step: SMEs, independently or with support from consultants, propose project idea to AMU with explanation of the solutions for energy saving or/and CO2 emission reduction and their expected investment plan. AMU will proceed to check the eligibility of the project idea with help from PMU (project management unit) if needed.

Result of this step: SMEs agree to prepare their applications and submit them to AMU. Standard Application Form will be provided to SMEs by AMU.

The Second step: SMEs submit their applications and required documents to AMU. AMU checks and accepts their applications and transfer them to TSP for pre-check of the EE investment project in SME.

Result of this step: SME application at TSP.

The Third step: TSP as an independent inspector goes to inspect in SME. The main duty of TSP is to foresee factors that can affect the success of project implementation; to check and estimate energy saving potentials of the proposed EE project, as well as check and revise investment items related to investment in proposed EE solutions and their total cost so that they are reasonable. After completion of the checking process, TSP completes Pre-check Report and sends it to AMU.

Result of this step: Pre-check Report at AMU office.

The Fourth step: AMU will send Pre-check Report to PMU and PMU will evaluate them, and then inform Evaluation results to AMU if all eligible criteria are met. AMU will inform SME to carry out borrowing procedures and invest in EE solutions. AMU will inform EDK for approval of loan guarantee and EDK will request Fund Holding Bank to issue Letter of Guarantee to lending banks for SMEs. In the most cases, the work can be done in parallel with pre-check work of TSP, and SME's application to lending bank and preparation for investment implementation.

Results of this step: SME invests in EE solutions, borrows loan and gets loan guarantee from GIF.

The Fifth step: After EE solutions are implemented and in operation for at least 800 working hours, AMU will request TSP to go to the field to inspect the actual situation of the EE implemented solution, check and calculate real percentage of energy savings of those EE solutions. After checking, TSP will finalise their Post-check Report and submit to AMU. AMU will send it to PMU to get approval.

Result of this step: Post Check Report written by TSP is at AMU Office and satisfied by AMU and PMU.

The Final step: AMU, based on criteria, informs EDK about EE award level and amount of money, so EDK will request FHB to transfer money to the SMEs loan account at lending bank.

Result of this step: Eligible SME receives ESA and money transferred to reduce SME's loan at lending bank.

The following standard forms are available at AMU office and on LCEE Website http://www.lcee.vn: Application Form, Pre-check Form, and Post check Form.

Based on some previously done solutions, the guideline has been prepared for known solutions. The above formats are only for general cases; there will be some difficulties in applying to each EE solution. In the future, the Guideline will be improved to cope with arising issues and Guideline for new upcoming EE solutions will be developed.

This TSP Guideline describes the works that need to be done by TSP when inspecting "Solution of Non-Fired Brick production".

2 The standard solution

2.1 Scope of standard solution

(Referring to Application form parts 4.1 and 4.2; Pre-check form parts 2 and 2.1).

This solution applies to investments in production facilities for production of

- Concrete blocks – vibrator or static compression

The solution considers on a case-by-case basis:

- Cellular Light Concrete (CLC) or Foam Concrete Blocks and Panels.
- Compressed mud blocks.

The solution does not apply to AAC's (aerated autoclaved concrete blocks).

The solution applies to investments in process equipment including raw material storage, internal transportation, batching, mixing, and forming. The solution does not apply to investments in peripheral structures such as buildings, roads, power supply etc.

2.2 Technical description of standard solution

(Referring to Application form parts 4.1 and 4.2, Pre-check report part 2, Post-check report part 1).

2.3 Energy and environmental benefits of non-fired bricks

As compared to fired bricks, the direct energy consumption for production of NFB is negligible. The production does not require any fuel input, and even for electricity the consumption is much less than for fired bricks.

The concrete blocks use cement as input to the production. When the energy consumption for the production of the cement used is included in the calculation, concrete block production consumes about 50% as less energy and contribute about 50% as less CO_2 emissions as compared to fired bricks[1]. The energy consumption for the production of the compacted mud bricks is considerably less than for concrete blocks.

2.4 The production process of concrete blocks

The production of concrete blocks consists of four basic processes: mixing, molding, curing, and cubing.

[1] Please refer to Project Identification form of the GEF UNDP funded project on NFB promotion: http://www.thegef.org/gef/sites/thegef.org/files/gef_prj_docs/GEFProjectDocuments/Climate%20Change/Vietnam%20-%20(4801)%20-%20Promotion%20of%20Non-fired%20Brick%20(NFB)%20Production%20and/PIMS%204546%20VIE%20NFB%20PIF%20110412.pdf

2.4.1.1 Mixing

1) The raw materials such as sand, crushed stone, and mineral admixtures, i.e. fly ash or bottom-ash (wastes from the thermal power plant) are stored outside in piles and are transferred into storage bins in the plant by a conveyor belt or by a wheel loader as they are needed. The Portland cement is stored outside in large vertical silos to protect it from moisture.

2) As a production run starts, the required amounts of sand, crushed stone, cement and mineral admixtures are transferred by gravity or by mechanical means to a weigh batcher which measures the proper amounts of each material.

3) The dry materials then flow into a stationary mixer where they are blended together for several minutes. There are two types of mixers commonly used. One type, called a planetary or pan mixer, resembles a shallow pan with a lid. Mixing blades are attached to a vertical rotating shaft inside the mixer. The other type is called a horizontal drum mixer. It resembles a coffee can turned on its side and has mixing blades attached to a horizontal rotating shaft inside the mixer.

4) After the dry materials are blended, a small amount of water is added to the mixer. If the plant is located in a climate subject to temperature extremes, the water may first pass through a heater or cooling system to regulate its temperature. Admixture chemicals and coloring pigments may also be added at this time. The concrete is then mixed for six to eight minutes.

2.4.1.2 Molding

5) Once the load of concrete is thoroughly mixed, it is dumped into an inclined bucket conveyor and transported to an elevated hopper. The mixing cycle begins again for the next load.

6) From the hopper the concrete is conveyed to another hopper on top of the block machine at a measured flow rate. In the block machine, the concrete is forced downward into molds. The molds consist of an outer mold box containing several mold liners. The liners determine the outer shape of the block and the inner shape of the block cavities. As many as 15 - 50 blocks may be molded at a time.

7) When the molds are full, the concrete is compacted by the weight of the upper mold head coming down on the mold cavities. With a modern production technology, this compaction may be supplemented by air or hydraulic pressure cylinders acting on the mold head. Most block machines also use a short burst of mechanical vibration to further aid compaction.

8) The compacted blocks are pushed down and out of the molds onto a flat steel pallet (or flat plastic pallet). The pallet and blocks are pushed out of the machine and onto a chain conveyor. In some operations the blocks then pass under a rotating brush which removes loose material from the top of the blocks.

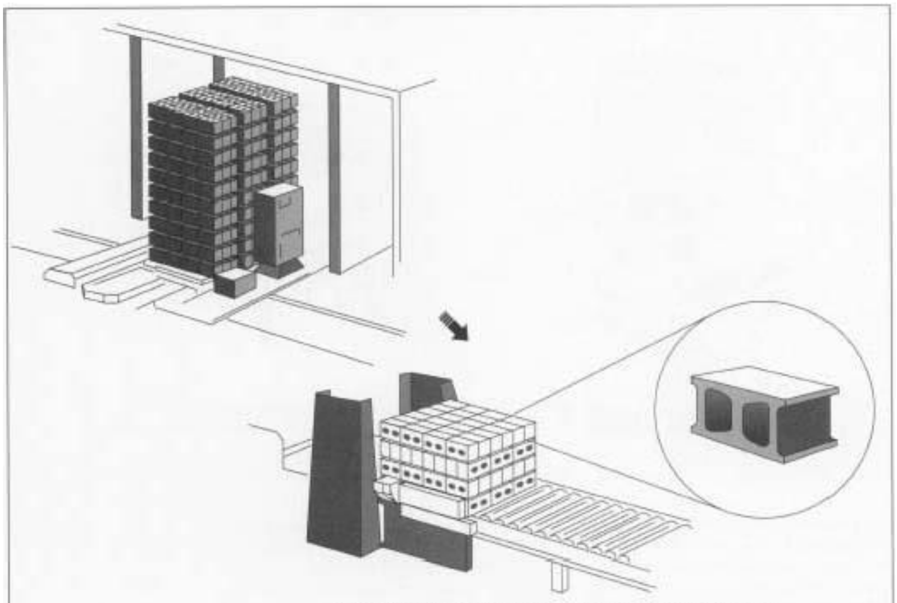
9) As the block travels down the belt, a rotating brush removes loose particles of aggregate from the top surface of the block. Afterwards the concrete blocks are placed into a curing chamber at normal temperature for at least 24 hours in order to harden and achieve the required mechanical properties before curing

2.4.1.3 Curing

10) Curing plays an important role on strength development and durability of concrete block. Curing usually takes place two days after concrete molding, and involves maintenance under

the desired moisture and temperature conditions, both at depth and near the surface, for extended periods. Properly cured concrete has an adequate moisture content for hydration and development of volume stability and resistance of concrete.

11) This curing process also helps decreasing porosity of concrete to assure the low water adsorption of concrete block below 12-14%, water permeability below 350 ml/m^2.h



Cured blocks pass through a cuber which aligns each block and then stacks them three across by six deep by three to four blocks high.

2.4.1.4 Cubing

12) Boards of cured blocks are removed from the curing chamber (or sprinkler system) and transported by the automated forklift to a stacking unit. Stacked blocks are then moved to an outdoor storage yard. Large quantities of blocks are stored until declared ready for transport to the construction site.

2.5 Quality Control

The manufacture of concrete blocks requires constant monitoring to produce blocks that have the required properties.

- The quality of raw materials must be monitored constantly.

- Cement: although it is possible to produce concrete blocks with any type of cement, in Vietnam cement PCB 30 is usually used for making concrete blocks.

- Aggregate (sand, bottom ash, crushed stone): plays an important role in creating a solid skeleton for concrete blocks. The optimum proportions of sand, bottom ash and crushed stone in the aggregate mixture should be calculated, it will help assuring the concrete block quality and economizing cement quantity.

- The raw materials are weighed electronically before they are placed in the mixer. The trapped water content in the sand, crushed stone, admixtures may be measured with ultrasonic sensors, and the amount of water to be added to the mix is automatically adjusted to compensate. At the end of the mixing cycle, the exact moisture level is controlled in order to avoid a mixture being too wet or too dry. In areas with harsh temperature extremes, the water may pass through a cooling system or heater before it is used.

- Mix design: The strength of concrete blocks is mainly dependent on the water to cement ratio and usage of excessive water will decrease the compressive strength of the blocks.

- Compression force and vibrating frequency: These technological factors also influence to the concrete blocks quality: high density and resistance, low water adsorption, low water permeability. Therefore, the machine has to work with stability with suitable compression force and vibrating frequency

As the blocks emerge from the block machine, their height may be checked with laser beam sensors.[2]

2.6 Possible factors affecting the success of the project

From the perspective of energy efficiency, the most critical factor is to keep the use of cement at the lowest possible level while at the same time keeping the expected brick quality. This is due to the fact that the cement is the most important contributor to energy consumption for production of non-fired bricks.

For a given strength required, the share of cement can be reduced through a well-controlled apportioning of raw materials as well as through an effective mixing of the concrete or through using admixtures such as: fly ash, slag…which reacts with $Ca(OH)_2$ from cement to form gel C-S-H (similar as hydration products of cement).

In the case of compressed mud bricks, there is no cement used and the total energy consumption for the production of these can be considered to be negligible as compared to fired bricks.

The commercial success of a NFB project is depending on several key parameters such as:

- Quality of the bricks: The brick or block quality mostly depends on the following factors:
  - The quality of raw materials;
  - The optimum concrete mix design (proportions of each component);
  - Effective mixing of the concrete;
  - Proper filling of concrete into molds (not too much, not too little);
  - Equipments in the production chain must operate stably and synchronously;
  - Curing system for concrete block (sprinkler system);
- High availability of the production equipment:
  - In Vietnam the experience with non-fired brick production is very mixed. Many technologies, especially small manual capacity production have a very high rate of break-down, incurring high costs of maintenance as well as reduced production output.

For concrete blocks the production technology should preferably:

[2] Description from http://www.madehow.com/Volume-3/Concrete-Block.html#ixzz3tWbtnqHv

- Use a combination of vibration and compression forming: most technology without vibration has frequent break-downs. This solution can be applied for a high capacity production, i.e. 20-30-40 million SBU per year. However, the noise pollution should be considered in this solution.
- Use the static compression forming: this solution can be applied for a small capacity production i.e. below 7-10 million SBU per year, and small investments.

2.7 Technical minimum criteria

(*Referring to: Pre-check report part 2 and Post-check report part 1)*

For concrete blocks, the following technical minimum criteria apply:

- The system must include automatic batching: the input of each composition must be automatically weighed before adding into the mixer;
- Mixing time should be automatic;
- Compositions of materials to produce concrete blocks have to be specified.
- The technology provided must be included in the list of suppliers in Annex 1.
- The production equipment must prove to be able to produce a uniform quality of bricks complying with the standard TCVN 6477: 2011.

In those cases, it assumes as concrete block and compressed mud blocks production consumes as less than 50% of energy and contribute as less than 50% CO_2 emissions as compared to fired bricks[3].

For compressed mud blocks and CLC blocks, due to no available national quality standard of these blocks at moment, SMEs have to register and be responsible to SME's product quality with local authority.

2.7.1 Economic assessment

(Referring to Application Form parts 4.4 - 4.6. Pre-check report part 2.1 and 3. Post-check report part 3)

Investment costs

The following types of costs are eligible for support from the GIF:

- System design costs;
- All production process technology including batching, mixing, forming and curing, inter-production transport equipment etc;
- Installation fees and technical transfer fees to SME.

Priority to technologies with high-level automation.

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[3] Please refer to Project Identification form of the GEF UNDP funded project on NFB promotion: http://www.thegef.org/gef/sites/thegef.org/files/gef_prj_docs/GEFProjectDocuments/Climate%20Change/Vietnam%20-%20(4801)%20-%20Promotion%20of%20Non-fired%20Brick%20(NFB)%20Production%20and/PIMS%204546%20VIE%20NFB%20PIF%20110412.pdf

2.7.2 Calculation of energy savings award

(*Referring to post-check report part 3)*

Referring to part 2.2.1 and 2.4, the energy savings award of concrete blocks, CLC and mud blocks will be 30% of loan paying forf eligible costs, provided that the project complies with the minimum criteria and is in continuous operation by the time of the post-check.

The following calculation method presented below is primarily to help the TSP to calculate the annual Energy Savings/CO2 reduction achievement by the project and report it in the Post-Check Report for PMU's database on LCEE indicators.

Depending on each enterprise investment, data in table 1 can be used as baseline to calculate total energy saving of each project. For new NFB investor, minimum baseline data should be used as tunnel kiln in table 1.

Table 1. Baseline Energy consumption of FCB manufacturing

No	Production technology for FCB	MJ/m³of bricks	MJ/SBU	Reference
1	Clamp kiln	3,042.65	4.22	Table II.3[1]
2	VSBK	1,870.22	2.59	Table II.5[1]
3	Tunnel kiln	2,281.34	3.16	Table II.7[1]
4	Hoffman kiln	2,080.27	2.89	Table II.9[1]

It should be aware of that fact: Energy consumption depends on the ratio of material mixtures to manufacture NFB. Standard material composition for NFB production can be referred to in Table 2:

Table 2. Concrete Block Energy demand and raw materials

(Per m³ using sand or stone dust as aggregate[4])

Parameter	Unit	Consumption using sand as aggregate		Consumption using stone dust as aggregate	
		Solid bricks	Hollow bricks	Solid bricks	Hollow bricks
Sand	kg/m³	2,055 (93%)	1121 (92%)	N/A	N/A
Stone dust	kg/m³	N/A	N/A	2,055 (93%)	1121 (93%)
Cement	kg/m³	145 (7%)	97 (8%)	145 (7%)	97 (8%)
Water	kg/m³	25 (5%)	15 (2%)	25 (5%)	15 (2%)
Electricity	kW/m³	< 5 kW	< 4 kW	< 5 kW	< 4 kW

[4] Gross density of final product solid concrete brick product of 2,200 kg/m³ and 1,218 kg/m³ for the hollow concrete block bricks

Reference of energy consumption of standard concrete block bricks using right material composition (table 2) is showed in the table 3:

Table 3. Concrete Block Energy consumption

Product type	MJ/SBU	$kgCO_{2e}/SBU$	$kgCO_{2e}/m^3$
Concrete solid block brick	0.67	0.149	107.39
Concrete hollow block brick	0.45	0.100	72.20

The application form as well as precheck should calculate the expected annual energy savings. The following method is applied.

Estimated total energy savings = $(X_1 – X_2) \times Y$

Where X_1: initial energy consumption per reference FCB SBU (table 1)

X_2: energy consumption per NFB SBU (table 3).

Y: Total annual NFB production capacity calculated in SBU.

Calculation of total energy saving during post-check should be based also on production process.

Real total energy consumption = $(X_1 – Z) \times Y$

Where X_1: initiall energy consumption per FCB SBU;

Z: post-check calculted energy consumption per NFB SBU

Y: Total annual NFB production capacity calculated in SBU.

2.7.3 TSP responsibility in Pre-check and Post-check

Necessary activities of pre-check:

- Check the compliance with the solution scope: the project should include only eligible components;
- Check the compliance with minimum requirements;
- Estimated energy savings and CO_2 reduction of the project;
- Check the overall feasibility of the project: location, raw materials, environmental impact assessment, layout, storage facilities etc;
- Review the project budget to secure that the overall budget is within range for the technology chosen
- Verify investment costs and payback period from application form and suggest revision if necessary
- Submit the below estimated energy saving calculation table and summarized result table in excel format containing all calculation formula for monitor and evaluation purpose.

- Calculate total annual energy savings and total annual CO2 emission reduction beneficent from the project. The submitted table is discribed below:

Energy savings and CO_2 reductions obtained from project				
	A	B	C	D
	Energy carrier or fuel	Annual Energy consumption before project implementation	Annual savings	CO2 reduction (tons/year)
1	**Electricity**	MWh/year	MWh/year	
2	Coal	TOE/year	TOE/year	
3	Oil	TOE/year	TOE/year	
4	LPG	TOE/year	TOE/year	
5	Natural gas	TOE/year	TOE/year	
6	Biomass	TOE/year	TOE/year	
7	Solar	TOE/year	TOE/year	
8	Other	TOE/year	TOE/year	
9	**Total Fossil Energy** (∑ 2…5, 8)	TOE/year	TOE/year	
10	**Total Renewable Energy (RE)** (∑ 6…7, 8)	TOE/year	TOE/year	
11	**Total Energy Saving** (C1+C9+C10)	TOE/year		
12	**Conversion to RE**	*(C9 in conversion projects)* TOE/year		
13	**Total CO2 Reduction** (D1+D8+D9)	Ton/year		

If the output capacity of the new solution differs from the baseline situation, the baseline energy consumption must be reduced or increased to the equivalent of the output capacity of the new solution. For example, if a new NFB output capacity is two times higher than the old brick kiln, the baseline coal consumption should be adjusted to correspond to this new production capacity:

- *Specific energy consumption for baseline multiplied by number of product output units for the new solution.*
- *The specific energy consumption for baseline must be determined in accordance with the specific guideline.*

Necessary activities of the post-check

The post-check can take place after a minimum of 800 operation hours of the investment.

- Check compliance with minimum requirements;

- Calculate energy savings and CO_2 reduction;
- Check documentation from accredited test bureau that the system produces blocks of sufficient quality to meet requirements, i.e Vietnamese standard TCVN 6477-2011 or any others that is applicable;
- Check enterprise's reports on the production and sales of concrete blocks.
- Verify investment costs and payback period from application form and suggest revision if necessary
- Submit the below energy saving calculation table and summarized result table in excel format containing all calculation formula for monitoring and evaluation purpose.
- Calculate total annual energy savings and total annual CO2 emission reduction beneficent from the project. The submitted table is discribed below:

Energy savings and CO_2 reductions obtained from project				
	A	B	C	D
	Energy carrier or fuel	Annual Energy consumption before project implementation	Annual savings	CO2 reduction (tons/year)
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2	Coal	TOE/year	TOE/year	
3	Oil	TOE/year	TOE/year	
4	LPG	TOE/year	TOE/year	
5	Natural gas	TOE/year	TOE/year	
6	Biomass	TOE/year	TOE/year	
7	Solar	TOE/year	TOE/year	
8	Other	TOE/year	TOE/year	
9	**Total Fossil Energy** (∑ 2,3,4,5,8)	TOE/year	TOE/year	
10	**Total Renewable Energy (RE)** (∑ 6,7,8)	TOE/year	TOE/year	
11	**Total Energy Saving** (C1+C9+C10)	TOE/year		
12	**Conversion to RE**	*(C9 in conversion projects)* TOE/year		
13	**Total CO2 Reduction** (D1+D8+D9)	Ton/year		

3 Annex

Annex 1. List of eligible Vendors of concrete block production equipment.

Application Form

TSP Pre-check Form

TSP Post-check Form

Annex 1. List of eligible Vendors of concrete block production equipment.

No	Vendor name and address
1	**Thanh phuc Company for mechanical and building materials** (CÔNG TY CỔ PHẦN CƠ KHÍ VÀ VẬT LIỆU XÂY DỰNG THANH PHÚC) Address: Hoang Quoc Viet, Ngoc Son Ward, Kien An District, Hai Phong City; Tel :(+84)31.3876.593/ 3876.318/ 3591.868 Fax: (+84)313.878.900; Website: www.thanhphuc.com
2	**Doan Minh Joint Stock Company** (Công ty Cổ phần Đoàn Minh Công) (DmCgroup) Address: 105 Yet Kieu, Hai Duong Province Presentative address: No. 1803, building CT2, 583 Nguyen Trai, Thanh Xuan, Hanoi. Website: www.DmCgroup.vn
3	**Duc Thanh Join Stock Investment and Technology Company** (Công ty cổ phần Đầu tư & Công nghệ Đức Thành) Office in the North: 2304 Licogi Tower, 164 Khuat Duy Tien Str., Thanh Xuan Dist., Hanoi Tel: 043 8541 666 - Fax: 043 8540 888 Office in the South: No. 4, Nguyen Ba Tuyen Str., Ward 12, Tan Binh Dist., Hochiminh City Manufacturing plant: Phuoc Vinh An, Cu Chi, Hochiminh City Điện thoại: 0862 830 666 - Fax: 0862 835 666 Website: www.DucThanhgroup.com
4	**QUNFENG INTELLIGENT MACHINERY CO.,LTD.** Address:NO.11,ZHITAI ROAD,QUANZHOU ECONOMY&TECHNIQUE DEVELOPMENT ZONE,FUJIAN Zip code:362005 Tel:86-595-22356782 fax:86-595-22356788 E-mail:trade@qunfeng.com web:http://www.qunfeng.com Vietnam Agency: Vu Linh Joint Stock company Address: 3-5 Nguyen Van Linh Str., Long Bien, Hanoi
5	Other vendors are subjected to verify and approve by LCEE NTA