Analysis and assessment of energy situation of brick industry in Iran

Sourena Sattari, Akram Avami
Internatinal Institute of Energy Studies (iies)
No. 14, Sayeh St., Valiasr Ave., Tehran, **Iran**

Fax: 982122021603

*Abstract: -*Concerns toward the magnitude and direction of energy-related technological change have long been recognized as critical determinants of the outputs and policy conclusions particularly in the case of old technologies in the developing countries which have much improvement potential. Brick industry in Iran is a necessity to concentrate for policy makers which consume 16 percent of energy consumption of total industry and has a critical situation with regard to technological indexes and energy intensity (two-times of the average energy intensity of world).
Current available technologies are machinery and traditional ones that still contributes a large portion in the magnitude of production. Even the machinery firms must be replaced their current technologies in order to increase efficiency, productivity and decrease the environmental impacts especially the old Hoffman kiln with tunnel kiln. There exists 62 million lit of fuel oil savings equivalent to 2.1 million $ in FOB prices per production ton in comparison with the world energy intensity. As a result of monitoring all producing units in the country during 2005-2006, the following significant results achieved for policy makers: supporting of establishment the new higher efficient units, planning for increasing the raw material quality, conversion the traditional units into industrial ones, introducing new standards.
This paper discusses the present situation of brick industry from the technological point of view and related indexes, the possible solutions to the industry, possible policies in terms of its current technologies and available standards, the impact of policies in the whole industry situation and the role of policy makers.

Key-words: **Brick industry, Energy Conservation, Energy auditing, policy, Iran.**

1 Introduction

The industry sector plays a significant role in global energy consumption. Construction industry is one of the most important industrial sectors in Iran which can play a vital role towards sustainable development. Sustainable construction can be achieved with re-use and recycling of materials, waste and energy minimization. Material production industries have been attributed to be one of the largest fuel consuming sectors of the economy. This indicates that saving in fuel consumption in these industries could have a substantial impact on total fuel demand. Brick belongs to the wide family of construction materials and is mainly used for the construction of buildings. Brick production industry requires large inputs of resources and causes several negative environmental effects. Studies indicate that brick manufacture has a large impact relating to energy use and carbon emissions.
Therefore, environmental aspects, energy intensity and economical views are integrated to each other which must be thoroughly considered in order to increase efficiency and decrease costs.
Construction activities consume more raw materials by weight than any other industrial sector. As much as 50% of all materials extracted from the Earth's crust are transformed into construction materials and products. These same materials when they enter the waste stream, account for some 50% of all waste generated prior to recovery.
Recently, there has been increasing interest in using energy analysis techniques for energy-utilization assessments in order to attain energy saving. Numerous studies have been published on energy audit and energy analysis results for analysis
Koroneos and Dompros analyses the different stages followed during brick production and the materials and energy used in each stage. They use life cycle assessment (LCA) methodology to provide a quantitative basis for assessing potential improvements in environmental performance of a system throughout the life cycle [1].
Subrahmanya probes energy intensity and economic performance in small enterprises with reference to two energy-intensive small

scale industry (SSI) clusters in the state of Karnataka in India. Based on analysis of primary data collected from 38 bricks enterprises and 31 foundries, he brought out that there is a positive relationship not only between energy intensity and share of energy cost in total variable cost but also between energy intensity and value of output. But there is a negative relationship between energy intensity and factor productivities [2].

He also probes the role of labor efficiency in promoting energy efficiency and economic performance with reference to small scale brick enterprises cluster in Malur, Karnataka State, India. He found that in the bricks industry, the technology in use being similar, labor efficiency has a negative influence on energy cost. Therefore, those enterprises that exhibited higher labor productivities had lower average energy intensity and higher returns to scale as compared to those that had lower labor productivities [3].

The present paper will study the energy situation and utilization efficiency of brick factories in Iran. It reviews the total situation of industry, studies the different aspects of infrastructure and evaluates it from the energy point of view. It also assets the possibilities to improve the efficiency and save energy based on energy auditing programs in which the basic amount of energy required is calculated and compared to real data available from site-visit. Opportunities from the point of energy- and financial- saving will be chosen in order to promote the energy situation of each factory.

The main objective of this paper is to present an overview of the Iranian energy sector, focusing on the evolution, reforms, and the current situation of brick industry in order to identify the potentials of improvement. These elements are needed for a better understanding of Iranian's energy problem and its current energy policies.

2 Current situations in Iran

26 percent of total energy consumption in Iran is contributed to industrial sector that involves 29% petroleum products, 60% natural gas and 11% electricity (Figure 1).

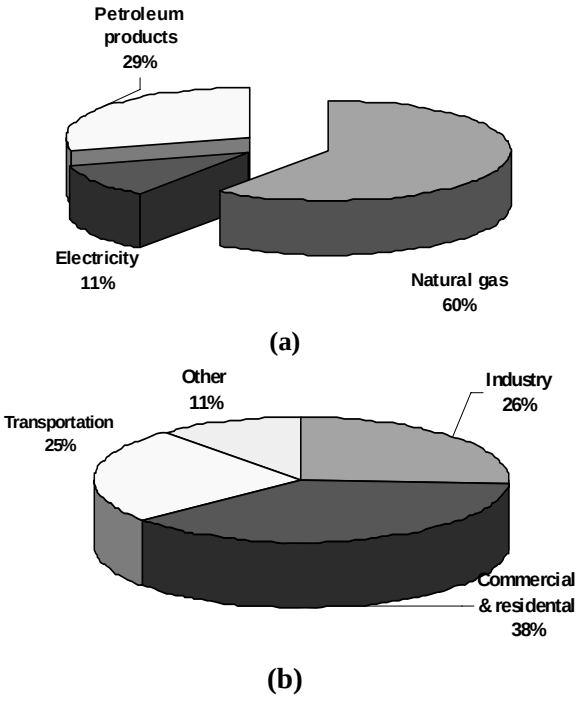

Figure 1 (a) Energy consumption (b) Quantities of energy carriers using in Industries (Iran, 2004) [4]

Figure 2 illustrates the trends of energy consumption in Iran from 1994 -2001. Currently the average yearly growth in industrial energy use is above 5%.

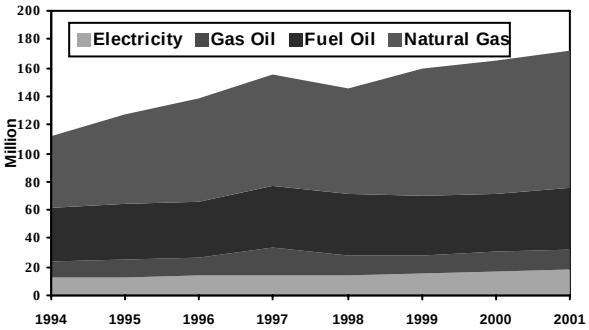

Figure 2 Energy consumption in Industries from 1994 -2001 [4]

There are different energy carriers used by different industries in these years, mostly toward the fossil fuels. Portion of oil products including LPG, kerosene, gas oil, fuel oil, and natural gas are changing due to governmental policies in recent years.

The leading policy of government in order to replace natural gas instead of other energy carriers emerge great increase in natural gas demand in 2005. A total reduction of 7.25 cubic meter of equivalent fuel oil in energy

consumption of industrial sector has been occurred in 2005 in comparison with 2003 as follow: 4.1 of LPG, 8.43 of gas oil, and 2.22 of fuel oil.

Since emissions are recognized to come primarily from energy consumption, organization and governments are engaged in developing methods of assessing energy efficiency. The contribution of industrial sector in releasing emissions is considerable. The following figures show different types of emissions released by industrial factories during recent years.

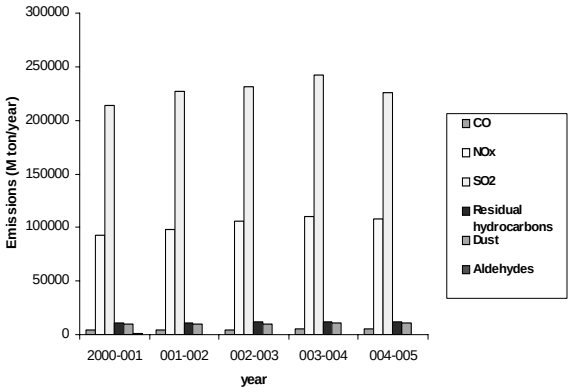

Figure 4 Emission gases produced by industrial section in Iran [4]

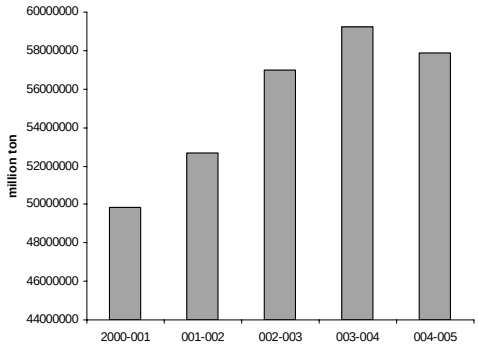

Figure 5 Total CO2 released by different industries [4]

On the other hand, energy efficiency improvement integrated with environmental management is the key to sustainable energy management.

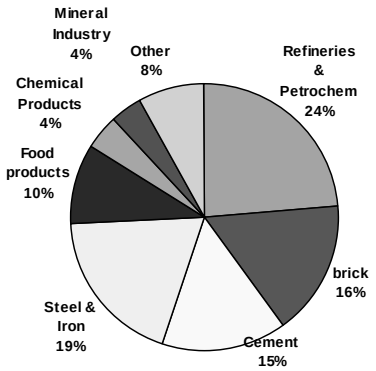

Figure 6 Energy consumption in different industries (005-006) [4]

Figure 6 also shows the amount of energy consumption by each industrial sector. The majority of processing industries still employ often 1960's and 1970's technologies, thus making it somewhat difficult to procure and furnish corresponding infrastructural investment for productivity gains.

SEC[1] is another important factor determines the energy situation in a typical industry. Figure 7 shows the gap between this index in Iran and world average in typical industries.

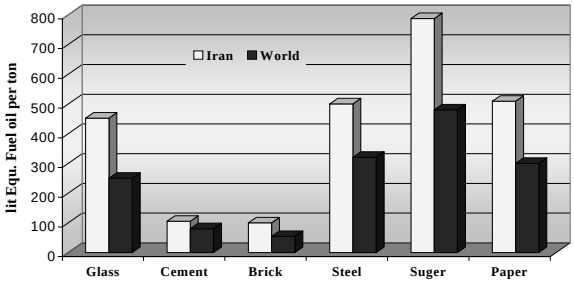

Figure 7 SEC index in Iran in comparison with the average of the world [4]

The total amount of energy consumption and also the deviation of the SEC for each section from the world average provide adequate information of the industry situation. As shown figure 6, brick is the third major energy-intensive industry and SEC index of this industry is two times of the average of the world (see Figure 7).

The specific energy consumption of brick factories has a great distance with the international standards and current old technologies need to special policies in order to upgrade their technological aspects.

[1] SEC stands for Specific Energy Consumption

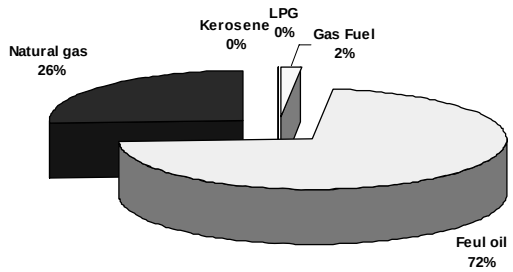

Figure (8) Different energy carrier used in brick industry [4]

At present, more than 6500 brick plants use more than 3780 million liter fuel oil and 120 million liter gas oil with over 53 million ton production capacity per year. Fuel oil is the main energy source (72%) in brick production (Fig. 8). Brick industry consumes 42% of total industrial consumption and is the major consumer of fuel oil. The following figure shows the diversity of brick production in the country.

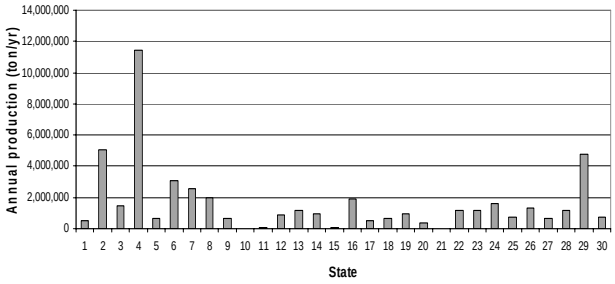

Figure (9) The annual production of each state [4]

Figure 10 illustrates the different amount of gas fuel and fuel oil consumed by each state in brick production units.

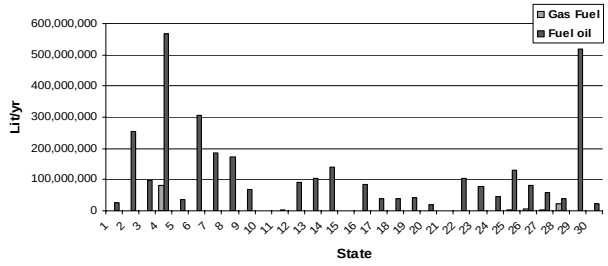

Figure (10) Annual consumption of gas fuel and fuel oil in each state [4]

3process description

Current available technologies are machinery and traditional ones that still contributes a large portion in the magnitude of production. Even the machinery firms must be replaced their current technologies in order to increase efficiency, productivity and decrease the environmental impacts especially the old Hoffman kiln with tunnel kiln or new technological furnaces such as SBF and microwave ones.

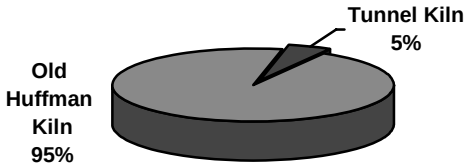

Figure (11) The Current Situation of Brick Industries in 2005 [4]

There are 95 % Hoffman and old technology kilns equivalent to 21 million and 5% tunnel kilns equivalent to 2 million per year in this industry.

The main manufacturing process consists of raw material preparing, drying and firing. The following subsystems are: (a) Mining and extraction (b) Preparation of raw material (c) Use of appropriate soil: The main raw material is Clay-Clay minerals. The basic ingredient of clay is kaolin (Al_2O_3,2 SiO_2, 2H_2O). Other chemicals are: SiO_2, Al_2O_3, $CaCO_3$, Fe_2O_3, Na_2O, K_2O, Mn, S, Mg, …. The percentage of kaolin affects the plasticity of clay. Clays with high content in kaolin are called greasy clays while the ones with low content are called non-greasy clays. Greasy clays have high water absorbency and when mixed with water have high plasticity, which makes them easier to process. Bricks constructed with greasy clay tent to fracture and shrink during the baking and drying processes. Non-greasy clay is harder to process but the bricks do not shrink or fracture during the baking and drying processes.

(d) Shaping and production of non baked bricks by add water in specific portion (more than 25% of humidity)

(e) Drying non baked bricks (f) Baking process (g) Packaging and storage of bricks.

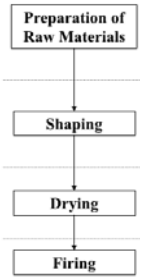

Figure (12) Overall schematic of brick production units in Iran

In traditional methods the drying process is done by applying the natural resources while industrial factories use drying equipments. Shaping is also done by hand in traditional units. Moreover, furnaces still consume a lot of resources and product quality is poor.

Table 1 The total amount of electrical consumption in brick making

Stage	Electrical consumption (KWh)
Preparation	2-12.5
Production	5-12.5
Drying	6.5-12.5

Especially, electricity and fuel are used extensively in this industry in order to obtain high heat temperatures for product in this sector. Baking of the bricks is the most energy intensive process.

Table 2 Required energy for different kilns

Type	Thermal required energy (kcal / kg)
Traditional	850-1000
Hoffman	320-520
Zigzag	300-500
Tunnel	310-600

Energy consumption share of each subsection in brick manufacturing is given in Figure 13.

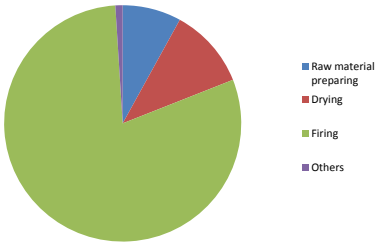

Figure (13) Energy consumption percentages in different stages of brick production [4]

4 Research methodology

Energy audits are the most comprehensive approaches to improve an existing system's energy efficiency. These audits can identify specific opportunities for increasing energy efficiency and lowering atmospheric emissions including carbon dioxides (CO_2), nitrous oxides (NO), and sulfur oxides (SO) and particulate. During 2005-2006, energy audits of approximately all production units of above industries have been conducted in Iran.

The energy auditing team does their job in two levels: primary and final auditing. At first, they study the historical consumption trends and technological information of the factory; identifying the potential of saving opportunities roughly and preparing the primary report. In the final stage they measure the electrical and thermal characteristics', plan the necessary experiments, calculate the intensity according to national standards for cement energy usage. They provide mass and energy balance in different sectors, identify waste streams and find the solution in order to descend these wastes. Finally, the possibility studies and economical calculations are done and the final report will be prepared.

Saving potential will lead to significant improvement in other integrated parts as direct and indirect savings such as requisite brick production, transportation of brick, decreasing the heat lost.

Some opportunities are as follow: recycling/reuse of scrap bricks, increasing the quality of raw material clays, appropriate selection of equipments according to physical and chemical characteristics of raw materials, sufficient support of upgrading technological level, planning to convert traditional units into modern efficient ones, planning to switch fuel, replacing kilns, training experts.

5 Results and discussion

Technological upgrading in the older industrial sections is inevitable and it has great influence both in the local and global industry situations and related sectors.

Brick industry in Iran has a critical situation with regard to the amount of consumption (4.2 % of total consumption), energy intensity

(two-times greater than that of the world average) and technological indexes.
As a result of monitoring all producing units in the country during 2005-2006, there exists 62 million lit of fuel oil savings equivalent to 2.1 million $ in FOB prices per production ton in comparison with the world energy intensity.
It is also determined that 1400 million lit of equivalent fuel oil will be saved through applying the specified quotas. The following table shows the present situation of overall brick industry in Iran.

Table 3 The present situation of brick producing units in IRAN in 2005 [4]

The total number of production units	6547	units
The main producing units	505	units
The total annual production	53	Million ton
Summation of fuel oil quota for brick factories	3800	Million lit per year
Summation of gas oil quota for brick factories	120	Million lit per year
Achievable savings due to applying gas oil quota	33	Million lit per year
Achievable savings due to applying fuel oil quota	1400	Million lit per year

Policy and solutions of the problem

Some solutions in improving energy efficiency in factories are as follow:
1-Baking in Hoffman furnaces is old and traditional and most of them use fuel oil as a major fuel and most energy consuming sector in industry is furnaces. So any attempt in order to optimization of energy consumption will lead to significant results.

Table 4 Current situation of energy intensity of different processes

Type of process	Iran	World
machinery	4.22 GJ/ton	2.18 GJ/ton
traditional	2.46GJ/ton	-

2-Types of soil as raw material have important influence on the quality of the product and baking temperature. The type of soil has crucial impact in determining of the baking temperature. The amount of calcium carbonat is the second important ingredients in baking of brick and color and dimension and temperature is directly affected. The following table shows the optimum condition for raw material.

Table 5 Different analysis of soil

Chemical Analysis	Min and Max Values	Optimal values	Typical analysis
L.O.I	3.49-17.38	4.9-9.1	18.21
SIO2	47.38-72.36	49.2-68	33.59
AL2O3	7.01-21.87	10.2-19.4	11.59
Fe2O3+ TiO2	0.8-8	2.7-3	2.13
CaO	0.05-17.04	0.3-16.5	16.98
MgO	0.38-5.16	0.5-2.9	4.98
K2O	0.5-4.86	1.3-4	2.58
Na2O	0.1-1.96	0.3-1.2	0.95

3-Energy recovery of bricks after baking: By measuring in typical factory, it is determined that 7-10 percent of energy input is wasted after baking.
4-Recycling / reuse of scrap bricks: They are collected and used as raw material for the production of tiles although a mixture could be reused onsite as additives for brick production contributing economically and environmentally to the production plant.
5-Upgrading to more efficient burners.
6-Automating gas control of the burners. This opportunity was incorporated into the upgrade of the new efficient burners in order to reduce energy consumption, and improve productivity and product quality through the maintenance of more stable temperatures.
7-Insulating the kilns and fixing heat leaks.
8-Improving electrical demand control through the installation of electrical metering.
9-Adding a door to the end of each kiln and a variable speed dryer to the fan. This will allow more air to be redirected back to the dryer. To investigate this opportunity, the company measured the heat energy exiting from the kilns to determine the likely savings that could be achieved by adding doors.
10-Fuel switching is costly in terms of capital costs and was initially a result of environmental issues and value of fuel oil. Opportunity cost from this replacement is

high for the country and it provides the feasibility of fuel oil export.
The remaining opportunities identified during the assessment will continue to be investigated and considered for implementation.

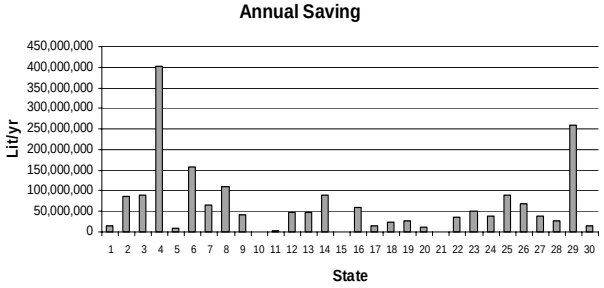

Figure (14) Achievable annual saving by allocating appropriate quotas in each state

The following significant results achieved for policy makers: supporting of establishment the new higher efficient units, planning for increasing the raw material quality, conversion the traditional units into industrial ones, introducing new standards, Awareness and Education.
An important contributor to energy efficiency improvement could be up-grading technology. Technological obsolescence has been a common feature of Iranian brick units across the sectors. Inefficient technology is bound to be energy inefficient as well, but up-grading technology across all factories would call for an enormous amount of investment at the macro level, and at the micro level, financial constraints would prevent many of the small producers from achieving energy efficiency by means of up-grading technology.
Given this, how to promote energy efficiency in brick production units is a major problem to policy makers in developing countries like Iran.

6 Conclusions

The aim of this study was to determine energy situation in Brick industry in Iran and the possible energy and financial saving potentials. Energy auditing is a powerful tool, which has been successfully and effectively used in the design and performance evaluation of energy-related systems.
Energy efficiencies of the all factories were analyzed too. It may be concluded that the analyses reported here will provide the investigators with a better, quantitative grasp of the inefficiencies and their relative magnitudes in evaluating the energy utilization performance as well as in developing energy policies for the country.
The upgrading and optimization of the industry structure is a long process and need governmental support. Iran should enhance energy technology innovation and should bring the R&D and industrialization of advanced energy technologies, on list of priorities, in line with the state mid- and long-term development plan.
Other major solutions include standardization, training and educational programs as a long term program, financial mechanism for energy management, and incentive programs, applying standards will help the industry to reduce energy costs in coming years.

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