Fuel Poverty and Comfort in Modern Residential Apartments in Developing Countries: A Case from Jordan

Nabeel AlKurdi and Abdulsalam A. Alshboul

Department of Architecture, Faculty of Engineering and Technology, University of Jordan, Amman 11942, Jordan

Abstract: Energy is one of the most important resources in the economy of developing countries. Jordan depends mainly on imported oil and gas at international prices. This creates a heavy burden upon Jordanian national economy, which is reflected in the same time on other sectors of the Jordanian society. The ever increasing fuel prices make it very necessary to look for new renewable energy resources. Jordan as a developing country with its fast growing urban development and construction projects will be studied. It is worthy to study the dynamic relationship between end user, fuel and comfort in the residential sector. Energy is a chronic problem in Jordan, due to lack of non renewable energy resources, the end consumer is influenced by this fact, in achieving his basic energy needs. This study tries to shed light on the fuel poverty line, definitions and parameters of fuel poverty. And to study what has been done in this regard on both international and local level. No studies have been identified in Jordan which, explore the problem of fuel poverty, especially after the vast and recent increase in fuel prices internationally and locally. This study will follow theoretical and field survey to understand the relationship between comfort, energy and building fabric. Method will depend mainly on field survey and statistical data, and necessary measurements, questionnaires will be adopted when necessary to explore comfort levels related to fuel consumption. Summary and recommendations will be concerned with how thermal comfort could be achieved within the ranges of fuel accessibility, building fabric, minimum pollution and cost.

Key words: Fuel poverty, household, residential sector, thermal comfort, primary energy, Jordan.

1. Introduction

Through the total life cycle of buildings, energy is needed for construction, operation and demolition. And this is almost valid under any climatic variation, this of course will be reflected on total building running costs.

Energy flows for any building which takes different fuel types and patterns, from the very fine type of energy like electricity on one hand, to the very crude form like diesel and kerosene.

Our study here is mainly concerned with the residential sector in Jordan for three reasons: First, a residence is occupied continuously for 24 h, and this requires maintaining the required level of comfort;

Second, this sector is almost the largest sector in the buildings stock in Jordan; The third reason, is the annual income for individuals who make it necessary to explore energy poverty in this sector, as an introduction to understand, evaluate and measure fuel poverty in this sector.

In Jordan, the number of home owners pays more money for maintaining the required comfort level in their homes; this is due to the successive increase in fuel prices, keeping in mind that a very slow increase in their salaries rarely happens. This in turn raises questions about quantifying fuel poverty in Jordan.

2. Definition of Fuel Poverty

Fuel poverty has been firstly introduced and identified since four decades, its social impact due to the insufficient energy consumption in the domestic

Corresponding author: Abdulsalam A. Alshboul, Ph.D., associate professor, research fields: technology of architecture, energy and buildings and environmental design. E-mail: alshboul@ju.edu.jo.

sector is evident [1].

Fuel poverty is a concept that may take various definitions, a standard qualitative definition first used by Lewis is: “The inability to heat the home adequately because of low household income and energy inefficient housing” [2], this definition was modified by Healy and Clinch [3].

One of these definitions that is used in policy-making is: “A household is in fuel poverty, if in order to maintain a satisfactory heating regime, it would be required to spend more than 10% of its income on all household fuel use including housing benefit or income support for mortgage interest [4]”. Boardman [5] introduced another definition: “It is the inability to obtain adequate energy services for 10% of household income”.

According to Morrison and Shortt [6], several factors affect the concept of fuel poverty, they argued about the preciseness of the definition of fuel poverty, and were called for greater clarity as regarding to income and adequate energy services.

Fuel poverty has certain consequences on health, especially on the elderly, this may lead to a physiological condition in humans known as “cold strain” which may result in cardiovascular and respiratory systems of the elderly, and at worst, chronic strain can result in fatal conditions and mortality [1].

3. Previous Studies and Literature

Studies regarding fuel poverty have been implemented all around world, specifically in Ireland. A project has been made by the British government to alleviate fuel poverty in England which has been conducted, where semi-structured interviews were carried out in a sample of 49 households of those who received energy improvements in five British districts, most householders reported an improved physical health and comfort, little evidence showed lower heating bills in this study [7].

In Scotland, the Scottish executive was concerned

with eradicating fuel poverty by 2016, a first step was made by knowing which areas are more likely to contain fuel-poor households, this was done based on local area fuel poverty indicators and on a small area statistics.

Morrison and Shortt [6], proposed an innovative methodology for refinement of the Scottish fuel poverty indicators using GIS software as a framework.

Shortt and Rugkasa [8] reported the findings from an evaluation of fuel poverty program in the Armagh and Dungannon Health Action Zone in northern Ireland. Researchers found that improving energy efficiency in households within the area under investigation, raises the level of thermal comfort and improves health as well, they also concluded that decreasing fuel poverty requires commitment from multiple sectors of society including health professionals and local communities [1, 8, 9].

Another important study was conducted to understand the effect of changing of fuel prices on the ability of household consumers to pay for energy and water this time, this study was done by Tepic and Fankhauser [10] which found that delaying tariff reform by few years makes little difference to affordability constraints, and may not be an effective way to mitigate the social impact of utility reform.

In India, an assessment of the extent of energy poverty and changes in energy distribution patterns are analyzed by applying a novel two-dimensional measure of fuel poverty. Also, they showed the elements of access to different energy types and quantity of energy consumed. It was recommended to apply such new measure to other developing countries [11].

Lenzen et al. [12] analyzed and quantified energy requirements of Sydney households in Australia, where they used input-output analysis with detailed household expenditure data aimed at reaching comprehensive energy use patterns for household consumers, study is applied on fourteen statistical subdivisions of Sydney, data were interpreted using

multivariate regression. Lenzen et al. [12] found strong correlation between energy use and income, household size, age and degree of urbanity. Researchers used structural path analysis to discover the relationship between lifestyles and different energy use characteristics.

In Jordan, few researchers tackled the issue of energy demand and poverty. Jaber and Probert [13] wrote about this issue, they detailed Jordan's pattern of energy use, energy pricing policy, energy types and access, as well as to urban households. And finally they discussed pollutions dissipated from total energy consumption [14].

Researchers in Jordan found no studies to explore the concept of fuel poverty in terms of its economic, social and health measures. All studies may be related to statistical data about energy types available in Jordan's market and some related pollution issues.

4. Measures of Fuel Poverty

Fuel consumption can be measured through different levels of the fuel supply chain, they may be summarized as follows:

- Primary energy which is the energy embodied in natural resources;
- End-use energy which is the energy content of fuel supplied to the consumer at the point of end use, electricity at the electric current meter for example;
- Useful energy which is the energy that has been

transformed in the form required for actual use;

- Energy services which is the direct demand by a householder like a hot shower for example.

Different approaches may be followed to measure fuel poverty, they may be stated as shown in Table 1.

Referring to Table 1, Goldemberg estimated basic primary energy needs to be 500 Watt per capita which was based on direct observation of his own energy basic needs, while the Advisory Board on Energy assumed that about 30 Watts of useful energy is needed per capita to meet cooking energy needs, and about 1.5 Watts of useful energy per capita are required to meet space heating needs, and the same amount is needed for lighting needs per capita.

The above mentioned values were calculated on the basis of various assumptions regarding what is considered as the basic minimum required to meet human needs, they count for a total of 33 W of useful energy per capita which is equivalent to almost 250 W of primary energy, which is the half of what Goldemberg has estimated [11].

5. Energy in Jordan and End Consumers

The main problem in Jordan resides in the fact that Jordan has very limited natural energy resources and it depends mainly on imported fuel to satisfy country's energy demands and needs. In past times, Jordan imported fuel from neighboring countries by special offers, which was reflected on alleviating the problem of energy demands in Jordan. Nowadays, there is no

Table 1 Approaches and procedures for measuring fuel poverty.

Measure or approach	Definition and description	Procedure
Economics-based approaches [15]	By defining an energy poverty line or fuel poverty line.	Making calculations to the average level of energy consumption of persons having a level of income or expenditure officially specified by the poverty line or minimum amount needed to meet basic needs.
Engineering-based approaches [16]	Engineering type estimates for determining the direct energy required to satisfy basic needs. And it is estimated to be about 500 W per person per time unit according to Goldemberg estimates.	This is based on a number of assumptions: type of energy consuming equipment, their sizes, efficiencies and intensity of use, the definition of basic needs.
Poverty and access to energy measures	This is achieved by determining access to energy services. As access to more efficient energy sources is related to an improvement in peoples level of well-being. A consumption based measure of energy poverty [17].	

opportunity but to buy fuel from the international market, following the international fuel prices.

Our study is concerned mainly on household energy consumptions, very few studies has been done to study energy demands, consumption and fuel poverty in Jordanian households. There is a need to study measures for fuel poverty in households, because researchers think that day by day the number of household occupants who falls in fuel poverty zone, increases continuously. A need to assess energy quality and energy access is of prime importance as well as it is directly related to the concept of fuel poverty.

As to Jordanian households, ever increasing fuel prices makes it probable that some households lie below the line of those who cannot satisfy their basic energy needs, and may find some difficulties to energy access.

Energy access to Jordanian households is directly related to fuel types used in homes and residences, Table 2 shows end use energy consumption in households in 2000-2005 as well Table 3 shows the development of fuel prices in five years.

Energy consumption for the individual in Jordan increased from 1,015 toe in 2000 to arrive at 1,281 toe in 2005, achieving an annual growth of 4%, and 1,218 kWh to 1,586 kWh in the same period, achieving 4.5% annual growth (Fig. 1) [18].

6. Power Requirements of Energy Services in Households

The average size of Jordanian family is decreasing with time because people are now trying to control new borns because of the high life costs, we may consider that the average size of the Jordanian family is six members household [20].

Table 2 End use energy consumption in households in 2000-2005.

Households	Year					
	2000	2001	2002	2003	2004	2005
End use energy consumption (TOE) × 1,000	881	849	868	945	1,007	1,060
End use electricity consumption in households (GW)	1,981	2,110	2,266	2,471	2,745	2,975

Fig. 1 Primary energy (a) and electricity consumption prediction (b) in Jordan for the coming 12 years [18].

Table 3 Development of fuel prices between 2000-2005 [19].

Fuel type	Unit price	Year					
		2000	2001	2002	2003	2004	2005
LPG (liquefied petroleum gas)	Fils/unit	2,080	2,400	2,500	3,000	3,250	3,750
Kerosene	Fils/L	91	110	120	130	135	220
Solar	Fils/L	106	110	120	130	135	220
Electricity	JD/t	72.5	72.5	77	82	88	180

1 Jordanian Dinar = 1.5 US\$. 1 Fils = 0.001 JD

Energy requirements for the average sized family in Jordan that may ensure acceptable level of life quality has not been estimated until this moment. Calculating basic energy needs for the average household in Jordan, by calculating the end use energy requirements for specific energy services, is an important step, many factors should be determined before starting any estimation of those basic energy needs like, fuel type used, yearly expenditure per capita, household size, household composition for different regions in Jordan.

Household composition is an important factor since young children and elderly people eat less than working adults, therefore, less energy is required for cooking for these members. Meenakashi and Ray [21] performed simultaneous estimation of a system of share equations to determine the scale and composition effects on expenditure shares in India, which showed effective and considerable results in Indian states. Similar work needed to be implemented in Jordan so that basic energy needs could be quantified on a statistical base [11].

7. Analysis of Energy Consumption Patterns in Residential Apartments

Residential apartments were always occupied by a wide variation of occupants who have different monthly incomes. Many of those occupants work in public sector, others are involved in private sector activities.

This work explored the middle income people, an example of these strata is well represented by school teachers working in public schools.

The total number of teachers working in public sector exceeds one hundred thousand teachers, which is considered as one of the largest sectors (Ministry of Education, 2013). It is important to mention here that the range of monthly salary for public school teachers ranges from 280 JD minimum up to 700 JD maximum for a teacher of twenty years' experience.

The field survey was applied on apartments

occupied by teachers only, future work may be done to extend this investigation to further house types. Also, a further study may be applied to other different income groups in Jordanian society.

A specific residential zone was chosen for the purposes of this study, picking up only apartments occupied by school teachers. The zone was a neighborhood near Sweileh, a district of Amman city. Related data is shown in Table 1.

The concept about measuring fuel poverty in this study was based upon the monthly net salary for the home owner, according to the definition of fuel poverty previously mentioned in the literature, a 10% of the net salary was calculated, and this value expresses the threshold poverty value for each home owner.

A sample of 25 apartments, were selected for analysis, the net area for each apartment, family size and monthly energy consumption by type were recorded. Fig. 2 shows an example of the architectural layout of one of the studied apartments.

The studied sample shows that all the monthly income for the sample does not achieve the minimum requirements for ensuring minimum energy demands. The 10% of the net monthly income is too small to follow the increasing energy costs.

Therefore, there is an evident proof that some of apartment owners of the total population are under fuel poverty line, whether this conclusion applies for other samples, needs further investigation.

The consequences of this conclusion, imply poor heating, poor cooling, and this is definitely reflected on the comfort inside those apartments, and health problems may arise.

Energy prices are increasing in Jordan on one hand, on the other hand, the net monthly income is increasing very slowly. This fact means that an increasing gap exists between the fuel poverty threshold value and the total energy costs in apartments.

In Fig. 3 as shown, each energy type still below the threshold fuel poverty value, for the three energy

An example of the studied apartments

Fig. 2 Example of the architectural layout for one of the studied apartments.

types, electricity, LPG and fuel, but the total summation of them is taken, this new value is always above the threshold fuel poverty value. This indicates that overall energy consumption is still an important problem for home owners. The problem gets more complicated if we know that an expected rise in energy costs is always probable.

While in Fig. 4, it is evident that the largest energy consumption in the studied apartments was electricity consumption, other fuel types and the LPG domestic were close to each other, and this is clear since the electricity is needed, and many devices were used. The LPG in apartments is used only for cooking, and in some instances for heating, this explains the reason why they are low in cost values.

8. Conclusions and Recommendations

Crossing through the survey that has been analyzed

previously, scientific work has been done exploring this issue on the international level, locally on the national level in Jordan, no work has been implemented to investigate and quantify basic energy needs for the average household.

It is not only important to have detailed statistics about end use energy consumption, but it is more important that we understand how this energy is consumed and the patterns of final energy consumption, especially, if we know that the average end use energy percent in the household sector was 22.7% of the total energy consumption in Jordan for the years 2000-2005.

Another factor that should be studied and explored in the Jordanian household sector is energy access, which means the ways of reaching different fuel types and this is related to expenditure per capita for energy consumption.

Fig. 3 Relationship between monthly income, average total energy costs and threshold fuel poverty value (JD).

Fig. 4 Total energy costs arranged by type: electricity, fuel, domestic LPG.

In this context, it is important to be aware of the fact that utilization of renewable energy resources is a must. And there should be policy strategies for public awareness about energy consumption savings on both national and personal level.

Further studies must be implemented to explore the facts about fuel poverty lines for other home owner categories, unless this step is made, there is still something missing about fuel poverty line, and this shortage in implementing more work about this will not enable the government to draw policies about

energy consumption, supply and management in Jordan.

At this end, one can draw a poverty line for households in Jordan based on real energy consumptions per capita of households, an issue which will enable policy makers to draw policies about how to shift such line and to exclude households from being under the line of fuel poverty.

Research remains open for investigating effects of family size and composition on energy use patterns in households in Jordan and probable increase in

consumption during the coming 20 years, and this will remain a rich research field.

References

- [1] J.D. Healy, J.P. Clinch, Fuel poverty, thermal comfort and occupancy: Results of a national household-survey in Ireland, *Applied Energy* 73 (2002) 329-343.
- [2] P. Lewis, Fuel Poverty Can Be Stopped, National Right to Fuel Campaign, Bradford, 1982.
- [3] J.P. Clinch, J.D. Healy, Alleviating fuel poverty in Ireland: A program for the 21st century, *International Journal for Housing Science* 23 (4) (1999) 203-215.
- [4] B. Boardman, S. Darby, G. Killip, M. Hennells, C.N. Jardine, J. Palmer, et al., Calculating the Environmental Impact of Aviation Emissions, Environmental Change Institute, University of Oxford, Oxford, 2005.
- [5] B. Boardman, Fuel Poverty: From Cold Homes to Affordable Warmth, Belhaven Press, London, 1991.
- [6] C. Morrison, N. Shortt, Fuel poverty in Scotland: Refining spatial resolution in the Scottish fuel poverty indicator using a GIS—Based multiple risk indexes, *Health and Place* 14 (2008) 702-717.
- [7] J. Gilberton, M. Stevens, B. Steill, N. Thorogood, Home is where the hearth is: Grant recipients' views of England's home energy efficiency scheme (warm front), *Social Science and Medicine* 63 (2006) 946-956.
- [8] N. Shortt, J. Rugkasa, The walls were so damp and cold' fuel poverty and ill health in Northern Ireland: Results from a housing intervention, *Health and Place* 13 (2007) 99-110.
- [9] J.D. Healy, J.P. Clinch, Quantifying the severity of fuel poverty, its relationship with poor housing and reasons for non-investment in energy-saving measures in Ireland, *Energy Policy* 32 (2004) 207-220.
- [10] S. Fankhauser, S. Tepic, Can poor consumers pay for energy and water?, An affordability analysis for transition countries, *Energy Policy* 35 (2007) 1038-1049.
- [11] S. Pachauri, A. Mueller, A. Kemmler, D. Spreng, On measuring poverty in Indian households, *World Development* 32 (12) (2004) 2083-2104.
- [12] M. Lenzen, C. Dey, B. Foran, Energy requirements of Sydney households, *Ecological Economics* 49 (2004) 375-399.
- [13] J.O. Jaber, S.D. Probert, Energy demand, poverty and the urban environment in Jordan, *Applied Energy* 68 (2001) 119-134.
- [14] J.O. Jaber, M.S. Mohsen, S.D. Probert, M. Alees, Future electricity-demand and greenhouse-gas emissions in Jordan, *Applied Energy* 69 (2001) 1-18.
- [15] V. Foster, J.P. Tre, Q. Wodon, Energy prices, energy efficiency, and fuel poverty, Working Paper, Latin America and Caribbean Regional Studies Program, The World Bank, Washington, DC, 2000.
- [16] J. Goldenburg, T.B. Johanson, A.K.N. Reddy, R.H. Williams, Basic needs and much more with one Kilowatt per capita, *Ambio* 14 (4-5) (1985) 190-200.
- [17] A. Barnett, Energy and Fight against Poverty, Livelihood Sector report, DFID (Department for International Development), UK, 2000.
- [18] Ministry of Energy and Mineral Resources, Annual report of 2006, Amman, Jordan.
- [19] Price development of fuel prices between 2000-2005, in: Eighth Arab Energy Conference, Amman, Jordan, May 14-17, 2006.
- [20] The Average Size of the Jordanian Family, Department of General Statistics, Amman, Jordan, 2012.
- [21] J.V. Meenakshi, R. Ray, Impact of household size and family composition on poverty in Rural India, in: ASARC Working Papers 2000-2002, The Australian National University, Australian South Asia Research Center, 2002.