# Sustainable issues in low-middle income apartments in urban Amman/Jordan: heating devices and health concerns

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## Abstract

Energy security constitutes a major challenge for sustainable development of the Kingdom of Jordan. This has led the Ministry of Energy and Mineral Resources to integrate a comprehensive energy master plan for developing the energy sector by 2029. Of the total residential energy consumption, 61% is consumed for heating spaces. GHG emissions produced by domestic stock in Jordan are anticipated to increase by 59% by 2018. Most households heat their houses using traditional devices such as portable unflued kerosene and LPG stoves. Combustion of such heaters generates toxic by-products causing symptoms and illness among residents as a result of poor indoor air quality.

This paper discusses aforementioned issues in view of urban low-middle income apartments in the capital Amman, aiming towards investigating types of stoves used and health implications associated with using them. A representative sample of 106 low-middle income households in urban Amman have been surveyed, through semi-structured interviews, to explore how they responded to the environmental conditions. Results showed that unflued kerosene and LPG stoves were used for heating spaces by around 39% and 89% of the total surveyed households, respectively. It was also found that almost 65% of them used more than one device for heating their apartments. Furthermore, around 50% of those households reported different health problems related to asthma which could partially be due to the use of these heating devices.

The field study also showed that almost 75% of households lived in apartments constructed with external envelopes of cement hollow blocks leading to poorer fabric performance.

The paper concludes with calling for thrift retrofit interventions for existing low-middle income apartments and raising inhabitants' awareness towards the proper use of stoves. This would enhance their thermal comfort, reduce carbon emissions and help improve residents' quality of life, which eventually would contribute in ameliorating related health issues.
*Key Words: Sustainable Development, Urban Amman, Low-Middle Income Apartments, Energy, GHG Emissions, Unflued Stoves, Health Issues, Retrofit.*

## 1 Introduction

Jordan's sustainable development is being faced by energy security as a major challenge. This has stimulated Ministry of Energy and Mineral Resources (MEMR) to develop and integrate a comprehensive master plan for energy - approved by council of ministers in 2004 - aiming towards developing energy by 2029 [1]. Alkurdi et al. [2] even went further to describe problem of energy in Jordan as "chronic", attributing this to the lack of the kingdom into natural resources of energy and its dependence on import for providing most of its energy needs, which makes energy sector vulnerable to international energy prices [2]. As a result, the ever escalating trend of fuel prices in Jordan has negatively affected low-income class of the society [3]. Moreover, dominant thermal load at residential stock in the country is heating, as around 61% of energy consumed by this sector is consumed for heating spaces [4, 5]. This purpose of heating also represents around 14% of total annual demand on national energy [4].

Most households in Jordan still heat their houses using traditional unflued kerosene and LPG heaters in addition to fixed flued stoves [4], which - according to Jaber [6] - results in producing indoor pollutants and emitting $CO_2$ to the atmosphere. For example, combustion of kerosene fuel involves serious health and environmental hazards [6]. Yet, large number of dwellings in Jordan experience significant amounts of energy losses [7]. This could be attributed to the claim stated by Johansson et al. [8] on the lack of buildings constructed last decades in Jordan into well adaptation to the climate which makes them vulnerable to more energy consumption for cooling and heating purposes.

Accordingly, by 2018 Greenhouse Gas (GHG) emissions produced by residential stock in the kingdom are expected to jump by 59%, based on 2008 levels [7]. Hence, this paper figures out types of heating devices used in low-middle income apartments in urban Amman – based on the reviewed literature and the conducted survey – with highlighting their health implications.

## 2 Background

### 2.1 Jordan, an overview

The kingdom of Jordan is an "upper-middle income country" [9], highly urbanised [1] with the highest of around 38.7% of its $6{,}530X10^3$ estimated population lives in the capital Amman [10], the "economic and industrial hub" of the kingdom [11].

According to data derived from Department of Statistics in Jordan (DoS) by Younis et al. [12], Jordanian society could be divided into four categories, namely: *Below Poverty, Below-Middle income, Middle income and Affluent* classes, as the first two classes form the *Low-income* group. The same researchers also found in their study that low-middle income households – which constitute a high of around 74% of total urban households in the capital Amman – seems to be vulnerable under energy crisis in the kingdom [12].

Energy in Jordan has been described as "chronic problem" due to kingdom's lack in natural resources [2], as around 95% of its energy needs are imported [13]. Around 30% of total energy consumed in 2009 was attributed to the residential stock [13], with round 61% of total consumption in Jordanian houses is attributed to heating spaces [4, 5]. Moreover, in their study, Al-Ghandoor et al. [7] have concluded that demands on fuels and electricity are anticipated to surge by 23% and 100%, respectively by 2018, which would consequently have implications of 59% jump in GHG emitted by residential stock by the same year, stimulating application of robust energy conservation measures as urgently needed. The researchers considered the population variable in their empirical models due to the positive correlation between population growth and the energy demand of residential sector [7].

Large amounts of Jordan's financial resources have been invested in construction industry [8]. According to a government's report, around 32,000 dwellings are yearly demanded in the kingdom, divided between two needs: new construction and upgrade of existing units [1]. Moreover – according to a report on "Jordan Poverty Reduction Strategy" – apartments form 73% of housing stock in the country, which constitutes more than 80% of total buildings across all Jordanian cities [1]. However, energy efficiency of houses in Jordan is substantially affected by significant energy losses [7], given that buildings erected last decades in Jordan are claimed to be "not well adapted to the climate", which would imply the need for more cooling and heating loads [8]. Furthermore – according to Jaber [6] – only 5% of residential stock in Jordan is wall insulated.

Given the above discussions, it's worth highlighting the heating devices used by the vulnerable classes of the society, namely low-middle income groups and health hazards implications associated with their use. The following section will discuss those two issues.

## 2.2 Heating devices used and their health implications

### 2.2.1 Overview

Heating water and spaces in Jordanian dwellings is mainly dependant on combustion of fossil fuels [4, 6], as kerosene and LPG were found to be the most dominant and popular fuels used for these purposes [4, 6, 14], which would have significant $CO_2$ pollution implications [4, 6]. Portable heaters are the most commonly used devices across the households, particularly by low-income classes [4], to cut heating energy costs [6]. For example, according to statistical data analysed of the household survey for the years 2006, 2008 and 2010 – it has been found that kerosene/diesel and LPG heaters were the dominant types used by low-middle income households in urban Amman over these periods [12]. Younis et al. [12] also continued to figure out that these households constituted around 87% of total households in urban areas of the capital, who used kerosene for heating their apartments [12]. Jaber et al. [4] claimed that reliance of *poor* households on using kerosene for heating purposes comes from their use of cheap kerosene based heaters which could simultaneously be utilised both for space heating and cooking. This type of dual usage, claimed for the kerosene based heater, has also been reported to be true for LPG based heaters [15]. Moreover, households in Jordan tend to use small kerosene or LPG heaters as back-up for each other, or when central heating is turned off [4,6]. This could be attributed to the coldness that could be experienced by inhabitants inside the house in addition to their tendency to cut cost on fuels used.

Yet, and due to the energy adjustment programme launched in 1993, prices of kerosene were increased as a result of lifting subsidies - which were being offered previously by the government on fuels - and to reflect more upon their real economic cost, which led people to use LPG fuels more for heating spaces [4, 6, 15]. The wide spread usage of LPG in Jordan is also attributed to the cleaner and reliable nature of LPG as compared to kerosene [4] and for excluding it from elimination of petroleum subsidies [4, 16]. For example, according to KAP Household-Baseline Survey conducted in Jordan over the 12 governorates with sample size of 1000 respondents, 68% and 54% of households were found using LPG and kerosene fuels, respectively for heating spaces with a very few of 7% and 13% used central heating and electrical heaters, respectively for the same purpose [14, 17].

Accordingly, it could be claimed that the dwellings in Jordan, especially of low-middle income classes, had a lot of pollutants and health hazards implications, given the dominant types of heating devices used for heating spaces and water for Domestic Hot Water (DHW) purposes, as well as the way the inhabitants' used to utilise them. Hence, following section will be discussing associative health hazards of the issue.

### 2.2.2 Health hazards

Design of indoor environment should provide basic human requirements of healthy and comfortable interior spaces without compromise on low energy consumption [18]. Yet, for example, there is a noteworthy gap in information necessary to inform precise evaluation and draw conclusions for environmental

and health implications of kerosene and/or portable heating appliances used in Jordan [19]. Combustion of fossil fuels – on which residential sector in Jordan depend heavily – is a significant contributor to air pollution and building up carbon dioxide ($CO_2$) in the atmosphere [4]. Further, combustion of unflued devices used for heating spaces emits high levels of toxic by-products, such as carbon monoxide (CO), that often exceed accepted ones which eventually result in poor indoor quality of living [4, 6]. Al Momani and Ali [20] claimed that 80% or more of occupants should feel satisfied and have no harmful complaints, to meet accepted levels of indoor air quality standards. For example - according to Bierwirth [21] – at levels above 800 parts per million (ppm) of $CO_2$, occupants of an indoor environment would be vulnerable to different symptoms, such as respiratory illnesses, headaches and fatigue.

Moreover, combustion of kerosene produces a mixture of pollutants that significantly affects indoor quality of houses, especially poorly ventilated ones. Such pollutants involve CO, sulphur oxides, polycyclic aromatic hydrocarbons (which are extremely carcinogenic) and nitrogen oxides, to name a few [19]. Locally produced kerosene and diesel has a sulphur content of 0.2% and 1.2% by weight by international standards, respectively [19] compared to the maximum allowed contents of 0.01% for kerosene in USA and Japan [15], for instance. Such sulphur content of kerosene manufactured locally is relatively high, given its direct combustion through unflued stove inside the dwelling for heating purposes [15]. Comparatively, although LPG fuel is considered as more efficient and cleaner compared to kerosene, it also has hazards like gas leakage and direct exposure to fire, which (the latter) is a common characteristic with kerosene stoves [4].

Relatively, Al Momani and Ali [20] have investigated the issue of Sick Building Syndrome (SBS) in their study, which has been conducted across 40 apartments in different cities in Jordan including Amman. Participants were asked to fill in questionnaires which were informed by literature in ASHRAE, WHO, NIOSH, and Burton. Different symptoms that could happen and has a temporal correlation with a specific building have been involved in the study. For instance, drowsiness and shortness of breath has been possibly attributed to $CO_2$ emissions while Nausea and impaired vision have been potentially associated with CO pollutant. An interesting finding of Al Momani and Ali [20] study is the significant effect of different variables, such as building envelope and location of the apartment within the building on SBS (Al Momani and Ali, 2008). The latter point may highly evoke retrofit issues for apartment buildings to contribute in providing healthy environments for their inhabitants. Moreover, Reliance on using un-vented stoves should be associated with utilising it for short times in well ventilated spaces and following manufacturers' guides to avoid accumulative exposure of inhabitants to gaseous pollutants [6].

Economically, Jaber [6] claimed that there is a negative correlation between use of kerosene fuel and household's income. This claim may coincided with Shirnding's (1991) point-as cited in [19] - of that urban poor are vulnerable to exposure to pollutants of high levels by combustion of such fuels inside their dwellings, due to their reliance on grimy and less efficient fuels. The same

researcher goes further to report about accidents and death cases, as result of suffocation, or health implications – such as respiratory diseases - which stem from inhabitants' exposure to gaseous pollutants produced by combustion of fuels inside poorly ventilated dwellings while they are sleeping and/or staying in such unhealthy environments. Furthermore, urban poor usually live in heavily populated areas surrounded by industrial and waste-dumping locations, which should be read as added burden to their economic status and polluted houses [19].

On the other hand - in addition to gaseous pollutants - combustion of kerosene and LPG also produces water vapour which condenses on cold surfaces and results in dampness and fungi areas, particularly in poorly ventilated houses (Jaber et al. (1993)-as cited in [6]). Around 53% of households in Jordan suffer from dampness problems [6] which, according to reports issued by Ministry of Energy and Mineral Resources in 1997 and National Electricity Company in 2000 in Jordan-as cited in [19] - would provide healthy environment for mould growth and eventually results in bronchial ramifications.

Hence, the aforementioned discussions stimuli the urgent need for highlighting the issue of heating devices used in Jordan, especially urban Amman, and their health implications. It could be inferred also that urban poor were found as the mostly vulnerable to such scenarios.

## 3 Research methodology

In winter season 2015 a survey has been conducted with a representative sample of 106 households across the five sub-districts of urban Amman, namely Marka, Qasabat Amman, Al-Queisma, Al-Jama'a and Wadi Al-Seir. The survey aimed towards exploring thermal comfort and energy efficiency issues at these apparently vulnerable groups. The interviewees were asked a series of questions related to household and apartment characteristics, types of heating stoves used inside the apartment and their behaviour in this regard, fuel expenditures, their thermal comfort, for example. Some photographs have been captured also inside and outside some visited apartments to support some research claims. QSR NVivo 10 and Microsoft Excel 2010 were used for analysing the collected data.

## 4 Results and discussions

Data analysis has generated different results that were found coincident with some of the issues discussed above in section 2. Only four of those profound results will be highlighted in this piece of research. Firstly, it has been found that around 38.7% and 88.7% of surveyed households used kerosene and LPG stoves, respectively to heat their apartments (see Figures: 1-3 below). Almost 51.2% and 53.2% from those were low-income households (below-poverty and below-middle classes) who consumed kerosene and LPG, respectively for the same purpose. This finding of households' more tendency towards using LPG stoves over others meets also with results of KAP Household-Baseline Survey discussed above. Also, the noticeable difference between users of kerosene and

LPG stoves may be attributed (as discussed above) to the jump of kerosene prices after lifting the subsidy which was applied on it and the consideration of users for LPG stoves as cleaner than kerosene ones. Hence, more studies with larger sample size are recommended to further investigate this issue.

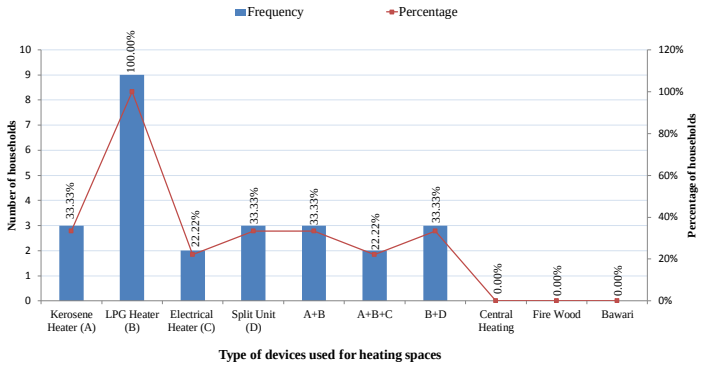


Figure 1: Types of heating devices used by surveyed below poverty households.
Source: Younis, 2015, unpublished

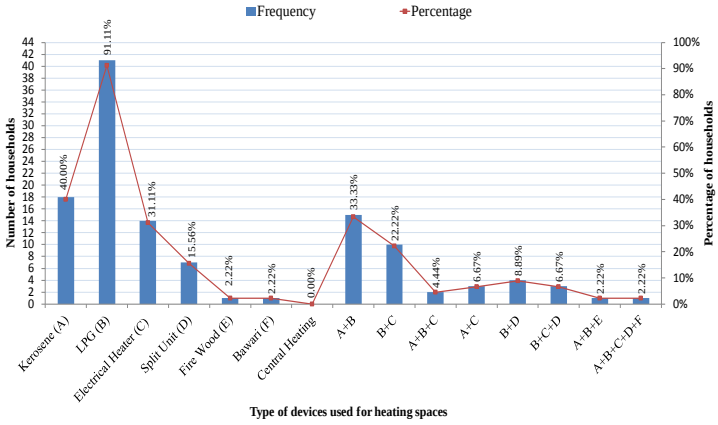


Figure 2: Types of heating devices used by surveyed below-middle income households.
Source: Younis, 2015, unpublished

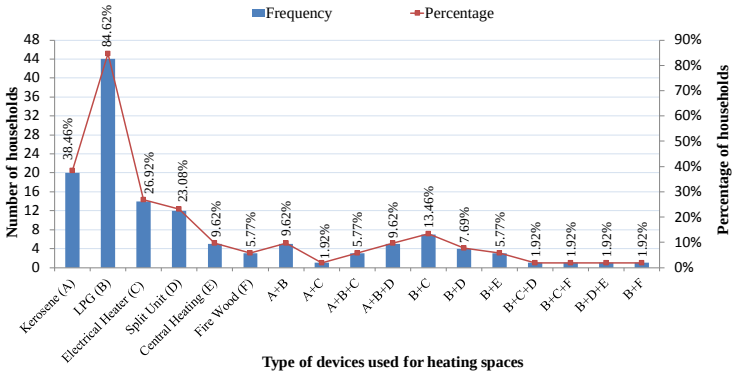


Figure 3: Types of heating devices used by surveyed middle income households.
Source: Younis, 2015, unpublished

Secondly, the figures also clearly show that dominant types of stoves used by surveyed low and middle income households were kerosene and LPG stoves. However, the survey also revealed that around 65.1% of total households used more than one heating device inside the apartment as back-up to each other. This point would meet with Jaber et al. [4] and Jaber [6] as aforementioned. The graphs further illustrate that unflued kerosene and LPG heaters were common among the back-up stoves used. In their study, Johansson et al. [8], found that average measured ventilation rate in an apartment in Amman was as low as 0.3ach +/- 13% in winter, compared to 2.38ach +/- 13% in summer. Moreover, interviewees reported different accidents occurred inside houses in Jordan and were caused by heating stoves. For example, various fatalities were reported which occurred when the inhabitants utilised it inside the bathroom with the window closed, or when they run it while they were sleeping, a hazard point that meets with Shirnding (1991) point discussed in section 2.2.2 above. This, when taken in parallel with the related discussions in section 2 above, may worsen the situation and increase health hazards inside such poorly ventilated houses.

Thirdly, results show that around 50% of surveyed low and middle income households suffered from health problems and/or safety issues which were associated with different types of devices used for heating water (for DHW purposes) and spaces. Almost 54.7% of this percentage represented low income households who reported such problems. Further, around 23.6% of the surveyed households complained about fungi areas inside their apartments, as 56% of those where the low-income class. Consequently, one of the interviewees became an asthmatic due to the mould growth inside their house, for instance. Many of the respondents tried to eliminate such annoying diseases living with them by cladding the affected walls with “Japanese Plaster” or “Moral” (called locally: teena yabaneyya) – see Photograph 1 - ceramic tiles, gypsum boards or even by repainting the wall. The choice of different techniques to overcome

these problems seemed to depend on economic status of the household. Yet, the former material (as obvious in the photograph) was spoiled by rain water penetrated through the leaky window of this apartment. Also, according to the householder, the material didn't prove to be thermally efficient as was recommended to him. This may reflect the bad envelope this household had in their apartment. Some households also preferred to keep windows and doors closed while heaters were running inside the room they used to gather in. This behaviour, associated with coldness, may have hazardous health implications. Occasionally, these devices have even caused serious accidents to different households, namely scalds, malformation and suffocation, for example.

Photograph 1: The Japanese Plaster (teena yabaneyya) used by a low-income household.
Source: Younis, 2015, unpublished

Photograph 2: The apartment, showing the window in photograph 1 circled.
Source: Younis, 2015, unpublished

Lastly, households were asked about construction materials of their apartments' envelopes as well. Surprisingly, it was found that around 74.5% of total surveyed apartments had an envelope of two layers of 2.5cm cement plaster (inside and outside the apartment) with an in-between 15cm thick concrete hollow brick. Further, almost 78.5% of those had only this type of construction (not mixed with other types) for all the house's external envelopes.

Comparatively, dominancy of this type of construction material coincides with the findings of Younis et al. [12], as a result of their analysis of the massive

data collected from DoS, that most dominant construction material of low and middle income apartments in urban Amman was the concrete hollow blocks. Also the two results coincide with Jaber's claim as discussed above in section 2.1 about the very tiny percentage of available wall insulated dwellings in Jordan. According to El Hanandeh [22], U-value of this type of wall is 2.38 $W/m^2.K$, which largely exceeds the optimum range – recommended by Ouahrani [23], required for apartments' roofs and walls in Amman, i.e. 0.50-0.70 $W/m^2.K$.

Accordingly, and given the discussions aforementioned above in section 2, it could be claimed that such apartments are thermally in-efficient and this type of envelope would provide an ideal environment for the growth of fungus and mould. For instance, such fungi areas could be explained partially by the low ventilation rate found by the researchers as discussed above, so inhabitants would be able to beat coldness allowed in by thermal bridges and infiltration. At the end of the day, this would render such apartments as thermally uncomfortable and may imply a lot of health hazards and accidents, given the inevitable emissions of pollutants, such as carbon dioxide and monoxide.

## 5 Conclusion and Recommendations

This paper intended to investigate heating devices used for heating low-middle income apartments in urban Amman and health implications associated with their usage. A survey was conducted with a representative sample of 106 households across the five sub-districts of urban Amman in winter 2015. Results showed that around 39% and 89% of surveyed households used kerosene and LPG stoves, respectively to heat their apartments, with almost 65% of total used more than one heating device as back-up to each other. Furthermore, findings revealed that about 50% of the surveyed low and middle income households suffered from different health problems e.g. asthma and/or safety issues which were associated with different types of stoves used. Finally, it was also found that around 75% of the total surveyed apartments had a thermally poor external envelope with high U-value.

Literature review has highlighted that indoor pollutants and carbon emissions produced by combustion of such petroleum fuels, which may have serious health and environmental implications. Also, it implied that external envelopes of residential stock in Jordan are thermally in-efficient, which has been found as a significant driver behind SBS. Accordingly, unless energy efficient measures applied to those existing apartments, supported by lifting awareness level of occupants towards the proper use of such apparently needed stoves, then relatively temporal health implications and the 59% surge of GHG emissions by 2018, as found in the literature, may be inevitable.

Given the aforementioned discussions, this paper would highly recommend thrift retrofit packages for low-middle income apartments in question to improve human thermal comfort and reduce GHG emissions. Eventually, this may result in providing healthy indoor environment and enhancing inhabitants' quality of living. Alongside with this urgent call, it would be highly beneficial to create/lift

awareness level for/of those households towards the proper and safe use of heating stoves inside their apartments.

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