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THE RELATIONSHIP BETWEEN DWELLING AREA AND ENERGY CONSUMPTION IN JORDAN

Jamal Alnsour*

Abstract: *This paper aims to examine the relationship between the area of the current average dwelling space and energy consumption in Jordan. Findings reveal that the current average dwelling area leads to increased energy consumption. The paper also investigates the reasons for unmerged the regulation in regard to dwelling area; the most important reason being that local government considers that occupancy ratio to the plot area, provides an indication for dwelling area. However, this is not the case. Therefore, this paper provides a valuable scenario designed to reduce the current average dwelling area in order to reduce energy consumption.*

Keywords: *Dwelling Area; Energy Consumption; Residential Regulations; Jordan.*

1. INTRODUCTION

A change in lifestyle as a result of rapid urbanization has caused an increase in consumption, changing the quality of life in many countries. One of the urbanization manifestations that has created high economic and environmental costs in both developed and developing countries is the use of energy in buildings. Worldwide, the building industry is one of the largest consumers of energy (Santin *et al.* 2009). In the northern section of the European Union, about one third of the total final energy consumption comes from residential use (Santin *et al.* 2009).

Energy is an indispensable resource to improve quality of life, and, due to the challenges caused by high energy consumption, several countries have developed strategies and standards aimed at raising the energy efficiency of the housing sector (Santin *et al.* 2009). For example, the European Performance-Based Energy (EPBD) initiative was approved in 2003, which aims to reduce energy consumption in buildings. In addition, several studies (for example, Nicolae & George-Vlad, 2015; Liu *et al.* 2015; Rocha, 2015; Lin & Liu, 2015) have discussed the relationship between construction techniques and building materials, in an attempt to determine best

* Jamal Ahmad Alnsour, Associate Professor, Dean of Faculty of Business, Al-Balqa Applied University, Jordan, *E-mail: Jamal.alnsour@bau.edu.jo*

practice in lowering energy consumption. Nevertheless, the rate of demand for energy has increased substantially. According to the International Energy Agency (2008, p. 81), the demand for energy will increase during the period from 2006 to 2020 at an average annual growth of 3.2% for the Middle East, 1.4% for Africa, and 2.0% for Latin America.

Therefore, the importance of managing cities within the context of available resources should be taken into account when determining urban policy. The primary aims of urban policies are to improve cities spatially, socially, economically, culturally, and environmentally in a sustainable manner. In many countries, laws, regulations, models, policies, standards and programs which are set in place to manage the urban environment take the availability of resources into account. Among the most important policy instruments that deal with energy consumption are building regulations; this topic has been examined in the current literature. Song & Choi (2012) determined that, in South Korea, most current building regulations for the residential sector increased the consumption of energy. Regarding England and Wales, Pan & Garmston (2012) examined the degree of compliance with building energy regulations, standards and codes in the community; their findings established that the level of compliance is poor, as a result of a complex system. In the Netherlands, Santin *et al.* (2009) studied the effect of occupancy and building characteristics on energy use; results concluded that building characteristics determine a large part of the energy use in a dwelling. Leth-Petersen & Togeby (2001) examined the impact of building regulations on energy use, concluding that buildings, which are constructed according to regulations, are consumed lower energy.

As Jordan one of the poorest countries in the world in terms of energy and water, it could assumed that building regulations would be used as an effective tool to save energy. A major issue with the current regulations is that there is little attempt to specify dwelling area. This means that people can build wherever they wish, provided they comply with the building regulations and standards. There are several key questions which require an answer. The first is whether undetermined dwelling area should remain within residential regulations, if energy consumption is taken into account, and whose perspective should be more important, the dweller or the policy makers? Secondly, is the current average house area suitable in terms of minimizing energy consumption? If not, what are the appropriate steps to take to deal with this challenge? This paper aims to answer these questions in order to identify the challenges and interventions required to improve the performance of residential regulations. It also provides valuable insights into urban housing regulations and energy consumption in Jordan, about which little has been written, and to explain the extent to which current dwelling patterns fit local urban economic resources, particularly energy, in Jordan. Finding solutions to these questions will assist decision makers to improve the way they manage urban housing in the light of the lack of natural resources, and improve scholars' definition and understanding of the relationship between a dwelling area and energy consumption.

2. RESIDENTIAL REGULATIONS

Building Regulations Ordinance of 1979, No. 67, aims to (1) reduce the overall average expansion of urban settlements; (2) achieve a balance in development and growth, to reduce economic, environmental and social costs due to the lack of natural resources and; (3) maintain quality of life in urban centers. Construction for the residential sector is by far the largest part of the building industry in Jordan; therefore, residential regulations should take the energy challenge into consideration (See Table 1).

Table 1
Residential Regulations in Jordanian Municipalities.

		Min. Setbacks (m^2)						
Zones	*Plot area/M^2*	*Front*	*Side*	*Rear*	*Max. No. of Storeys*	*Building Height /m*	*Min. Plot Frontage*	*Occupancy Ratio*
A	1000	5	4	5	4	14	25	39%
B	750	4	3	4	4	14	20	45%
C	500	3	2.5	3	4	14	18	50%
D	250	3	2	2.5	3	11	15	54%
E	170	2	2	2	3	11	12	60%

Note: These regulations are used in the municipalities of Jordan except Amman Municipality, which has specific regulations very similar to these regulations.

In Jordan, land within an urban area is divided into zones, each zone has specific standards. Reasons for differentials in standards and zoning within residential subdivisions are linked to income level, population density, infrastructure and services (Alnsour & Meaton, 2009). Residential Zones A and B are designated as "high income", Zone C as "middle income", Zone D as "middle to low income" and Zone H as "low income".

Within the aforementioned residential zones, the land is divided into plots. The designated plot size varies from one zone to another (as evident in Table 1). Zoning within the residential areas is designed to enable all income groups to access land (Alnsour & Meaton, 2009). Nevertheless, research on urban housing policy has shown that down zoning has failed to provide equitable land distribution for the housing sector. In all Jordanian urban centres, it is clear that more land has been planned for Zones A and B than for the remaining zones. Additionally, despite scarcity of energy and water, planning authorities continue to provide large residential plots (Alnsour & Meaton, 2009). Another issue is optimisation of land use; for example, regulations for Zone B allow the construction of four storeys, containing a maximum of eight apartments, within a residential building. In many cases, the plot is used to build one or two storeys only.

Residential setbacks are mandated in most urban planning policies, even those with only minimal standards, to ensure the continuance of a ventilation space between houses and to protect public health and the environment (Alnsour & Meaton, 2009). Residential standards mandate the minimum amount of ventilation space; they do not specify a maximum amount. There is no information available to explain the technical bases by which the setbacks currently mandated in Jordan were adopted. It appears that they are related to plot area, the extent of construction upon the plot, and the occupancy ratio. The basic difference between zones is the difference in the amount of space which is mandated as a setback; the space is increased in Zones A and B (that is, for high income residents), and decreases for the remaining zones, with Zones D and E having the minimum mandated setback. This difference relates directly to plot size, which is increased in the more expensive zones and decreased in the less expensive zones, in order to achieve consistency between the lot to setbacks ratio (Zagha, 2003).

Table 1 also illustrates that the total number of storeys differs from one residential zone to another; again, there is no information available to determine the means by which the number of storeys was specified in the act. The act specifies the maximum number of storeys, but does not specify the minimum number. In practice, the specification of a minimum number is important, as optimum utilization of a plot requires that environmental factors and maximization of resources are taken into account. It also enhances the urban shape of the settlement, in that uniform building size is more aesthetically pleasing than non-uniform.

In reference to engineering considerations, there is no consistency between building heights and zoning. The mandated building height for both residential Zones D and E zones is lower than that pertaining to the other zones; this can be explained by the fact that Zones D and E are inhabited by low income residents, where a reduction in height directly reduces the cost of construction. However, studies have confirmed there is a relationship between the height of a building and energy consumption. In the case of Hong Kong, Bojjc & Yik (2007) argue that a substantially higher residential building design contributes to a higher consumption of energy.

Plot frontage and occupancy ratio to the plot are other standards by which housing construction can be controlled. The essential purpose for specification of a minimum frontage is to decrease infrastructure cost; a longer length of plot frontage implies a higher infrastructure cost (ALnsour & Meaton, 2009; Zagha, 2003). Table 1 states the minimum frontage required for each plot type in Jordanian municipalities.

Maximum occupancy ratio to plot size is specified by the planning regulations to ensure green space, setbacks and provision of parking spaces inside a plot. (Table 1 presents these ratios.) It is important to note that the current regulations do not specify a minimum green space ratio for new housing estates; this is contrary to contemporary thought, where green space is demonstrated to have a positive impact on an urban environment.

In fact, the basis of many urban planning regulations refers to the U.K. planning system (Meaton & Alnsour, 2012). Current building regulations are based on reports conducted by foreign consultants from the U.K., as well as some input from local academics (Zagha, 2003). Alnsour & Meaton (2009) examines the extent to which residents comply with residential regulations; results of the study disclose that the ambiguity of residential regulations is one of the most important factors which has contributed significantly to a low level of compliance with residential regulations in Jordan. In the same vein, Meaton & Alnsour, (2012) argue that some current building regulations have negative consequences; this is due to the fact that these regulations focus on engineering concepts and design, and neglect the social-economic context and environmental challenges. For instance, urban issues such as dwelling design, building numbers, tiling, position of the main entrance, area of the dwelling, and provision of windows compared to size are not considered in the urban planning regulations. Thus, people have been able to build not only almost wherever they wish, they may also build almost any design they consider attractive or cost effective, and this has resulted in increased energy and water consumption, with consequent environmental problems (Meaton & Alnsour, 2012).

3. RATIONAL FOR DWELLING AREA

It should be noted that energy consumption is not influenced by dwelling area alone. Several variables have been found to affect energy consumption in both national and international studies. These variables can be summarized as follows:

- Urbanization has an impact on energy consumption (for example, Jaber and Probert, 2001: Jordan; Assimakopoulos, 1992: Greece).
- Building regulations can influence energy consumption (for example, Song & Choi, 2012: South Korea)
- Socio-economic characteristics such as household size, income and age have a direct affect on energy consumption (for example, Liao & Chang, 2002: U.S.A.; Jeeninga *et al.* 2001: the Netherlands; Schuler *et al.* 2000: Germany; Pachauri 2004: India).
- Design of dwelling affects energy consumption (for example, Goussous et al. 2015: Jordan; Hassouneh *et al.* 2015: Jordan; Leth-Petersen & Togeby 2001: Denmark; Haas *et al.* 1998: Australia; Liao & Chang, 2002: U.S.A.).
- Behavior associated with peoples' preferences and values impacts on energy consumption (for example, Linden *et al.* 2006: Sweden; Iwashita & Akasaka, 1997: Japan; Vringer *et al.* 2007: the Netherlands).
- Category of energy used also affects energy consumption (for example, Al-Ghandoor, 2013: Jordan; Leth-Petersen & Togeby 2001: Denmark).

This study discusses variables of dwelling area which may impact on energy consumption for the following reasons:

1. It is important for urban policy in Jordan to examine whether the current average size of dwelling area should be reassessed for residential regulations.
2. Most previous studies have focused on factors affecting energy consumption; they have paid very little attention to the impact of the dwelling area itself on energy consumption.

3. Theoretical practice concerning housing regulations is still in its infancy; development and evaluation of such housing regulations which currently exist and the development of testable hypotheses will help to structure theory in line with best practice.
4. Examination of innovative design would help to produce a better understanding of urban policy theory with regards to managing energy resources and consumption.

3. THE ENERGY SECTOR IN JORDAN

Jordan is a small country in the Middle East, covering an area of about 90,000 square kilometers, 80% of which is semi-desert. It consists of twelve governorates, with a total population of 6.5 million inhabitants, the vast majority of which (in the region of 83%) live in urban areas (Department of Statistics, 2013). From 1948 until the present, Jordan has received successive, massive refugee migrations, including approximately 2 million Palestinians (UNRWA, 2014), 1.4 million Iraqis, and 1.4 million Syrians (Alnsour, 2014).

About 98% of Jordan's energy is imported (Verdeil, 2014). Crude oil and related products represent 82.2% of the primary energy consumption, while natural gas accounts for 11.7% (Ministry of Energy & Mineral Resources, 2014). Figure 1 indicates that energy consumption rose substantially from 4,674,000 tons in 2006 to 6,665,000 tons in 2012 (Ministry of Energy & Mineral Resources, 2014). The increase in energy consumption is a direct result of the influx of refugees from surrounding countries into Jordan.

Rapid urban growth following the increase of demand for housing means that distances travelled have also raised, coupled with raising the average number of households which own cars. The number of cars increased from 995,000 in 2009 to 1,264,000 in 2012 (Department of Statistics, 2013). In recent decades, an increase in the standard of living and a transition towards new social practices has led to a considerable increase in the use of energy in daily life (Verdeil, 2014). The proportion of the population with access to the public electricity network rose from 78% in 1979 to 100% in 2012 (Department of Statistics, 2013). At the same time, the population increased from 1.5 million to about 6.2 million (Department of Statistics, 2013). Jordan also became a member of the World Trade Organization (WTO) in 2000; since then, the demand for electric products and machinery used in the transport and industry sectors has also increased, with a corresponding increase in energy consumption. For example, in the year 2000, only 89% of the urban population owned a refrigerator or a washing machine, compared to 97% of the population in 2007 (Verdeil, 2014).

The growing use of electrical appliances is primarily linked to the change in lifestyle in relation to consumption values (Verdeil, 2014). Today, households consume approximately one quarter of the total energy consumption of Jordan; furthermore, this consumption is increasing yearly (Ministry of Energy & Mineral Resources, 2014). In the context of electricity consumption, the residential sector has been the major contributor to growth. Between 2007 and 2013, residential consumption increased from 36% to 41% of the total amount (Ministry of Energy & Mineral Resources, 2014). Energy sources used in the residential sector include electricity, diesel, kerosene and natural gas. These are primarily used for lighting, space and water heating, air conditioning, cooking and electrical or motorized appliances (Meaton and Alnsour, 2012). Table 2 illustrates average house area, together with energy consumption indicators across the major Jordanian cities. As could be expected, the table also demonstrates that an increase in house area is often accompanied by an increase in energy consumption. The only exception to this is Aqaba, perhaps due to its harsh climate.

Table 2
Average House Area and Energy Consumption Indicators for Major Jordanian Cities. Source: Ministry of Energy and Mineral Resources, Energy Consumption Survey for the Residential Sector, 2013

City	*Average Dwelling Area*	*Diesel (Liters / month)*	*Kerosene (Liters / month)*	*Gas Cylinders* (Average No / month)*	*Electricity Consumption (Giga Watts / hour)*
Amman	167.81	1368	305	3.16	6458
Zarqa	132.88	905	208	2.67	5844
Balqa	143.58	1572	233	2.81	5171
Madaba	175.88	1142	317	4.04	6352
Irbid	164.34	703	373	2.92	5654
Mafraq	158.74	1135	340	3.51	5253
Jarash	152.03	1275	221	2.95	5210
Ajloun	164.53	1851	314	3.44	5167
Karak	151.49	740	361	3.10	5250
Tafila	129.05	938	284	3.09	5565
Ma'an	145.65	1023	101	2.84	5160
Aqaba	120.27	1658	105	2.00	6869
Jordan Average	**155.40**	**1192.5**	**263.5**	**3.05**	**5666.55**

*Each gas cylinder weighs 16.5 Kg.

It appears that an increase in home area is often accompanied by an increase in electricity consumption. Worldwide, the average dwelling area varies from one country to another. Table 3 presents average home size and electricity consumption (kWh/

Table 3
Average Dwelling Area and Electricity Consumption in Selected Countries

Country	*Average Dwelling Area*	*Electricity Consumption (kWh / year)*
U.S.A.	201	11,700
Canada	181	11879
U.K.	76	4,600
China	60	1,300

Sources: http://worldbank.tumblr.com/post/70192273280/average-house-size-by-country.
http://shrinkthatfootprint.com/average-household-electricity-consumption

year) in several countries. It demonstrates that countries with the largest average of home size also have the largest averages of electricity consumption. In general, most averages are related to the availability of natural and economic resources in these countries. For instance, the average house area of 60 m^2 in China is generally suitable for the available resources, income level and population size.

Until 2003, international trade agreements with Iraq guaranteed a supply of cheap oil to Jordan, which enabled the government to sell energy products cheaply (Verdeil, 2014). However in 2003 Jordan entered a new era, whereby local energy prices followed the world market (World Bank, 2005). As a result, Jordan amended its energy policy and replaced oil with natural gas for electricity generation. Furthermore, Jordan had signed an agreement with Egypt that natural gas would be supplied at a fixed price until 2022; the agreed cost was estimated to be one-third of the market price (Verdeil, 2014). Since the Egyptian revolution which began in 2011, the delivery of natural gas has ceased. As a result, Jordanian power plants have been forced to rely on crude oil, with overspending estimated to be 1 billion Jordanian Dinars each year (Verdeil, 2014). Hence, as oil invoices now represent 21% of GDP, and the government is unable to pay for sufficient oil to satisfy demand, there has been a significant increase in local energy prices. Surprisingly, however, the high prices have not lead to a reduced demand for energy. In contrast, the Ministry of Energy & Mineral Resources (2013) estimates that demand for energy will grow annually at an average of 5.1%, with the demand for electricity in particular rising by an average of 6.4% annually.

Despite the fact that several initiatives have been instigated to manage the energy sector in Jordan, such as the Energy Strategy and the Amman Green Growth Strategy, there is an urgent need to assess the role of building regulations in terms of reducing energy consumption.

4. STUDY HYPOTHESES

Residential regulations which do not regulate dwelling areas can be seen as a stimulus for residents to build wherever they wish. However, an increase in family size and income usually leads to an increased demand for space. These motives create incentives to build a larger dwelling, which in turn results in increased energy consumption. Table 2 demonstrates that the current average dwelling size in Jordan is 155.40 m^2. Therefore, the main hypothesis of this study is that the current average dwelling area has lead to an increase in energy consumption rates. As Jordan consists of twelve main governorates, the second hypothesis is that the current average dwelling area in Jordanian governorates has lead to an increase in energy consumption rates.

5. METHODS AND DATA

A mixed method approach was seen as appropriate to meet the study objectives. A quantitative method was used to satisfy the research hypotheses. The data for this study was obtained from the Energy Consumption Survey for the Residential Sector, conducted by the Ministry of Energy and Mineral Resources in 2013. This survey was undertaken in 2013, and includes data on housing features and energy consumption in a sample of 4,910 houses across Jordan. It was an interview-based survey which included questions on household characteristics, such as use of the dwelling, quality of the dwelling, homeownership, housing type, energy consumption, oil products used within the home, insulation materials, insulation per surface, insulation for walls, type of heating system, energy saving, use of renewable energy, and space heating behavior. The main advantage of the database thus obtained is that sample size is quite large (around 5,000 cases) and that it was implemented randomly across Jordan.

A qualitative method was used to obtain in-depth information and more understanding in order to generate appropriate implications. Fifteen face to face in-depth interviews were conducted with experts in urban housing and energy. The target was to conduct 25 interviews; unfortunately, this was not possible.

Correlation analysis is used in this study, as all research variables are metric. Correlation analysis is used to describe the strength and direction of the relationship between two variables (Pallant, 2001). In order to judge the strength of the relationship between the variables, Bryman and Cramer (2001, p.174; citing Cohen and Holliday [1982]), suggest the following: 0.19 and below is very low; 0.20 to 0.39 is low; 0.40 to 0.69 is modest; 0.70 to 0.89 is high; and 0.90 to 1 is very high.

6. FINDINGS & DISCUSSION

The hypotheses of this study aimed to investigate the relationships between dwelling area and the extent of energy consumption. This section examines the hypotheses and the discussion is presented below.

6.1. The Relationship between Dwelling Area and Energy Consumption

Table 4 confirms that there is a significant relationship between house area and the rate of energy consumption. Empirical findings illustrate that there is a modest correlation between dwelling area, fuel products (such as diesel and kerosene) and electricity, and there is a low correlation between dwelling area and the average number of gas cylinders used per month. This reveals that the current average dwelling area leads to an increase in energy consumption.

Empirical results prove that the highest correlation is between dwelling area and electricity consumption rate. Using electrical appliances rather than those with other fuel sources is easier, and thus the demand for electricity is always higher. Electricity is the only source which can be used in all rooms and utilities in a house, both internally and externally, which again increases the consumption. According to interviewees, there are several practices that contribute to increased electricity consumption. In the first instance, 80% of the total land area of Jordan is designated as a desert environment; the climate is hot and dry in summer, which encourages many people to use air conditioning. This agrees with data collected by the Department of Statistics (2008), in

Table 4
Correlation Matrix

Governorates	*Average Dwelling Area*	*Diesel (Liters / month)*	*Kerosene (Liters / month)*	*Average No. of Gas Cylinders / month*	*Electricity Consumption (Giga Watt / hour)*
Average Dwelling Area	1.000	0.412**	0.405**	0.371*	0.423**
Diesel (Liters / month)	0.412**	1.000	0.103	0.117	0.203*
Kerosene (Liters / month)	0.405**	0.103	1.000	0.085	0.112
Average No. of Gas Cylinders/ month	0.371*	0.117	0.085	1.000	0.0917
Electricity Consumption (Giga Watt/ hour)	0.423**	0.203*	0.112	0.0917	1.000

** Significant level ≥ 0.01
* Significant level ≥ 0.05

which the use of air conditioning has risen from 4.9% of the population in 2000 to 10.6% in 2008. Secondly, using electricity for heating is also on the rise, with 16.5% of households using electricity for heating purposes (Department of Statistics, 2008). The increase in the use of electrical appliances is evidently related to the social transition in Jordan. These findings reveal that undetermined categories of dwelling areas in residential regulations have contributed to an increase in energy consumption.

Table 5 presents the relationship between dwelling area and energy consumption rates in the twelve Jordanian municipal regions, known as governorates. It proves that there is a significant correlation between dwelling area and energy consumption rates in six cities, partial correlation in three cities, and no significant relationship in three cities.

Table 5
Correlation between Energy Consumption and Dwelling Area in Jordanian Cities

Governorate	*Result of Correlation*	*Degree of Correlation*
Amman	Significant Correlation	Modest
Zarqa	No Correlation	-
Balqa	Partial Correlation	Low
Madaba	Significant Correlation	Modest
Irbid	Significant Correlation	Modest
Mafraq	Significant Correlation	Modest
Jarash	Partial Correlation	Low
Ajloun	Significant Correlation	Modest
Karak	Partial Correlation	Low
Tafila	No Correlation	-
Ma'an	No Correlation	-
Aqaba	Significant Correlation	Low

In the nine cities in which the relationship between dwelling area and energy consumption is either totally or partially significant, electricity consumption has the highest correlation with dwelling area. Amman, which represents 40% of the total housing stock in Jordan, has the highest correlation ($R = 0.486$) with a significant level of 0.01 between dwelling area and rate of energy consumption. Therefore a general conclusion can be drawn that there is a relationship between dwelling area and energy consumption at the national level.

6.2. Reasons for Lack of Regulations Pertaining to Residential Dwelling Areas

Interviewees were asked why dwelling area is not embodied within the residential regulations. It has been demonstrated above that the current average dwelling area of 155.40 m^2 is inappropriate for energy consumption in Jordan. They revealed that, "from a local government's perspective", occupancy ratio, which is determined by regulations, is used as an indication for dwelling area. In practice, the occupancy ratio does not specify the dwelling area; it determines the horizontal building area only. For instance, (based on the findings illustrated in Table 1), in residential Zone A, people can build up to 390 m^2 horizontally and up to four storeys vertically, which means that the dwelling area is equivalent to 1,560 m^2. A range of between 390 m^2 and 1,560 m^2 is very wide, and thus it is difficult to determine the occupancy ratio based on these regulations.

Most of the interviewees also noted that the Building Regulations Ordinance which was issued in the 1970's took effect in a period of significantly lower population size and higher economic conditions. They argued further that building regulations from that period (which are still in practice at the present time) were based on a scenario of approximately 20 – 30% of the current housing stock. Therefore, it is necessary to examine the regulations in the context of the housing available at that time.

The interviewees also argue that the planning authorities consider the down zoning approach, which is one of the most often used urban policy tools to control growth and development, is designed to allow people to build on a large dwelling area. They confirmed that master plans in Jordan often allocate in the region of 70% of residential land to Zone A, thereby encouraging people to build over a large area.

Finally, the interviewees believe that economic factors are also an important factor in the lack of regulation for dwelling area. In Jordan, a large percentage of the housing stock has been constructed incrementally; that is, people often make several extensions or alterations to the original dwelling, as a result of an increase in family size or family savings. Therefore, the process of determining a standard area of dwelling in the first instance is difficult.

7. SCENARIO TO REDUCE ENERGY CONSUMPTION

Based on interviews with academics and professionals, this study has developed a scenario which both reduces dwelling area and decreases energy consumption while taking socio-economic considerations and current planning regulations into account.

The main premise of the scenario is to reduce dwelling size; however, it is important that income bracket and family size are taken into account, in order to make this scenario more able to effectively meet the needs of residents. According to the Department of Statistics (2010), income groups in Jordan can be divided as follows

(1) High Income: annual income ≥ JD 12,000 per year; this group represents 17.9% of households.

(2) Middle Income: annual income JD 6,000 - 12,000 per year; this group comprises 37.3% of households.

(3) Low Income: annual income ≤ JD 6,000 per year; this group represents 44.8% of households.

According to the Department of Statistics (2013), family size is on average 5.4 persons. Standard home size should satisfy an average family's need for space; many studies suggest that 70 m^2 should be appropriate for a family consisting of 5 persons.

It should be noted at this point that there are two residential zones which are excluded from this scenario, namely the "special zone" and the "green zone". The reason for this exclusion is due to the fact that these zones are subject to exceptional regulations, as they are not designed for normal residential use, but rather for palaces and villas. These zones are characterized by large plots and represent a very low proportion of residential use. Furthermore, these types of residential use are not specific to Jordan, but are to be found worldwide.

Table 6 reveals that the scenario developed during the study suggests that three residential zones only are required, rather than the five zones which currently exist, and presented in Table 1. The reasoning behind this suggestion is that residential divisions should be in line with level of income. The scenario reduces plot areas in three residential zones (See Table 6). Justifications for this reduction can be summarized as follows:

1. The proposed plot areas are in accordance with income level
2. These plot sizes will enable low income people to access housing
3. Smaller plot sizes will reduce construction costs accordingly, which means that residents will be more able to afford good quality building materials, and will correspondingly save energy.

Table 6
Suggested Proposal for Residential Zones

Zone	*Current Plot Area m^2*	*Proposed Plot Area m^2*	*Dwelling Area m^2*	*Area Mean*	*Income level*	*Ratio to Total Housing Stock*	*Average Family Size (5.4)*
A	1,000	500	150-200	175	High	About 20%	Satisfied
B	750	250	100-150	125	Modest	30-40%	Satisfied
C	500	150	70-100	85	Low	40-50%	Satisfied
D	250	These zones are not required for the proposed scenario					
E	170						

Table 6 suggests three types of dwelling area aligned with income level, household size and current residential regulations. According to interviewees, a household which consists of 5 to 6 persons in a low income bracket can satisfy their housing requirements with a dwelling area from 70 m^2 to 100 m^2. The proposed dwelling areas do not contradict existing residential regulations. For example, the maximum occupancy ratio to plot size should not exceed 63% of the total plot area; in the three proposed dwelling areas the occupancy ratio to plot size is less than 60%.

As argued earlier, the current regulations pertaining to residential zoning does not consider low and middle income groups objectively. The suggested scenario takes both the size of dwelling area and the income bracket of households into account.

Based on the categories suggested in Table 5 for dwelling areas and the mean dwelling area of each zone embodied in Table 5, the overall mean of dwelling area can be calculated by the following formula:

$$Mda = \frac{\Sigma x(x1 + x2 + x3)}{\Sigma y(3)}$$

Where:

Mda : is the overall mean of dwelling area

x: is the mean of dwelling area in Zones 1, 2 and 3.

y: is the number of means.

Hence,

$$Mda = \frac{175 + 125 + 80}{3} = 126.66$$

This scenario reduces the average dwelling area by about 28.9 m^2. Based on the empirical findings, it was found that houses with an area between 120 m^2 and 130 m^2 consume energy less than those who are larger than 130 m^2 with an average of 15%. Table 7 presents the reduction in energy consumption rates.

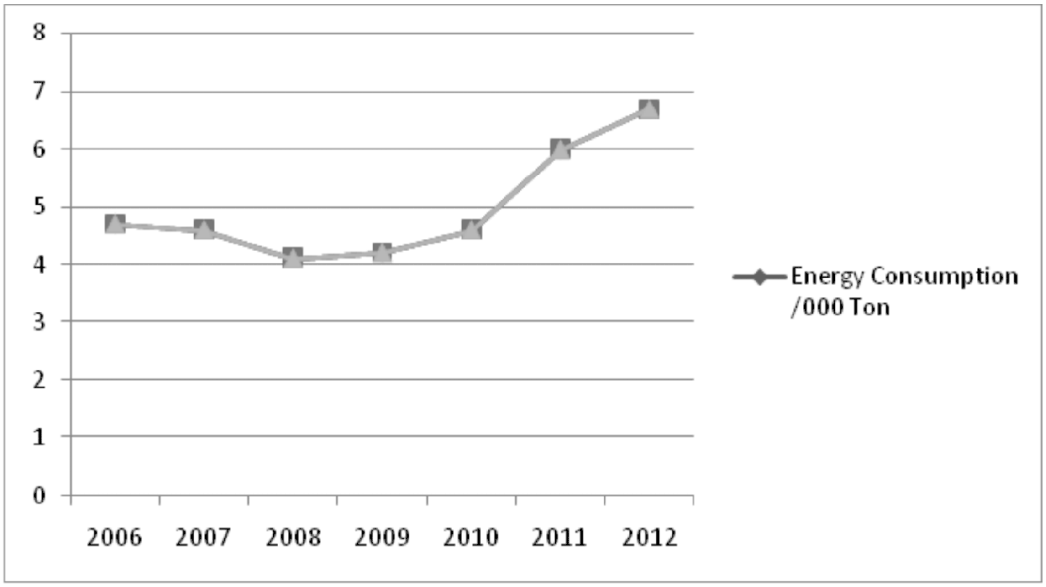
Table 7
Reduction in Energy Consumption

Indicators	*Average Dwelling Area*	*Diesel (liters / month)*	*Kerosene (liters / month)*	*Average No. of Gas Cylinders / month*	*Electricity Consumption (Giga Watt / hour)*
Current	155,40	1192,5	263,5	3,05	5666,55
Proposed	126,66	1013.6	124	2,59	4816,56

8. CONCLUDING REMARKS

This case study of housing in Jordan has revealed several conclusions regarding the relationship between urban policy and energy issues. It has clearly demonstrated that

Figure 1: Energy Consumption in Jordan. Department of Statistics, Statistical Yearbook (2013)



the demand for energy and housing is escalating, and that, as there is a significant relationship between dwelling area and the rate of energy consumption, the current average area of dwelling leads to increased energy consumption. Non-regulation of dwelling area in the existing residential policy is chiefly related to the perspective of local governments, in that occupancy ratios are specified by the current regulations; the study demonstrates that this belief is not accurate. Findings determine that the demand for electricity is higher than all other sources of energy, and thus the relationship between dwelling area and electricity consumption rate is the highest.

This study also provides a valuable scenario which attempts to reduce the current average of dwelling area in order to reduce energy consumption. The scenario suggests a mechanism to reduce the average dwelling area from 155.40 m^2 to 126.66 m^2 by which energy consumption would decrease by approximately 15% in the residential sector. This scenario is useful for both national and international literature, but in particular for research on urban planning and energy in Middle Eastern countries.

Finally, further research should examine the impact of other building regulations on energy consumption in Jordan, which could then be extrapolated to other environments similar to Jordan in the Middle East.

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