Enabiling Activities for Preparation of Syria's Initial National Communication to UNFCCC

# Mitigation of greenhouse gas emissions within the Building Sector in Syria

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Ministry of State for Environment Affairs (MSEA), in collaboration with United Nation Development Programme (UNDP) in Syria, and Global Environmental Facility (GEF).

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# Mitigation of greenhouse gas emissions within the on Building Sector in Syria

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**Damascus** **February 2010**

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*This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 28.2.2010, in Samiramis Hotel, Damascus.*

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## Executive Summary

### 1. Introduction

Building sector (residential, commercial and service) in Syria is the most energy consuming sector, especially electric power. It is difficult to predict its energy demand, due to multiple factors, including geographical, climatic, and surrounding environmental conditions, economic and social factors, living standards, and the availability of energy sources and possibilities of their use.

There are many reasons for the low efficient use of energy in the residential, commercial and service sectors in Syria, including, for example, poorly designed buildings, the use of inappropriate technologies and the incorrect behavior of its residents.

The design and implementation of low energy buildings, and the use of energy efficient equipment, lead to improve the performance of buildings in terms of energy consumption, and to achieve the required comfort. The rationalization of energy consumption in building depends also on the procedures and methods followed by the buildings users.

Renewable energy and energy efficiency (RE&EE) are essential factors that will contribute to reduction of the energy bill and conservation of natural resources in buildings. The development of renewable energy use in building can contribute effectively to the efforts directed to the diversification of energy resources, and it will result in important saving of fossil fuels.

In Syria, there is a need for socio-economic development and poverty alleviation to improve the standard of living in the region’s poor and rural areas. Renewable energy technologies (RETs) could be selectively applied to various rural and urban applications, potentially generating income, improving health and educational quality, improving the GDP, achieving gender equity, and increasing labor productivity.

Data on conventional sources of energy supply in Syria are gathered from the Ministry of Electricity and Ministry of Oil & Mineral Resources, but those on end-use have to be collected through customer surveys, which are not conducted regularly or on a uniform basis. Similarly, in the household sector, collecting data on traditional and non-traditional fuel use is not an easy task.

This situation is further complicated because GHGs mitigation analysis requires that data for the energy, building, agriculture, etc. sectors be matched with those on the socio-economic impact of a mitigation option.

Statistical Abstract issued by the Central Bureau of Statistics does not include any kind of classification. The data available in this reference are restricted to the following:

- Licensed buildings,

- Accomplished residential & non-residential buildings,

- Expenditure on accomplished residential & non-residential buildings,

- Conventional dwellings occupied and vacant,

- Average cost per floor area square meter of well-finished & conventional residential building.

Anglosphere

On average -Definitions: According to a post on Word Spy, a blog on unusual words, the term was first used by author Neal Stephenson in his 1995 novel The Diamond Age. Stephenson did not use the term in any specific geopolitical sense but rather to describe a fictional race called the Atlantans who, when about 85% of the population in Syria lived in self-owned houses in Syria [3].

Figure (i) shows the evolution of the number of dwellings in Syria between 1970 and 2008. The number of dwellings has been increased by 74% between 1970 and 2008 or by 60% between 1970 and 1994 or by 37% between 1994 and 2008 [2].

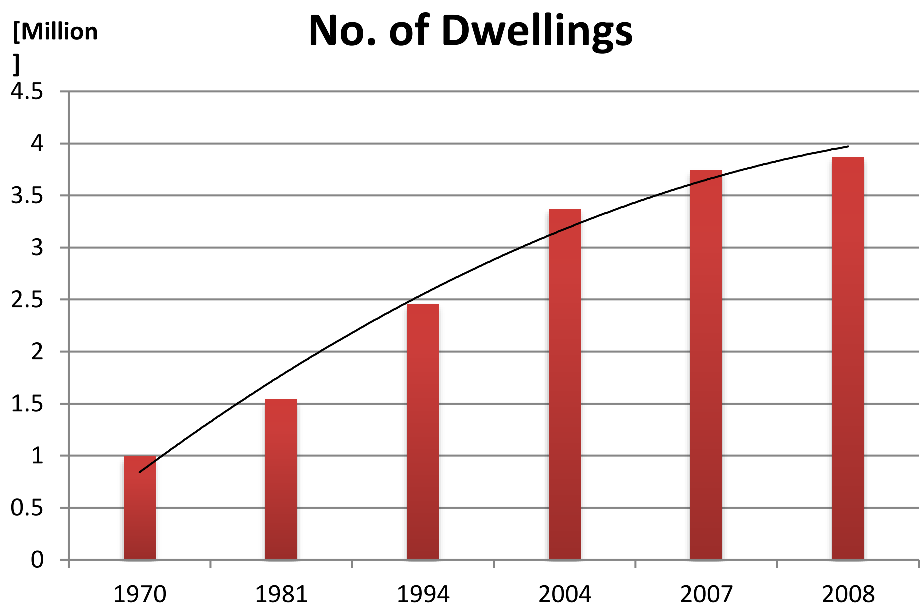


Figure (i): Evolution of the number of dwellings in Syria between 1970 and 2008

The average floor area per capita has been almost doubled from 10.83 $m^2$ in 1970 to 20.30 $m^2$ in 2008.

The total number of dwellings in Syria was estimated at 3.479 or 3.5 million dwellings in 2005 [4] (43% in rural areas and 57% in urban areas). Assuming an average occupancy rate of 88% in rural areas and 89% in urban areas, the number of occupied dwellings equal to 3.0914 million dwellings. As the average surface area of the dwelling is about 100 square meters, the total area of the inhabited dwellings is about 310 million square meters.

The average floor area occupied per capita in the service sector is estimated at about 22 square meters in 2005. By multiplying this area by the number of employees in the service sector (2.785 million) we find the total floor area in the service sector is 61.25 million square meters.

## 2. Energy Consumption in the Residential, Commercial and Service Sectors

The residential, commercial and service sectors have become the major consumer of electricity with a share of 68% [2]. Hence, it is essential to reduce energy consumption and improve end-use energy efficiency in these sectors; bearing in mind the fact that these sectors are also the major contributors to peak loads.

The distribution of the energy consumption in the residential sector is as follows: space heating occupies first place in terms of energy consumption (1441 ktoe), followed by cooking (772 ktoe), water heating (671 ktoe), specific uses (678 ktoe), and finally the consumption of air conditioners (27 ktoe) [4].

The distribution of the energy consumption in the service sector is as follows: space heating occupies first place in terms of energy consumption (420 ktoe), followed by specific electrical uses (162 ktoe), thermal uses (155 ktoe), air conditioning (90 ktoe), and finally the consumption of transport (28 ktoe) [4].

By dividing the amount of final energy consumption in the residential sector in 2005 (3589 ktoe) to the total area of the inhabited dwellings (310 million square meters) we find the amount of energy consumed per square meter (energy intensity in the residential sector per square meter per year): 11.6 kgoe/$m^2$/year or 135 kWh/$m^2$/year [4].

By dividing the amount of final energy consumption in the service sector in 2005 (855 ktoe) to the total floor area of the dwellings (61.25 million square meters) we find the amount of energy consumed per square meter (energy intensity in the service sector per square meter per year): 14 kgoe/$m^2$/year or 163 kWh/$m^2$/year [4].

By dividing the total final energy consumed in the residential sector (3.5 million tons of oil equivalent in 2005 [5]), to the total number of dwellings in Syria in 2005 (3.5 million dwellings [4]) we find the consumption per single dwelling: one ton oil equivalent approx. Assuming that the number of dwellings in Syria will reach 7.9 million dwellings in 2030 and that a dwelling consumes one ton oil equivalent, the final energy consumption in the residential sector will reach 7.9 million tons of oil equivalent in 2030.

The distribution of the electricity consumption by type of use in the residential, commercial, and service sectors in 2005 is as follows: specific uses (lighting and powering other appliances) occupies first place in terms of energy consumption (63%), followed by water heating (18.4%), air conditioning (8.7%), space heating (7.6%), and finally the consumption of cooking (2.3%) [4].

## 3. Market of Solar Water Heating (SWH) Systems in Buildings

The solar thermal market has remained stable in Syria for many years due to many different reasons. The most important among them is the hard competition that it faces from the conventional energy sources. Diesel oil, electricity and LPG were offered at very low prices.

Starting from 2005, a number of Syrian companies promote cheap evacuated tubes imported from China.

Data on imported SWH collectors and systems between 2005 and 2008 in terms of weight and value are obtained from the Syrian Customs. The total square areas of these collectors & SWH systems are estimated at about 220,000 $m^2$. The accumulated installed area of SWH systems in the country up to 2008 is shown in Table (i).

Table (i): Estimated SWH Market Volume

| Year | Installed SWH ($m^2$) | Remarks |
|---|---|---|
| Up to 2005 | 87000 | Accumulated installed SWH systems |
| 2005-2006 | 2000 | Resulted from implementing the "National Pilot Project for Promoting SWH systems" |
| 2006-2008 | 6000 | Estimated SWH systems locally manufactured |
| 2005-2008 | 220,000 | Imported solar collectors & SWH systems. |
| Total | 315,000 | |

## 4. Calculation of Saving Gained from Proposed Energy Efficiency Measures in the Residential Sector

### a- Thermal Insulation in Buildings

The calculated savings in diesel oil (for space heating) and electricity (for air conditioning) from the proposed insulated dwellings up to 2030 are presented in Table (ii). Table (iii) shows same saving but in term of kilo tones oil equivalent.

Table (ii): Potential Savings in Fuel & Electricity from the Proposed Insulated Dwellings in 2030

| Scenario | Total number of insulated dwellings in 2030 | Saving in diesel oil ($10^6$ liter) | Saving in electricity (GWh) |
|---|---|---|---|
| Low | 200,000 | 149 | **587** |
| Medium | 600,000 | 447 | **1760** |
| High | 1,000,000 | 745 | **2933** |

Table (iii): Potential of Total Saving from the Proposed Insulated Dwellings in 2030

| Scenario | Unit | Diesel oil | Electricity | Total (%) |
|---|---|---|---|---|
| **Low** | ktoe | 128 | 147 | **275** |
| | % | 47% | 53% | **100%** |
| **Medium** | ktoe | 384 | 440 | **824** |
| | % | 47% | 53% | **100%** |
| **High** | ktoe | 641 | 733 | **1374** |
| | % | 47% | 53% | **100%** |

### b- Solar Energy Applications

Table (iv) summarizes the total saving resulting from the proposed actions and possible measures to reduce energy consumption through the implementation of the solar thermal and PV technologies in the residential, commercial and service sectors up to 2030.

Table (iv): Sum of Total Energy Savings from Renewable Energy Applications in Residential, Commercial and Service Sectors up to 2030

| | Unit | Diesel oil | Electricity | Total (%) |
|---|---|---|---|---|
| Energy saving gained from SWH systems in residential sector | ktoe | 303 | 76 | **379** |
| | % | 80% | 20% | **100%** |
| Energy saving gained from SWH systems in commercial & service sectors | ktoe | 6.0 | | **6.0** |
| | % | 100% | | **100%** |
| Energy saving gained from PV applications | ktoe | 1.21 | | **1.21** |
| | % | 100% | | **100%** |
| **Total** | **ktoe** | **310.21** | **76** | **386.21** |

### c- Reflective Surfaces of Solar Radiation (Cool Roofs)

Table (v) shows the total annual saving in 2030 resulting from reducing cooling load by converting 1% of the entire surface of existing buildings in Syria in 2010 and 2% of the entire surface of the residential buildings, expected to be constructed between 2010 and 2030, to cool roofs.

Table (v): Potential Saving in 2030 by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings

| **Measures** | **Unit** | **Electricity** |
|---|---|---|
| Potential saving in cooling load from transferring 1% of the roofs on residential buildings existing in 2010 to cool roofs | GWh/yr | **8.34** |
| | ktoe | **2.1** |
| Potential saving in cooling load from transferring 2% of the roofs on residential buildings expected to be constructed between 2010 & 2030 to cool roofs | GWh/yr | **26.1** |
| | ktoe | **6.53** |
| **Total** | GWh/yr | **34.44** |
| | ktoe | 8.63 |

## d- Lighting and Electrical Appliances

Table (vi) summarizes the potential saving from EE measures in lighting and electrical appliances in the residential, commercial, service, and industrial sectors in 2030.

Table (vi): Potential Saving from Energy Efficiency Measures in Lighting & Electrical Appliances in the Residential, Commercial, and Service Sectors in 2030

| Measure | Unit | Electricity |
|---|---|---|
| Increasing energy efficiency in lighting and electrical appliances | GWh | **2051.9** |
| | ktoe | **512.9** |

## e- Total potential saving resulting from the proposed RE&EE measures

Table (vii) shows the total potential saving resulting from the proposed RE&EE measures in the residential, commercial and service sectors in 2030.

Table (vii): Total Potential Saving from the Energy Efficiency Measures in the Residential, Commercial, and Service Sectors in 2030 (ktoe)

| Measure | Diesel oil | Electricity | Total |
|---|---|---|---|
| Thermal insulation (low scenario) | 128 | 147 | **275** |
| Reducing cooling load from transferring 1% of the roofs on residential buildings existing in 2010 to cool roofs | - | 2.1 | **2.1** |
| Reducing cooling load from transferring 2% of the roofs on residential buildings expected to be constructed between 2010 & 2030 to cool roofs | - | 6.53 | **6.53** |
| Increasing energy efficiency in lighting and electrical appliances | - | 512.9 | **512.9** |
| Total | 128 | 668.53 | 796.53 |

#### f- Total Potential Saving Resulting from the Proposed RE&EE Measures

Table (viii) shows the total potential saving resulting from the proposed RE&EE measures in the residential, commercial and service sectors in 2030.

Table (viii): Total Potential Saving from the RE&EE Measures in the Residential, Commercial, and Service Sectors in 2030 (ktoe)

| Measure | Unit | Diesel oil | Electricity | Total |
|---|---|---|---|---|
| Renewable energy measures | ktoe | 310.21 | 76 | **386.21** |
| Energy efficiency measures | ktoe | 128 | 668.53 | **796.53** |
| **Total** | ktoe | **438.21** | **744.53** | **1182.74** |
| | Tj* | **17529** | **29781** | **47310** |

## 5. Conclusion

The total saving in 2030 is: 1183 ktoe, which represents 6.0% of the primary energy consumed in Syria in 2005 (19.6 Mtoe), or 7.75% of the final energy consumed in Syria in 2005 (15.25 Mtoe). Also, the total saving represents 2.45% of the final energy consumed in Syria in 2030 48.359 Mtoe).

## 6. Economic and Environmental Impacts of Proposed Measures

To reach the goal of the study of economic and environmental impacts of the proposed plan for RE&EE applications in the residential sector, an analytical study for the implementation of the proposed measures should be undertaken. The results of this study should be presented in terms of economic feasibility and environmental and in terms of availability of the necessary funding to implement the plan. The expected direct and indirect impacts could be:

**Environmental Impacts**

- Reducing greenhouse gas carbon dioxide in 2030 by about 1735 kilotons, or 3% of the total emissions in 2005 (58350 kt).

- Improvement of environmental conditions by the use of clean renewable energy applications.

**Economic Impacts**

- Reduction in the consumption of fossil fuel, thereby reducing the import bill of diesel fuel,

- Reduction in electric power consumption, thereby reducing the electric peak demand,

- Increasing income resulting from the reduction of energy consumption,
- Promotion of opportunities for local manufacturing of the energy-saving tools and equipment,

- Creating new job opportunities.

To achieve this goal, a national model should be design to:

- Estimate the economic effects of direct and indirect impacts on various economic sectors,

- Study the impact of inputs and outputs with economic and demographic variables at the national level,

- Provide a framework to study the adverse impacts of the economic events between the various sectors of the economy.

# 1. Introduction

Syrian engineers has left us with many religious and civil buildings, which has seen during the period between the second and seventh centuries AD significant developments both in the forms of building materials or in terms of finishes and the development of doors and windows. The old houses in Damascus are built of soft unbaked bricks, wood, and stone. Contemporary buildings are built of concrete, while hewn stone is reserved for official buildings, mosques, and churches.

Starting from the 1930s, Syria faced a lot of changes in the field of urban planning and architecture. The architectural language of western modernism had been used. The most relevant disposition was the reversion from the introverted courtyard house to the extraverted apartment house. Typical 1930s architecture came to origin, indicated by good proportions, rows of windows and sensitive detailing, resulting from the existence of qualified handicraftsmen.  Buildings in that area and time are mainly indicated by huge balconies, extraordinary window shapes etc. The urban development during the 1960s, 70s and 80s is represented via multi-storey buildings.

The pace of change in Syria from an agricultural to an industrial economy, and the accompanying migration to the cities, led to an acute shortage of housing. Aggravating the shortage, young adult males migrating from rural areas to the cities are increasingly breaking with tradition by leaving their parental homes for their own. The Ministry of Housing undertakes the construction of blocks of low-income flats in the cities.

Recently, the Syrian building industry benefits from the economic growth and the inflow of foreign capital and is regarded as a very promising market. It is growing rapidly, and numerous projects in the field of house building and the construction of office premises are planned.

Building sector (residential, commercial and service) in Syria is the most energy consuming sector, especially electric power. It is difficult to predict its energy demand, due to multiple factors, including geographical, climatic, and surrounding environmental conditions, economic and social factors, living standards, and the availability of energy sources and possibilities of their use.

There are many reasons for the low efficient use of energy in the residential, commercial and service sectors in Syria, including, for example, poorly designed buildings, the use of inappropriate technologies and the incorrect behavior of its residents.

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In Syria, there is a need for socio-economic development and poverty alleviation to improve the standard of living in the region’s poor and rural areas. Renewable energy technologies (RETs) could be selectively applied to various rural and urban applications, potentially generating income, improving health and educational quality, improving the GDP, achieving gender equity, and increasing labor productivity.

## 2. Population in Syria

Table (1) shows the population existed in Syria at the time of population censuses (1960, 1970, 1981, 1994, and 2004) and their estimates in other years.

Table 1: Population Existed in Syria at the Time of Population Censuses and Their Estimates in Other Years

| Year | Urban | Rural | Total |
|---|---|---|---|
| 1960 | | | **4.565** |
| 1970 | | | **6.305** |
| 1981 | | | **9.046** |
| 1994 | | | **13.782** |
| 2004 | | | **17.921** |
| Mid 2005 | | | **18.269** |
| Mid 2006 | | | **18.717** |
| Mid 2007 | 10.257 | 8.915 | **19.172** |
| 1/1/2008 | | | **19.405** |
| Mid 2008 | 10.511 | 9.133 | **19.644** |
| 1/1/2009 | | | **19.880** |
| Mid 2009 | 10.769 | 9.356 | **20.125** |
| 1/1/2010 | | | **20.367** |

Source: [1]

Table (2) shows the annual population growth rate according to 1981, 1994 - 2004 censuses and its estimates during (1995-2000) & (2000-2005) [1].

Table 2: Annual Growth Rate According to 1981, 1994 - 2004 Censuses and Estimates of Annual Population Growth Rate During (1995-2000) & (2000-2005)

| Annual Population Growth Rate | | |
|---|---|---|
| **1981 - 1994** | **1995 – 2000** | 2000 – 2005 |
| 3.3% | 2.7% | **2.45%** |

Source: [1]

# 3. Overview of Buildings in Syria

## 3.1 Data Availability

Data Systems for the collection of data on EE&RE are often the weakest in most countries. Data on conventional sources of energy supply in Syria are gathered from the Ministry of Electricity and Ministry of Oil & Mineral Resources, but those on end-use have to be collected through customer surveys, which are not conducted regularly or on a uniform basis. Similarly, in the household sector, collecting data on traditional and non-traditional fuel use is not an easy task.

This situation is further complicated because GHGs mitigation analysis requires that data for the energy, building, agriculture, etc. sectors be matched with those on the socio-economic impact of a mitigation option.

## 3.2 Classification of Buildings

**House:**
A house is generally a shelter, building or structure that is a dwelling or place for habitation by human beings. The term includes many kinds of dwellings ranging from rudimentary huts of nomadic tribes to high-rise apartment buildings can be built in a large variety of configurations. A basic division is between free-standing or detached dwellings and various types of attached or multi-user dwellings. Both sorts may vary greatly in scale and amount of accommodation provided.

Building classification is generally based on purely matters of style rather than spatial arrangement or scale.

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- Licensed buildings,

- Accomplished residential & non-residential buildings,

- Expenditure on accomplished residential & non-residential buildings,

- Conventional dwellings occupied and vacant,

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On average -Definitions: According to a post on Word Spy, a blog on unusual words, the term was first used by author Neal Stephenson in his 1995 novel The Diamond Age. Stephenson did not use the term in any specific geopolitical sense but rather to describe a fictional race called the Atlantans who, when about 85% of the population in Syria lived in self-owned houses in Syria .

### 3.3 Characteristics of the Housing Market in Syria

Characteristics of the housing market in the Middle East, North Africa, and Central Asia region (MCD) countries are summarized in Table (3), which splits the market into three categories: homeownership, and rental and social housing. It is perhaps remarkable to observe a similar average homeownership ratio in Syria compared to advanced countries. For comparison, about 65 percent of the population, on average, lived in self-owned houses in the Organization for Economic Co-operation and Development (OECD) countries between 1995 and 2007. In Syria, this percentage is 85 percent. For the other two housing market categories, rental and social or subsidized housing, there is a relatively smaller fraction of rentals in Syria compared with other Arab countries [3].

Table 3: Characteristics of the Housing Market in Emerging in Middle East, North Africa, and Central Asia region (MCD)

| | Home ownership | Rental & Leasehold | Informal and Social (Subsidized) Housing | House Price/ Income Ratio | Supply Gaps |
|---|---|---|---|---|---|
| **Algeria** | 0.45 | 0.3 | 0.25 | 12 | Yes |
| **Bahrain** | 0.68 | 0.2 | 0.12 | 12 | No |
| **Egypt** | 0.38 | 0.33 | 0.29 | 7 | Yes |
| **Jordan** | 0.71 | 0.17 | 0.12 | 3 | No |
| **Kuwait** | 0.68 | 0.27 | 0.05 | --- | Moderate |
| **Morocco** | 0.65 | 0.22 | 0.15 | 9 | Future |
| **Qatar** | 0.72 | 0.28 | --- | --- | Moderate |
| **Saudi Arabia** | 0.56 | 0.44* | --- | --- | Future |
| **Syria** | 0.85 | 0.07 | 0.08 | --- | Moderate |
| **Tunisia** | 0.77 | 0.08 | 0.15 | 5 | No |
| **UAE** | 0.55 | 0.45 | 0.05 | >12 | No |

Source: [3]
*Note that this is the sum of both the rental (23%) and leasehold (21%) share.

### 3.4 Evolution of the Number of Residential Dwellings

The conventional dwellings (occupied & vacant), rooms, floor areas and number of persons per room (urban & rural) in the years 1970, 1981, 1994, 2004 and 2008 are presented in Table (13) in Annex (1). Figure (1) shows the evolution of the number of dwellings in Syria between 1970 and 2008. The number of dwellings has been increased by 74% between 1970 and 2008 or by 60% between 1970 and 1994 or by 37% between 1994 and 2008 [2].

The number of dwellings (Occupied & Vacant) was increased during the period from 1970 to 1981 from 989,936 to 1,538,946 dwelling at a rate of 50,000 dwelling a year. The resident population in the same period was increased from 6.305 million in 1970 to 9.046 million in 1981. So the rate of increase in this period was a dwelling for every 5 persons.

The number of dwellings in 1994 was 2,457,903 dwelling with a rate of increase of 71,000 dwelling a year between 1981 and 1994. The resident population in the same period was increased from 9.046 million in 1981 to 13.782 million in 1994. So the rate of increase in this period was a dwelling for every 5.15 persons.

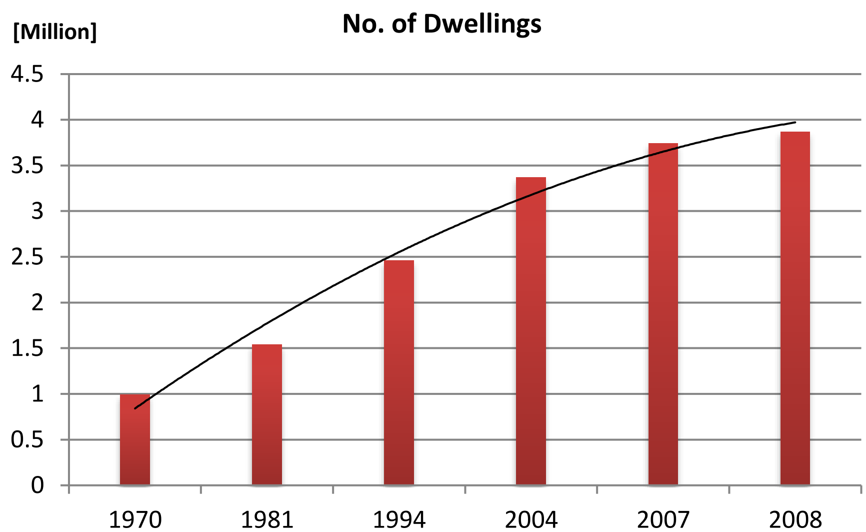



Figure 1: Evolution of the number of dwellings in Syria between 1970 and 2008- Source: Extracted from [2]

The number of dwellings in 2004 was 3,368,342 dwelling with a rate of increase of 91,000 dwelling a year between 1994 and 2004. The resident population in the same period was increased from 13.782 million in 1994 to 17.921 million in 2004. So the rate of increase in this period was a dwelling for every 4.55 persons.

The number of dwellings in 2007 was 3,740,665 dwelling with a rate of increase of 124,000 dwelling a year between 2004 and 2007. The resident population in the same period was increased from 17.921 million in 2004 to 19.405 million in 2007. So the rate of increase in this period was a dwelling for every 4.0 persons.

The number of dwellings in 2008 was 3,870,536 dwelling with a rate of increase of 129,871 dwelling a year between 2007 and 2008. The resident population in the same period was increased from 19.405 million in 2007 to 19.880 million in 2008. So the rate of increase in this period was a dwelling for every 3.7 persons.

It follows from the foregoing that the rate of increase in the number of dwellings during the period between 1970 and 2008 has been improved from a dwelling for every 5 persons to a dwelling for every 3.7 persons. Assuming that a rate of 4 persons per dwelling will last until 2030, the Syrian population is expected to be 31.47 million in 2030. We deduce the expected number of dwellings in 2030: 7867500 (or 7900000) dwelling. On the other hand, assuming that the number of dwellings in Syria at the beginning of 2010 is 4 million dwellings, it means that the number of new dwellings between 2010 and 2030 will be 3.9 million dwelling.

Table (4) summarizes the annual rates of increase in the number of dwellings in Syria.

Table 4: Annual Rates of Increase in the Number of Dwellings in Syria

| Period | Annual rate of increase (dwellings/year) | Number of persons Per dwelling |
|---|---|---|
| 1970-1981 | 50,000 | **5** |
| 1981-1994 | 71,000 | **5.15** |
| 1994-2004 | 91,000 | **4.55** |
| 2004-2007 | 124,000 | **4.0** |
| 2007-2008 | 129,871 | **3.7** |
| 2010-2030* | 195,000 | **4.0** |

Source: Extracted from [2]
* Estimated numbers based on statistical data

The average floor area per capita has been almost doubled from 10.83 $m^2$ in 1970 to 20.30 $m^2$ in 2008.

## 3.5 Evolution of the Total Floor Area of Residential Dwellings

We note from Figure (2) that the rate of increase in housing investment from the beginning of the seventies and until the year 2004 (~79%) is much greater than the rate of population growth in the same period (~65%). The difference between these two rates is 14%. However, this phenomenon has decreased during the period from 2004 to 2008. The difference between both rates of increase became smaller (7%): ~ 16% for the housing and ~9% for the population (See Table 13 in Annex 1).

## 3.6 Accomplished Residential & Non- Residential Buildings in Private & Cooperative Sectors

Starting from the 2000s, the Syrian building industry benefits from the economic growth and the inflow of foreign capital. The accomplished residential (Figure 3) & Non- Residential (Figure 4) buildings are growing rapidly between 2000 and 2008 (See Tables 11 & 12 in Annex 1).

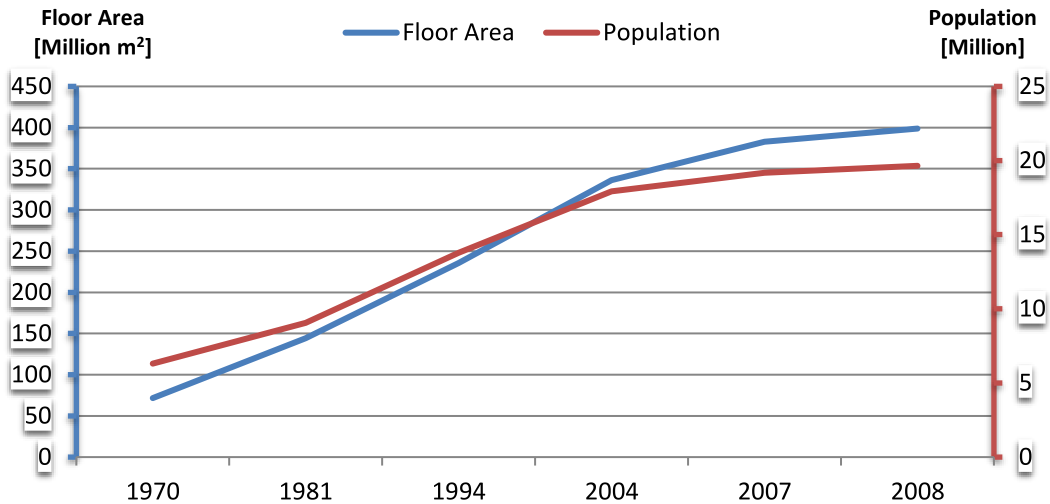



Figure 2: Evolution of the Population & the Total Floor Area of Residential Dwellings in Syria 1970-2008 - Source: Extracted from [2]

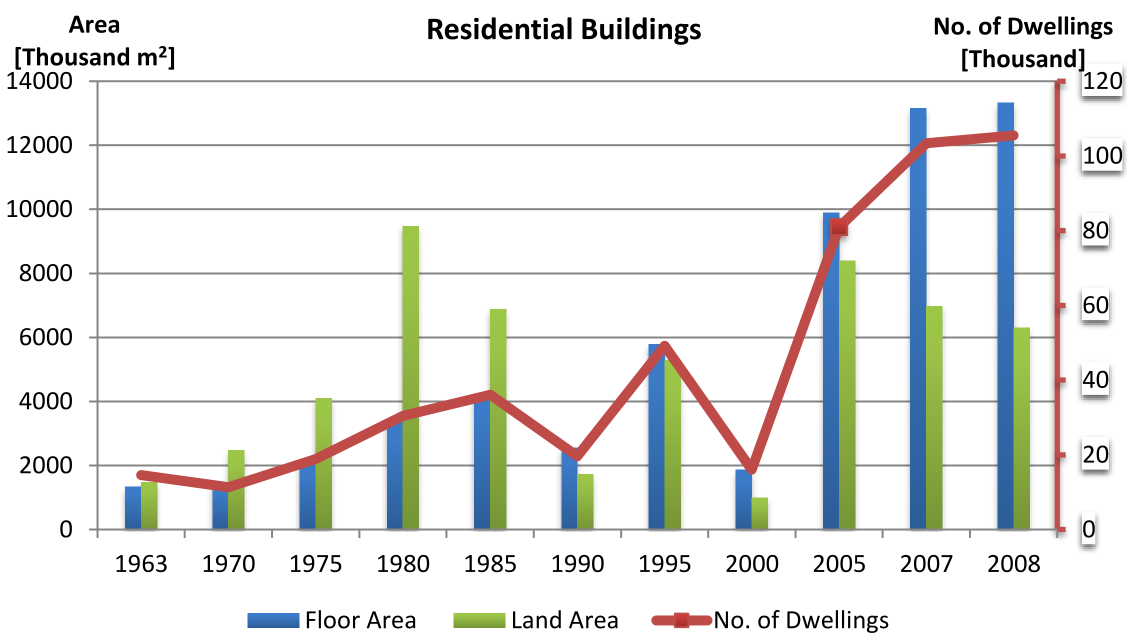



Figure 3: Accomplished Residential Buildings and the Corresponding Floor & Land Areas between 1963 and 2008- Source: Extracted from [2]

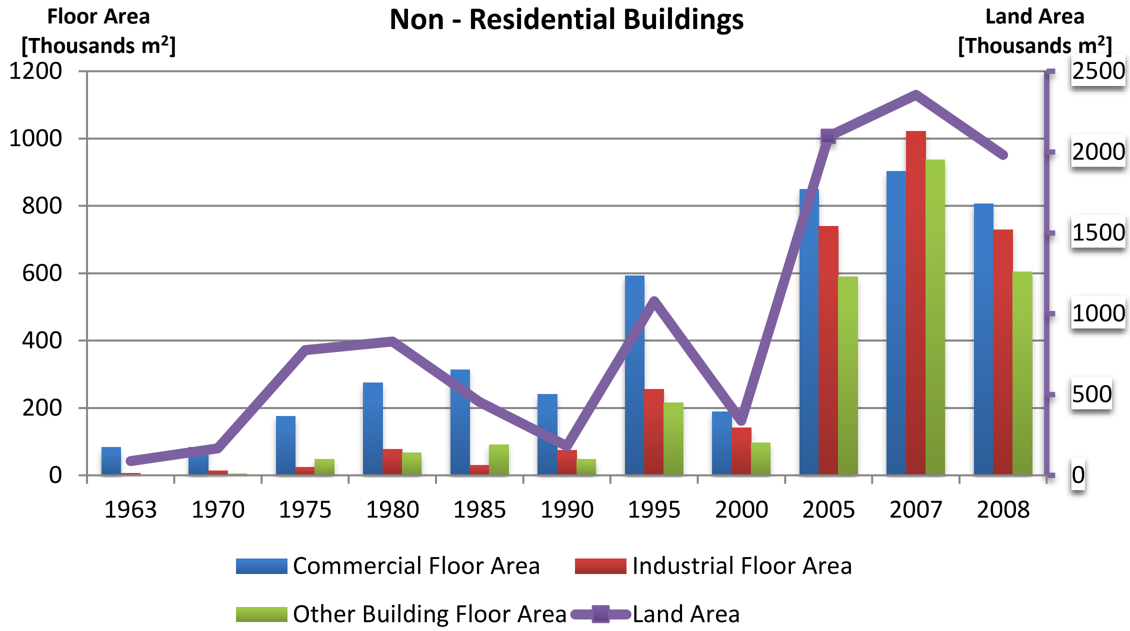



Figure 4: Accomplished Non-Residential Buildings and the Corresponding Floor & Land Areas between 1963 and 2008- Source: Extracted from [2]

# 4.Energy Consumption in the Residential, Commercial and Service Sectors

The residential, commercial and service sectors have become the major consumer of electricity with a share of 68% [2]. Hence, it is essential to reduce energy consumption and improve end-use energy efficiency in these sectors; bearing in mind the fact that these sectors are also the major contributors to peak loads.

With the increase in energy tariff in the past two years in Syria, energy management in the residential, commercial and service sectors should be practiced in addition to seeking new cheaper alternatives to provide energy.

There is a great potential to reduce GHGs emissions in the residential, commercial and service sectors through the use of energy-saving lamps instead of incandescent bulbs, the use of energy-efficient equipment and appliances, the use of thermal insulation and solar water heaters, and improving the efficiency of the traditional oil-stoves.

## 4.1 Breakdown of the Energy Consumption by Type of Use in the Residential and Service Sectors

### 4.1.1 Residential Sector

Energy in households is used for lighting, electric appliances, space & water heating, air conditioning, and other activities. Usually electricity is too expensive for cooking, so gas is used for cooking. People who do not have electricity use kerosene lamps and candles that provide poor illumination and inadequate working hours at night, thus, seriously limiting educational attainment and standing as an obstacle in the way of eradicating illiteracy.

The distribution of the energy consumption in the residential sector for cooking, space and water heating, air conditioning, powering of electrical appliances and other purposes is presented in the Table (5) [4]. Space heating occupies first place in terms of energy consumption (1441 ktoe), followed by cooking (772 ktoe), water heating (671 ktoe), specific uses (678 ktoe), and finally the consumption of air conditioners (27 ktoe).

Table 5: Breakdown by Type of Use of the Energy Consumption in the Residential Sector in 2005

| | | Unit | Fossil fuel | | | Electricity | Solar energy | Traditional fuel | Total or % |
|---|---|---|---|---|---|---|---|---|---|
| | | | Diesel | Kerosene | LPG | | | | |
| Total (Urban & rural) | | Ktoe | 1656 | 1.4 | 717 | 968 | 1.8 | 245 | 3589 |
| Cooking | Total | Ktoe | | | 672 | 31 | | 69 | 772 |
| | | % | | | 87% | 4% | | 9% | 22% |
| | Urban | Ktoe | | | 349 | | | | 401 |
| | | % | | | 52% | | | | 52% |
| | Rural | Ktoe | | | 323 | | | | 371 |
| | | % | | | 48% | | | | 48% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Space Heating | Total | Ktoe | 1217 | | 25 | 46 | | 153 | 1441 |
| | | % | 84.5% | | 1.7% | 3.2% | | 10.6% | 40% |
| | Urban | Ktoe | | | | | | | 684 |
| | | % | | | | | | | 47.5% |
| | Rural | Ktoe | | | | | | | 757 |
| | | % | | | | | | | 52.5% |
| Water heating | Total | Ktoe | 436 | | 20 | 188 | 1.8 | 25 | 671 |
| | | % | 65% | | 3% | 28% | 0.3% | 3.7% | 19% |
| | Urban | Ktoe | | | | | | | 476 |
| | | % | | | | | | | 71% |
| | Rural | Ktoe | | | | | | | 195 |
| | | % | | | | | | | 29% |
| Air-conditioning | Total | Ktoe | | | | 26.5 | | | 27 |
| | | % | | | | 100% | | | 0.1% |
| | Urban | Ktoe | | | | 23 | | | 23 |
| | | % | | | | 86.7% | | | 87% |
| | Rural | Ktoe | | | | 3.5 | | | 4 |
| | | % | | | | 13.3% | | | 13% |
| Specific uses | Total | Ktoe | | | | 678 | | | 678 |
| | | % | | | | 100% | | | 18.9% |
| | Urban | Ktoe | | | | 420 | | | 420 |
| | | % | | | | 62% | | | 62% |
| | Rural | Ktoe | | | | 258 | | | 258 |
| | | % | | | | 38% | | | 38% |

Source: Extracted from [4]

The contribution of solar energy in the energy supply in both the residential and service sectors (1.8 ktoe) is very low in spite of the great potential available.

### **4.1.2 Service Sector**

The distribution of the energy consumption in the service sector for transport, space heating, air conditioning, thermal uses (space and water heating), and specific electrical uses (lighting and powering electrical appliances) is presented in the Table (6) [4]. Space heating occupies first place in terms of energy consumption (420 ktoe), followed by specific electrical uses (162 ktoe), thermal uses (155 ktoe), air conditioning (90 ktoe), and finally the consumption of transport (28 ktoe).

Table 6: Breakdown by Type of Use of the Energy Consumption in the Service Sector in 2005

| | Unit | Fossil fuel | | | Electricity | | | | Traditional fuel | Total or % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Transport | Space heating | Thermal use | Air-Condit. | Specific use | Space heating | Thermal use | Thermal use | |
| Total | ktoe | 28 | 364 | 80 | 90 | 162 | 56 | 57 | 18 | 855 |
| Trade, Restaurants & Hotels | ktoe | 0 | 29 | 43 | 28 | 56 | 11 | 17 | 18 | 202 |
| | % | | 8% | 54% | 31% | 35% | 20% | 30% | 100% | 24% |
| Communications, Storage & Transport | ktoe | 28 | 197 | 22 | 20 | 34 | 10 | 3 | | 314 |
| | % | 100% | 54% | 28% | 22% | 21% | 18% | 5% | | 37% |
| Other Services (Finance..) | ktoe | 0 | 93 | 10 | 14 | 23 | 7 | 2 | | 149 |
| | % | | 26% | 12% | 16% | 14% | 12% | 4% | | 17% |
| Gov. agencies, Worship places & Street lighting | ktoe | 0 | 45 | 5 | 28 | 49 | 28 | 35 | | 190 |
| | % | | 12% | 6% | 31% | 30% | 50% | 61% | | 22% |

Source: Extracted from [4]

## 4.2 Breakdown of the Energy Consumption by Type of Fuel in the Residential and Service Sectors

Table (7) shows the distribution of the final energy consumption by fuel type in the residential (rural and urban) and the service sectors in 2005 [4].

The total number of dwellings in Syria was estimated at 3.479 or 3.5 million dwellings in 2005 [4] (43% in rural areas and 57% in urban areas). Assuming an average occupancy rate of 88% in rural areas and 89% in urban areas, the number of occupied dwellings equal to 3.0914 million dwellings. As the average surface area of the dwelling is about 100 square meters, the total area of the inhabited dwellings is about 310 million square meters.

Table 7: Breakdown by Type of Fuel of the Energy Consumption in the Residential & Service Sectors in 2005 Source: Extracted from [4]

| Sector | | Unit | Fossil fuel | | | Electricity | Solar Energy | Traditional fuel | Total |
|---|---|---|---|---|---|---|---|---|---|
| | | | Diesel oil | Petrol/ Kerosene | LPG | | | | |
| Resid. | Total (urban & Rural) | ktoe | 1656 | 1.4 | 717 | 968 | 1.8 | 245 | 3589 |
| | | % | 46% | 0% | 20% | 27% | 0% | 7% | 100 |
| | Urban | ktoe | 941 | 0.2 | 466 | 645 | 1.6 | 9 | 2063 |
| | | % | 57% | 14% | 65% | 67% | 90% | 4% | - |
| | Rural | ktoe | 715 | 1.2 | 251 | 323 | 0.2 | 236 | 1526 |
| | | % | 43% | 86% | 35% | 33% | 10% | 96% | - |
| Service | Total | ktoe | 401 | 11 | 60 | 365 | 0 | 18 | 855 |
| | Trade, Restaurants. & Hotels | | 71 | | | 113 | - | 18 | 202 |
| | Communications, Storage & Transport | | 247 | | | 68 | - | - | 315 |
| | Other Services | | 103 | | | 45 | - | - | 148 |
| | Gov. agencies, Worship places & Street lighting | | 50 | | | 140 | - | - | 190 |
| Total | | ktoe | 2057 | 12.4 | 777 | 1333 | 1.8 | 263 | 4444 |

By dividing the amount of final energy consumption in the residential sector in 2005 (3589 ktoe) to the total area of the inhabited dwellings (310 million square meters) we find the amount of energy consumed per square meter (energy intensity in the residential sector per square meter per year): 11.6 kgoe/m$^2$/year [4].

The average floor area occupied per capita in the service sector is estimated at about 22 square meters in 2005. By multiplying this area by the number of employees in the service sector (2.785 million) we find the total floor area in the service sector is 61.25 million square meters.

By dividing the amount of final energy consumption in the service sector in 2005 (855 ktoe) to the total floor area of the dwellings (61.25 million square meters) we find the amount of energy consumed per square meter (energy intensity in the service sector per square meter per year): 14 kgoe/m$^2$/year [4].

By dividing the total final energy consumed in the residential sector (3.5 million tons of oil equivalent in 2005 [5]), to the total number of dwellings in Syria in 2005 (3.5 million dwellings [4]) we find the consumption per single dwelling: one ton oil equivalent approx. Assuming that the number of dwellings in Syria will reach 7.9 million dwellings in 2030 and that a dwelling consumes one ton oil equivalent, the final energy consumption in the residential sector will reach 7.9 million tons of oil equivalent in 2030.

In conclusion, the energy intensity 11.6 kgoe/m$^2$/year or 135 kWh/m$^2$/year in the residential sector and 14 kgoe/m$^2$/year or 163 kWh/m$^2$/year in the service sector are larges compared with the current trend in Europe towards an intensity of no more than 70 kWh/m$^2$/year. This call for a national energy efficiency policy, to help cut energy costs in these sectors.

## 4.3 Breakdown of the Electricity Consumption by Type of Use in the Residential and Service Sectors

Table (8) shows the distribution of the electricity consumption by type of use in the residential, commercial, and service sectors in 2005 [4].

Table 8: Breakdown by Type of Use of the Electricity Consumption in the Residential, Commercial and Service Sectors in 2005

| Electricity used for: | Residential Sector (GWh) | Commercial and Service Sectors (GWh) | Total (%) |
|---|---|---|---|
| Cooking | 360 | - | 360 (2.3%) |
| Space heating | 535 | 651 | 1186 (7.6%) |
| Water heating | 2186 | 663 | 2849 (18.4%) |
| Air- conditioning | 308 | 1047 | 1355 (8.7%) |
| Specific uses (Lighting and powering other appliances) | 7885 | 1884 | 9769 (63%) |
| Total | 11274 | 4245 | 15519* |

Source: Extracted from [4]

* According to the Central Bureau of Statistics this total consumption is 15109 GWh

## Legislations & Regulations in the field of RE&EE

**a. Establishment of the National Energy Research Centre (NERC)**

The "National Energy Research Centre" (NERC) was established in 2003 (Low No. 8 2003) to advise the government on energy policy questions, energy efficiency & renewable energy and fostering energy conservation awareness.

**b. Issuing the "Code of Thermal Insulation in Building"**

The "Code of Thermal Insulation in Building ", has been issued by a circular by the Prime Minister, on 22/11/2007, and has been applied from the date of 1/1/2008. The code includes the maximum values of the overall heat transfer coefficients (U-value) of the building elements [6].

**c. Issuing the "Law of Energy Efficiency Standards for Electrical Appliances in the Residential, Commercial, and Service Sectors"**

This law (No. 18), an important by-product of the project "*Supply-Side Energy Efficiency and Energy Conservation and Planning"*, has been issued on14/10/2008. The instructions for this law have been issued on 8/10/2009.

**d. Issuing the "Energy Conservation Law"**

The "Energy Conservation Law" (No. 3) has been issued on 22/2/2009. This law aims at [7]:

- Support to the economic and social development in the Syrian Arab Republic,
- Maximization of lifespan of fossil fuel reserves available in the Syrian Arab Republic,
- Minimization of negative environmental impacts resulting from the use of various conventional energy carriers,
- Contribution to fulfilling the sustainable development requirements.

To achieve the above objectives the law acts as follows:

- Dissemination and application of the energy conservation concepts, including the rationalization of energy consumption, energy conservation, and energy efficiency improvement in all areas of lasting impact on the production and consumption of energy.
- Dissemination of use of various renewable energy applications.

**e. Mandatory Thermal Insulation & Solar Water Heating for Building Permits**

The Ministry of Local Administration decision in November 2009 requiring building permits applicants to submit a study for supplying solar water heating system and thermal insulation of the building. The thermal insulation study should be in according with the "Code of Thermal Insulation in Building". There are sanctions for non-committed to this decision.

### f. Amending the Electricity Act

The Ministry of Electricity is currently amending the Electricity Act to include allowing the private sector to invest in power generation from fossil energy and renewable energy sources. It is expected to see the light of the new law during the 2010.

### g. Restructuring the Energy Carrier's Tariff

Within the framework of implementing the Tenth Five Year Plan the restructuring of the energy carrier's tariff in Syria was undertaken during the years 2007 and 2008. The diesel oil tariff was increased on 3 May 2008 from 7 to 25 Syrian pounds per liter and then declined later to 20 Syrian pounds per liter (the official price ) or 20.65 Syrian pounds per liter (retail price to the consumer). Also, the price of a liquefied gas bottle of 12 kg was increased from 145 to 250 Syrian pounds (official rate) and 275 Syrian pounds (retail price to the consumer). The new tariff for electricity has been applied on the first of September in 2007, and was subsequently slightly modified the tariff for the consumption above 1000 kilowatt hours per month in residential sector. Annex (2) includes the new electricity tariff.

The current average costs of one kilowatt hour produced from electricity, diesel oil, and liquefied gas (at 100% yield) are presented in Table (9).

Table 9: Average Unit Cost for Electricity, LPG, and Diesel Oil

| | Average unit cost (SL/kWh) |
|---|---|
| **Electricity** | 2.41* (plus taxes and fees) |
| **LPG** | 1.8** |
| **Diesel oil**[+] | 2.08*** |
| **Green Diesel, 50 ppm $SO_2$** | 2.21[++] |

* For a consumption of 1000 kWh/month (without taxes and fees).
**Assuming a retail price of SL 275 for one bottle gas and100% efficiency.
***Assuming a retail price of SL 20.65 per liter and100% efficiency.
[+] Diesel oil typically contains 0.7 percent sulfur.
[++]Assuming a retail price of SL 22 per liter and100% efficiency.

### h. Standards of Energy Efficiency in Buildings (in preparation)

Syria has to set standards for energy efficiency in new buildings based on the energy performance of the building. The methodology of calculation of energy performances of buildings shall include at least the following aspects:

(a) Thermal characteristics of the building (shell and internal partitions, etc.). These characteristics may also include air-tightness;

(b) Heating installation and hot water supply, including their insulation characteristics;

(c) Air-conditioning installation;

(d) Ventilation;

(e) Built-in lighting installation (mainly the non-residential sector);

(f) Position and orientation of buildings;

(g) Passive solar systems and solar protection;

(h) Natural ventilation;

(i) Indoor climatic conditions.

# Market of Solar Water Heating (SWH) Systems in Buildings

The solar thermal market has remained stable in Syria for many years due to many different reasons. The most important among them is the hard competition that it faces from the conventional energy sources. Diesel oil, electricity and LPG were offered at very low prices.

Starting from 2005, a number of Syrian companies promote cheap evacuated tubes imported from China. One of the major questions a consumer will have regarding the installation of solar panels is the choice between flat plate solar panels or evacuated tubes.

Despite recent growth of the SWH market in Syria, there are still substantial barriers to additional SWH technology diffusion. The most pervasive relate to the lack of established or accepted methods to address initial costs, relatively low energy prices, lack of public awareness campaigns, lack of equipment quality standards, and often policy, promotion, or technology failures.

Most of the solar collectors produced and sold in Syria are used for producing domestic hot water. Indirect storage or close-coupled thermosiphon systems are generally used. Direct solar systems are also used but owing to the risk of freezing. Whereas, forced circulation systems are predominate in the commercial sector. The most popular solar system has a storage tank of 200 liter separate from the collectors. The expected payback period is estimated to be 5 to 6 years.

There are in Syria some 10-15 companies that really manufacture Solar SWH systems, including one associated with the Ministry of Industry. They are small local industries with limited production capacity. The production capacity of the biggest industry of the public sector (CHAM) is about 400-500 systems per year. There is one testing facility in Syria which belongs to the government: the Scientific Studies & Research Centre in Damascus.

## 6.1 Analysis of Imported Solar Materials Data

Data on imported solar materials are obtained from the Syrian Customs. The detailed analysis of this data is shown in Annex (3).

Syrian Customs classify imported solar materials as follows:

1. Item: 8419.90.10 for solar collectors (flat-plate or evacuated tubes,
2. Item: 8419.19.00 for complete SWH systems.

Tables from (1) to (9) in Annex (3) summarize the weight and cost of the imported solar collectors and SWH systems from different countries for the years 2005, 2006, 2007, and 2008 [8].

The imported solar collectors between 2006 and 2008 in terms of weight and value are shown in Figure (5), while Figure (6) shows the imported SWH systems between 2005 and 2008 in terms of weight and value.

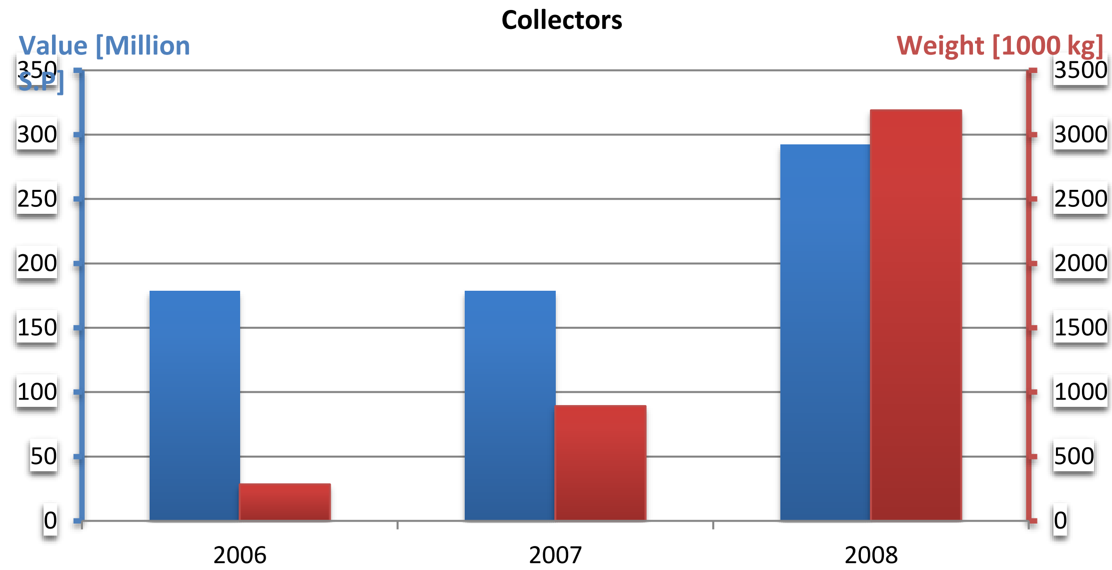



Figure 5: Weight and Value of the Imported Solar Collectors between 2006 & 2008- Source: from [8]

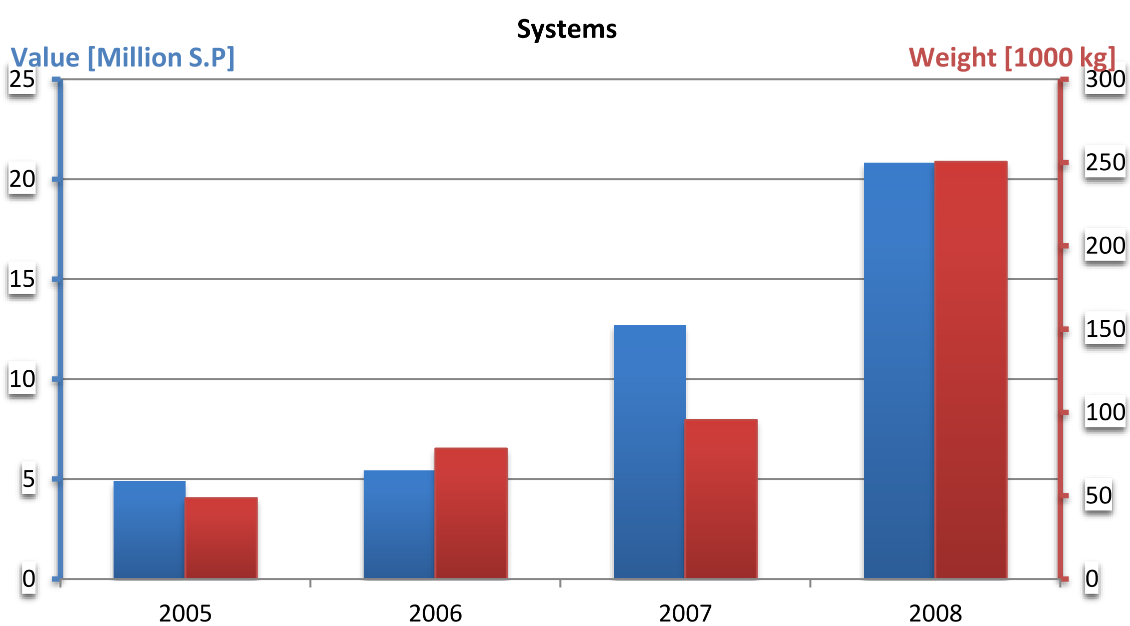



Figure 6: Weight and Value of the Imported SWH systems between 2005 & 2008- Source: from [8]

Figure (7) shows the imported solar collectors and SWH systems between 2005 and 2006 in terms of weigh, value, and country.

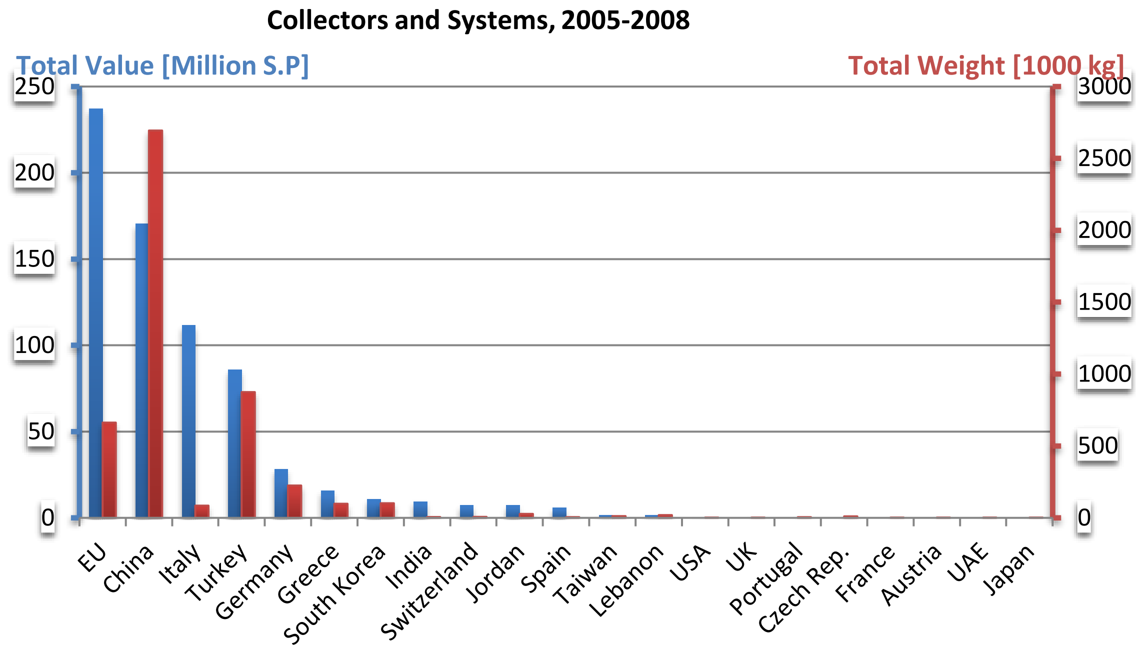



Figure 7: Imported Solar Collectors and SWH Systems between 2005 and 2008 in Terms of Weigh, Value, and Country Source: Extracted from [8]

It is difficult to extract the number or the total square area of the imported solar collectors and SWH systems from data providing by Syrian Customs.

In order to determine the total square area of the imported solar collectors and SWH systems, and according to Table (7) in Annex (3) the following assumptions are adopted:

- Surface area of a solar flat-plate collector is 2 $m^2$,
- Weight of a solar flat-plate collector including packaging is 50 kg,
- Surface area of a SWH system of flat-plate collectors is 4 $m^2$,
- Weight of a SWH system of flat-plate collectors including packaging is 200 kg,
- Surface area of one evacuated tube is 0.15 $m^2$,
- Weight of one evacuated tube including support and packaging is 3 kg,
- Number of evacuated tubes in a SWH system is 20 tubes,
- Surface area of a SWH system of 20 evacuated tubes is 3 $m^2$,
- Weight of a SWH system of 20 evacuated tubes including packaging is 60 kg,

- Evacuated tube collectors and SWH systems are imported from China, India, South Korea, Lebanon, and Taiwan,
- Flat-plate solar collectors and SWH systems are imported from other countries,
- Solar materials imported from USA, UK, Portugal, Czech Rep., France, Austria, UAE, and Japan are neglected due the low import costs.

The total square areas of imported solar collectors & SWH systems between 2005 and 2008 are then estimated and presented in Table (10).

Table 10: Total Square Area of Imported Solar Collectors & SWH Systems between 2005 and 2008

| Collector type | Total Collectors square area (m2) | Total Systems square area (m2) | Total square area (m2) |
|---|---|---|---|
| **Flat-plate** | 76,152 | 1636 | 77,788 |
| **Evacuated tubes** | 122,631 | 19,020 | 141,651 |
| TOTAL | 198,783 | 20,656 | 219,439 |

## 6.2 Average Cost per Square Meter of Imported Solar Materials

By dividing the total value of the imported solar collectors between 2005 and 2008 by the estimated total square meter of these collectors we find:

$$649{,}113{,}837/198{,}783 = 3265 \text{ SP/m}^2$$

This reasonable result indicates that the analysis shown in Annex (3) is acceptable.

## 6.3 Accumulated Installed Area of SWH Systems

The accumulated installed area of SWH systems in the country up to 2008 is shown in Table (11).

Table 11: Estimated SWH Market Volume

| Year | Installed SWH ($m^2$) | Remarks |
|---|---|---|
| **Up to 2005** | 87000 | Accumulated installed SWH systems |
| **2005-2006** | 2000 | Resulted from implementing the “National Pilot Project for Promoting SWH systems” |
| **2006-2008** | 6000 | Estimated SWH systems locally manufactured |
| **2005-2008** | 220,000 | Imported solar collectors & SWH systems. |
| Total | 315,000 | |

A high growth of the SWH systems is expected in the next years.

# Energy Audits

Energy audit is the first step towards improving the efficiency of energy use in any sector in general. Energy audits identify areas where energy is being used efficiently or is being wasted, and spotlight areas with the largest potential for energy saving. They are useful for establishing consumption patterns, understanding how the building consumes energy, how the system elements interrelate and how the external environment affects the building.

A UNDP-supported project on "*Supply-Side Energy Efficiency and Energy Conservation and Planning"* was completed in 2006. More than 250 walk-through, and 100 detailed energy audits have been conducted in industrial and commercial buildings, hotels and mosques. The potential for energy saving from these detailed audits of industrial and large commercial facilities is 30509 toe or USD 8.4 million per year. The results of the 100 detailed energy audit studies are summarized in Table (12).

Table 12: Summary of Energy and Cost Saving Opportunities Identified from 100 Detailed Audits of Industrial and Large Commercial Facilities

| Sum of annual saving opportunities | | Annual opportunities of thermal energy saving | | Annual opportunities of electric energy saving | | |
|---|---|---|---|---|---|---|
| toe | Million $ | Toe | Million $ | GWh | toe | Million $ |
| 30509 | 8.4 | 28914 | 5.6 | 416 | 1595 | 2.8 |

Source: [9]

On the other hand, the energy audits carried out by the reporter in two hotels, two restaurants and two homes in the old city of Damascus have shown that energy saving opportunities exist and vary from one location to another. Table (13) summarizes the results of these studies.

Table 13: Summary of Energy and Cost Saving Opportunities Identified from Six Energy Audits of Residential and Commercial Facilities in Old City of Damascus

| | Estimated Annual saving (SL) | Estimated annual saving (kWh) | Estimated annual saving (t $CO_2$) | Estimated implementation cost (SL) | Simple payback period (years) |
|---|---|---|---|---|---|
| **Restaurants** | | | | | |
| 1. Casablanca Restaurant | 129,869 | 40,813 | 14.53 | 329,000 | 2.7 |
| 2. Haretna Restaurant | 405,723 | 152,833 | 65.92 | 427,150 | 1.22 |
| **Apartments** | | | | | |
| 3. Aboud Apartment | 24,432 | 7711 | 3.9 | 101,250 | 4.1 |
| 4. Nahlawi House | 10,681 | 4986 | 2.56 | 64,950 | 5.2 |
| **Hotels** | | | | | |
| 5. Bait Rumman Hotel | 69,505 | 20,151 | 10.3 | 10,650 | 0.15 |
| 6. Alshahbandar Palace *hotel & café* | 150,341 | 44,841 | 21.82 | 138,600 | 0.92 |

Source: [10]

## Potential Measures of Reducing Energy Consumption, Energy Efficiency , and Mitigating GHG Emissions in the Residential Sector

### 8.1 Energy Efficiency Definition

Energy efficiency isn't about giving things up. It's about doing things better, and doing more with less energy. It's the genius of technological innovation- maximizing performance by boosting efficiency.

### 8.2 Energy Efficiency Indicators

The energy efficiency indicators are many and varied depending on the type of device and function. Among these indicators are, for example, and not limited to:

a- Energy Intensity Index

b- Energy Efficiency Index or Energy Efficiency Ratio

c- Seasonal Energy Efficiency Ratio – SEER

d- Annual Fuel Utilization Efficiency - AFUE

### 8.3 Rationalization of Energy Consumption

Rationalization of energy consumption must be accompanied with the implementation of EE measures in buildings. This depends primarily on behavioral measures to the owners or occupiers of buildings.

### 8.4 Energy Efficiency Standards

The energy performance of a building describes the overall energy efficiency of the building in terms of energy consumption by a standardized use.

The Energy-efficiency standards are a set of procedures and legislation to impose the required energy performance of buildings or equipment and prevent the sale of less efficient devices.

The energy efficiency requirements of the building shell or envelope have historically been the first to be regulated and they are today an essential part of nearly all regulations for energy efficiency in new buildings. The other segments of constructions and installations that influence a building's energy performance can be addressed in the regulation of energy efficiency, but these parts are more rarely included in the requirements. Therefore, the following areas: landscaping, form & Orientation, daylighting, indirect gain (sunspaces), heat storage, air filtration, venting, ventilation and passive cooling are considered out of scope of this study.

## 8.5 Potential of Energy Efficiency in Building Envelope

### 8.5.1 Thermal Insulation

The building envelope is a term for the parts of the building which surround the heated and cooled parts of the building. This includes external walls, floors or ground deck, roofs or constructions towards unheated ceilings, windows and doors. If a cellar is heated then the cellar walls and the cellar floor are part of the building envelope. If it is unheated, the building shell includes the floor between the ground floor and the cellar. The building envelope may also address heat loss through foundations or other thermal bridges.

A thermal bridge is a construction or a part of a construction that conducts heat more efficiently than the surrounding construction. Cold bridges can be foundations or massive parts of a construction that normally include insulation materials.

Requirements for energy efficiency in external parts of the building, the building envelope, are generally set based on resistance to heat transparency through a unit of the construction, R-values, or a value for the heat transparency through a unit by a specific temperature, a U-factor or a U-value ($U = 1/R$). In cold climates, low U-values or high R-values prevent heat from escaping from buildings, and in hot climates they prevent heat from entering buildings. U-values or U-factors will typically be given in $W/m^2$ per °C.

Given the importance of building heating and cooling to peak residential demand in Syria, and the generally poor thermal performance of buildings in Syria, improvements in building envelopes in a number of sectors of the Syrian economy is a significant opportunity for energy and peak power saving. This opportunity will become even greater as air conditioning (and the summer peak) becomes an increasingly important issue in electricity system planning. The Building envelope improvements apply a package of building envelope improvements in different case/sector combinations. The package of improvements include better wall and ceiling insulation, better window, better thermal seals, and possibly other relatively low-cost measures. Ultimately, a package of measure particularly developed for application with typical Syrian construction practices can and should be developed. The case/sector combinations to which the measure package is applied as part of a pilot program are:

- New Building Envelope Measures, Residential, Commercial and Governmental Buildings.
- Building Retrofit Envelope Measures, Residential Commercial and Governmental Buildings.

Energy saving in buildings depends on climatic conditions. In cold and heating based climates this will mainly depend on heating needs given by the Heating Degree Days, in hot and cooling based climate this will mainly depend on cooling needs given by Cooling Degree Days.

Table (12) summarizes the maximum values of the U-value for different construction elements in the “Syrian Code of Thermal Insulation in Buildings”.

Table 14: Maximum Values for U-Values

| Element | Max. U-value (W/m$^2$.K) | |
|---|---|---|
| Roof | $U_{roof}$ | 0.5 |
| External wall | $U_{ow}$ | 0.8 |
| Window, $A_{win} \leq 0.2\ A_{facade}$ | $U_{win}$ | 5.2 |
| Window, $A_{win} > 0.2\ A_{facade}$ | | 3.5 |
| Façade | $U_{facade}$ | 1.5 |
| Ground floor | $U_G$ | 1 |
| Intermediate floor | $U_F$ | 1 |
| Floor above crawl space | | 0.5 |
| $A_{facade}$: Surface area of the façade, $A_{win}$: Surface area of the doors & windows | | |

Source: [6]

For comparison, the thermal standard for buildings in Lebanon is the most developed standards of the neighboring countries. The small land area of Lebanon was divided into four climatic zones of significant variations between them (coastal region, western mid-mountain, inland plateau, and the high mountain). Table (15) presents the maximum U-values for the various construction elements.

Table 15: Maximum U-Values for the Various Construction Elements in Lebanon's Thermal Standard

| Maximum U-values[1] (W/m$^2$.K) | | | | | | |
|---|---|---|---|---|---|---|
| **Climatic Zone** | **Roof** | **Wall** | **Vertical Glazing[2]** | **Skylight[2]** | **Exposed Floor[3]** | **Semi- Exposed Floor[4]** |
| Excluding interior and exterior air films | | | | | | |
| 1.Coastal | 0.57 | 2.10 | 6.2 | 4.3 | 2.60 | 2.60 |
| 2.Western Mid-moun. | 0.57 | 0.77 | 4.3 | 4.3 | 0.76 | 1.35 |
| 3.Inland plateau | 0.57 | 0.77 | 4.3 | 4.3 | 0.66 | 1.00 |
| 4.High Mountain | 0.44 | 0.55 | 2.8 | 2.8 | 0.55 | 0.80 |
| Including interior and exterior air films[5] | | | | | | |
| 1.Coastal | 0.51 | 1.55 | | | | |
| 2.Inland plateau | 0.51 | 0.68 | | | | |

Source: [11]

1) The U-values do not include the effects of interior and exterior air films. Thus the calculation of the U-value of the proposed component should exclude interior and exterior air films.

2) For windows and skylights, the thermal transmittance values are for the center of the glass and do not include the effect of the frame used for glazing.

3) Exposed floor: ground floor in direct contact with the exterior air.

4) Semi-exposed floor: ground floor above a non air-conditioned space.

5) For comparison purposes, the reporter added the following air film resistances: 0.04 $m^2$.K/W for exterior air films adjacent to walls and roofs, 0.17 $m^2$.K/W for interior air films adjacent to roofs, and 0.13 $m^2$.K/W for interior air films adjacent to walls.

The thickness of thermal insulation (polystyrene) required to insulate the roof in Lebanon's thermal standard is shown in Table (16).

Table 16: Thickness of Thermal Insulation (Polystyrene) Required to Insulate the Roof in Lebanon's Thermal Standard

| Climatic Region | Maximum Required Roof U-value ($W/m^2.K$) | Minimum Required Roof U-value ($m^2.K/W$) | Base case Roof R-value ($m^2.K/W$) | Insulation R-value ($m^2.K/W$) | Thermal Conductivity of selected Insulation (W/m.K) | Required Insulation Thickness (m) |
|---|---|---|---|---|---|---|
| **1.Coastal** | 0.57 | 1.754 | 0.3913 | 1.363 | 0.039 | 0.05 |
| **2.Western Mid-moun.** | 0.57 | 1.754 | 0.3913 | 1.363 | 0.039 | 0.05 |
| **3.Inland plateau** | 0.57 | 1.754 | 0.3913 | 1.363 | 0.039 | 0.05 |
| **4.High Mountain** | 0.44 | 2.273 | 0.3913 | 1.881 | 0.039 | 0.07 |

Source: [11]

To compare the requirements of thermal insulation in Syria and Lebanon (Tables 14 and 15) the following are reflected:

1. Syria did not divided into climatic zones as is the case in Lebanon,

2. Syrian code does not contain thermal insulation thickness tables for some selected insulation materials,

3. If the following air film resistances are added to Lebanese U-value for the wall: 0.04 $m^2$.K/W for exterior air film, and 0.13 $m^2$.K/W for interior air film, the U-value for the wall in Syria (0.8) is much smaller than that for the coastal region in Lebanon (1.55), which means higher requirement to insulate the walls in the coastal region in Syria.

It follows from this comparison that the requirements of thermal insulation in the Syrian code are very difficult to enforce and should be reconsidered. Therefore these requirements are not adopted in the present study.

### 8.5.2 Windows

Windows, doors and other parts of buildings that include glass areas require special attention: beyond its role in insulation, glass provides buildings with daylight and heat from sunlight. In cold climates, solar heat gains can reduce a building's need for active heating. In hot climates, however, the heat from sunlight needs to be removed by cooling. The orientation of windows and glass areas should suit the different amounts of light approaching the building from the north, south, east and west and complement a building's needs for heating and cooling.

Special glass constants (G-values) for windows indicate the amount of sunlight that can penetrate each pane of glass. Calculations for windows can be rather complex and in US and Canada standards for windows include a range of solar heat gain coefficients (SHGC), visible light transmission (VLT) and shading constants (SC).

There are several methods to improve the efficiency of windows or other glass areas. These include increasing the layers of glazing to double- or triple-glazing, coating the glass, or filling the space between glass plates with an inert gas or a vacuum to reduce heat transfer. Window frames that position the glass and separate panes also offer the potential for thermal efficiency improvement. The thermal dynamics and lighting potential of windows and glass areas should be considered in specific rules or in calculation procedures.

Tables (17) and (18) summarizes major window glazing types and lists the corresponding average value of the key properties (U-value, light transmission, and Solar Heat Gain Coefficient-SHGC) for the window.

Table 17: Typical U-values for Glazing and Window Systems

| Glazing system | Center-of-Glass U-Value (W/m$^2$.K) | Total Window U-Value (W/m$^2$.K) | |
|---|---|---|---|
| | | Typical Frame | High-Performance Frame |
| Single | 5.91 | 6.30 | 5.90 |
| Double | 2.73 | 3.51 | 3.03 |
| Double, hard low-e + argon | 1.70 | 2.63 | 2.19 |
| Double, soft low-e + argon | 1.42 | 2.39 | 1.94 |

Source: [12]

Table 18: Typical Light Transmission and SHGC for Glazing Systems

| Glazing Light Transmission/Solar Heat Gain Coefficient (in percent) | | | | | |
|---|---|---|---|---|---|
| Glazing System (6mm glass) | Clear | Blue/Green | Spectrally Selective | Grey | Reflective |
| Single | 89/81 | 75/62 | 71/51 | 43/56 | 20/29 |
| Double | 78/70 | 67/50 | 59/39 | 40/44 | 18/21 |
| Double, hard low-e +argon | 73/65 | 62/45 | 55/34 | 37/39 | 17/20 |
| Double, soft low-e + argon | 70/37 | 59/29 | 53/27 | 35/24 | 16/15 |

Source: [12]

**Which glazing option is best?**

Because climatic conditions vary so much, and because important characteristics vary widely from one building to the next, it is impossible to provide one glazing specification that will be best for all buildings. Instead, the designers must do a whole-building lifecycle analysis for each project that takes into account:

- Lifetime building energy consumption, including lighting, heating, and air conditioning costs;
- Daylighting utilization; and
- The value of cooling equipment displaced by more advanced glazing systems.

In most cases, it is impossible to do this type of analysis intuitively or by hand calculations. Instead, building energy performance simulation software must be used. To illustrate how to carry out the required analysis, some simulation studies using DOE-2 software have been conducted for a well built, 9300 square meter commercial building in Los Angeles with a glazing area that constitutes 24 percent of the surface area of the wall [13]. For this building, a clear single-pane glazing is compared with five alternatives. The alternative glazing systems included double glazing, tinting, and spectrally selective coatings.

The results are shown in Table (19). The best choice, from a lifecycle costing perspective, is the double-pane selective tint glazing.

Table 19: Results of Simulation Study Using DOE-2 for 9300 Square Meters Commercial Building in Los Angeles

| | Glazing type | | | | | |
|---|---|---|---|---|---|---|
| | Single clear | Double bronze | Double selective clear | Double low-e | Single Selective tint | Double selective tint |
| Visual transmittance ($\tau_v$) | 0.88 | 0.47 | 0.68 | 0.44 | 0.66 | 0.41 |
| Solar heat gain coefficient (SHGC) | 0.83 | 0.49 | 0.42 | 0.37 | 0.51 | 0.28 |
| LSG ratio ($\tau_v$ /SHGC) | 1.06 | 0.96 | 1.62 | 1.19 | 1.29 | 1.46 |
| U-value W/(m$^2$K) | 6.2 | 2.72 | 1.65 | 1.76 | 6.30 | 1.65 |
| Annual energy saving ($/year) | N/A | 7179 | 8825 | 9730 | 7347 | 11842 |
| Present value of lifetime energy saving ($) | N/A | 71332 | 87687 | 96679 | 73001 | 117664 |
| Incremental glazing cost ($) | N/A | 48000 | 74400 | 64000 | 16000 | 88000 |
| Avoided cooling system cost ($) | N/A | 56600 | 67800 | 79300 | 59500 | 96500 |
| Simple payback period (years) | N/A | 0 | 1 | 0 | 0 | 0 |
| Net present value ($) | N/A | 79932 | 81087 | 111979 | 116501 | 126164 |

Source: [13]

**Assumptions:**

• Daylighting controls assumed for the perimeter

• Electric energy costs = $0.10/kWh

• Natural gas costs = $0.70/therm

• A/C system coefficient of performance = 2.0

• For present value calculation: discount rate = 10%, inflation = 2%, glazing lifetime = 20 years

• Incremental glazing cost represents cost of glass only. Labor and framing not included as these

will vary little from the baseline

• Avoided cost of cooling equipment based on $1,200 per ton

• Net present value calculated by subtracting the incremental glazing cost from the sum of the

present value of lifetime energy saving and avoided cooling system cost.

Note: N/A = not applicable

### 8.5.3 Shading

Shading, shutters and reflection can greatly reduce sun penetration of windows and other glass areas. Shading is a rather complicated issue which often requires complicated models which simulate three dimensions. For simple building these models can be complicated to use since they will require many information on the building for and shading parts which have to be calculated with concern of the movement of the sun on the sky in the actual building sight. Some countries have developed simplified guidelines to be used in connection with more simple buildings and by builders.

There are obviously seasonal variations near the equator. Solar heating becomes more important than in the upper latitudes. Beginning at the equator and moving north, the need for solar heating increases while the need for solar shading diminishes (See Figure 8).

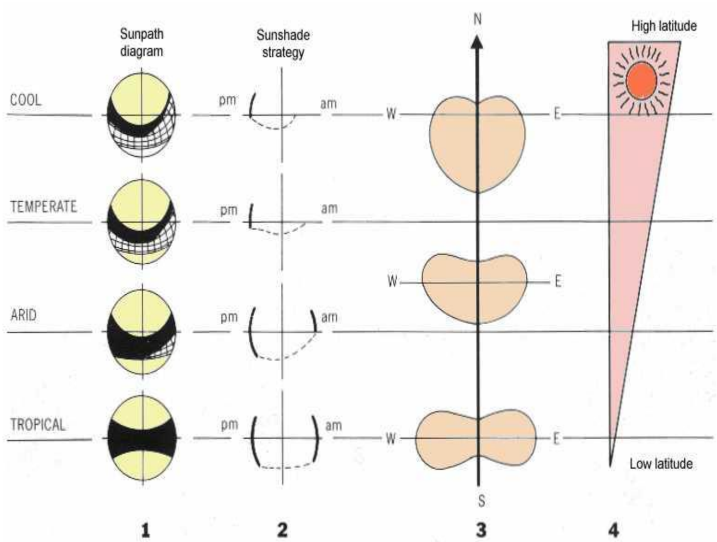



Figure 8: Solar Paths Requiring Shade (1), Sunshade Analysis (2), Insolation (3), and Sun Requirements During Winter (4)- Source: [13]

As Syria is located in the region bounded by latitudes 32.3˚ N and 37˚ N and the longitudes 36˚ E and 42.5˚ E. Figure (9) shows such an example for two latitudes 33° and 37° in Syria.

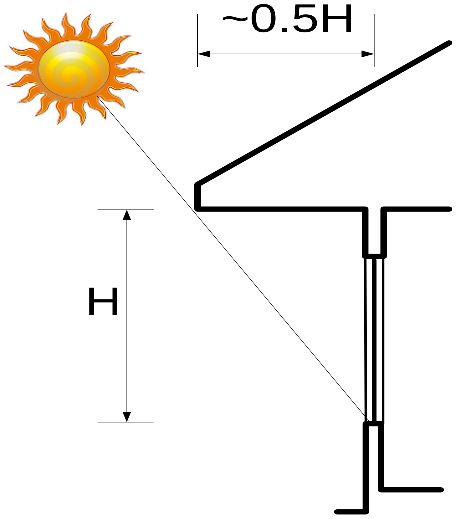
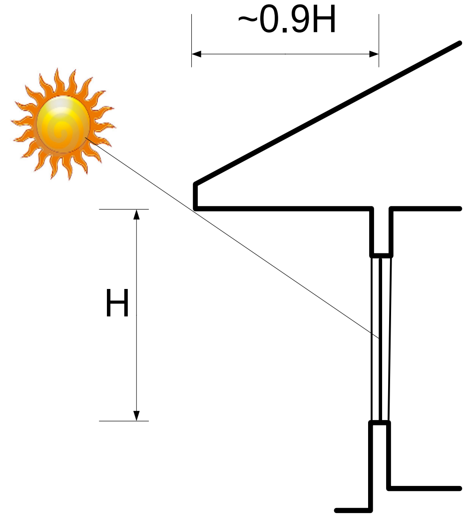
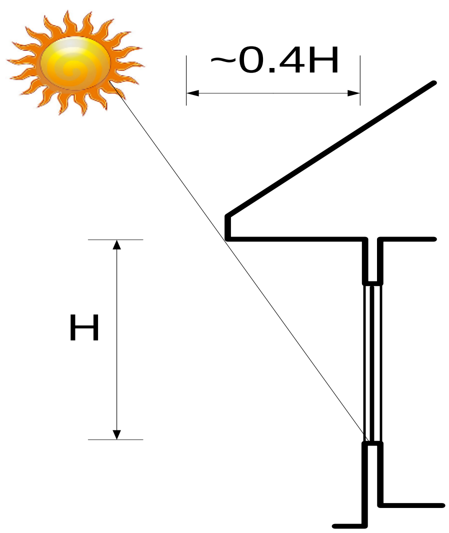
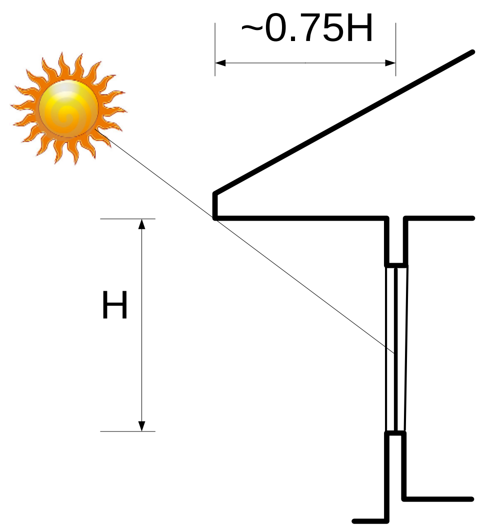
| Latitude | Minimum depth (noon August 21st) | Maximum depth (noon December 21st) |
|---|---|---|
| 37° |   |   |
| 33° |   |   |

Figure 9: Illustration of Solar Penetration and Shading for Latitudes 33° and 37°- Source: [14]

### 8.5.4 Passive Solar (Direct Solar Gains)

In a building heated by passive solar energy, glass areas are oriented and arranged so as to optimize the capture of solar light and heat. When buildings are highly insulated and energy efficient, passive solar energy can meet a substantial share of the heating demand, even in cold climates.

Because a building's exposure to solar energy varies over the year and during the day, constructions must be able to store and balance solar energy. Buildings capturing too much heat may require cooling, offsetting the efficiency gains of passive heating.

A passive house is a building in which a comfortable indoor climate can be obtained without a traditional heating or cooling system. Compared to traditional building they use far less energy. For most countries these demands are 70–90 % reduced compared to the actual energy efficiency requirements for heating and cooling, but this depends on the actual energy standards. For countries with high energy efficiency requirements it is less.

With increasing efficiency in passive house the consumption decrease, but the costs for construction goes up (See Figure 10).

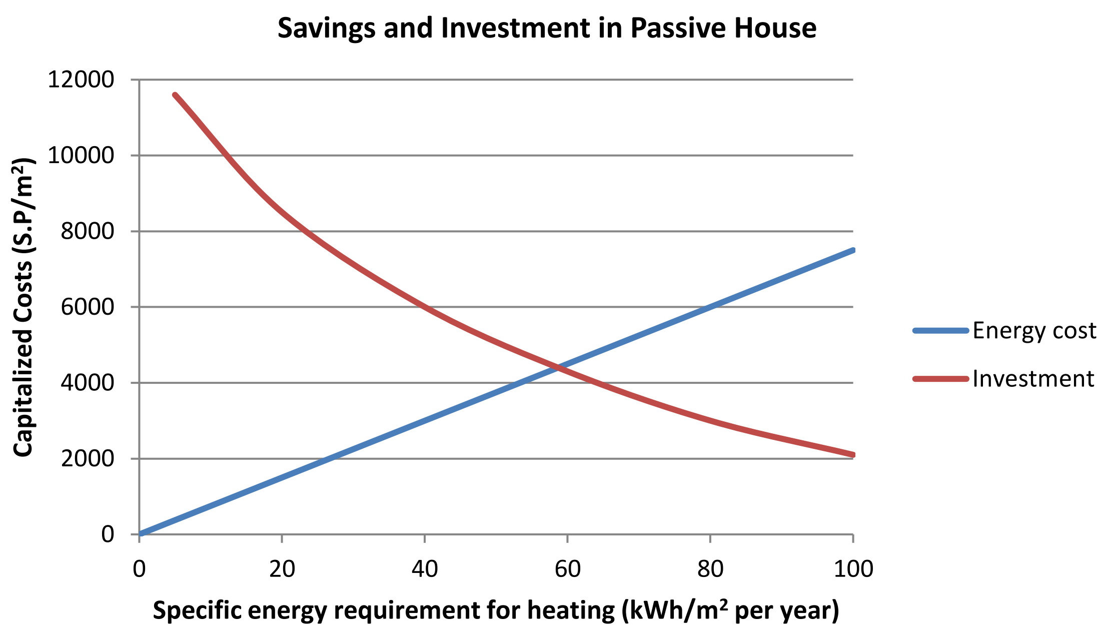



Figure 10: The Additional Costs and Saving in a Passive House

When increased investment costs and capitalized costs for energy over lifetime are added, the final costs for the improved energy efficiency can be found. Figure (11) shows an example of final costs for the improved energy efficiency together with the capitalized costs for energy.

It can be seen from the graph in Figure (11) that the total costs for a building, with 50 kWh/m² per year is lower than the total costs for buildings, which are built to a standard, which require 100 kWh/m².

In the example shown in Figure (11) the costs for a house, which requires only 30 kWh/m² per year, would be same costs as a house build with the demands in the building regulation with 100 kWh/m², when the costs are seen over lifetime (30 years for example). Over time there are no additional costs for the owners or users of passive houses.

The total costs for a building over lifetime for a passive house will hence be cheaper in a passive house (50 kWh/m² per year) compared to a house build according to a building regulation which require 100 kWh/m² per year.

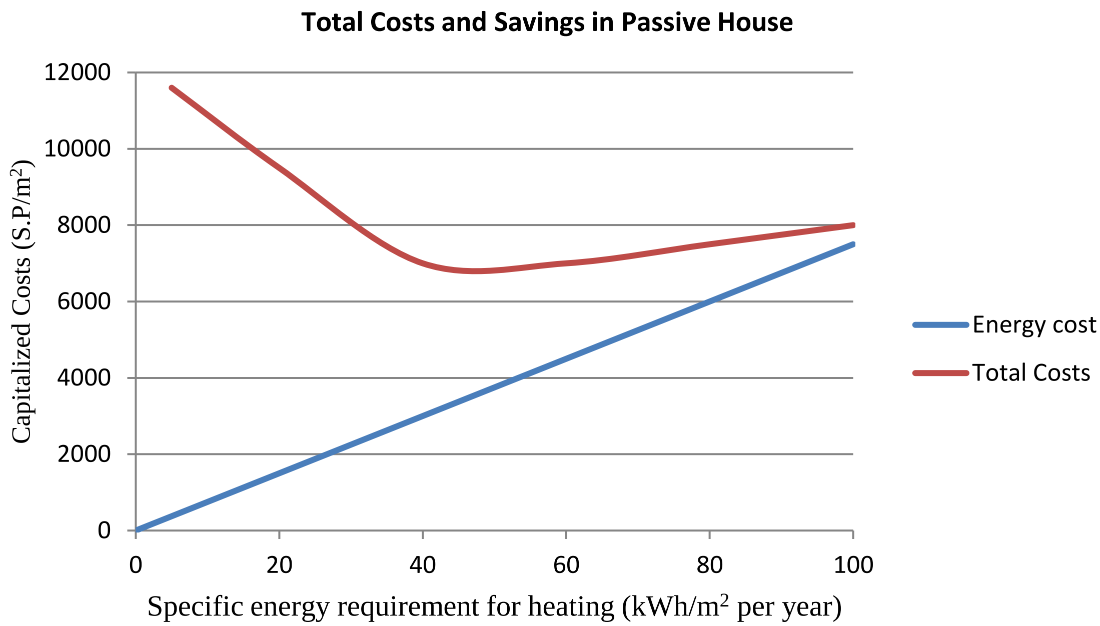



Figure 11: The Total for Improved Efficiency in a Passive House

Because of the high cost of the passive houses it is very difficult at the present time to adopt standards for local passive houses in Syria.

### 8.5.5 Reflective Building Roofs

On a sunny summer day, a non-cool-roof surface can reach temperatures nearly 35-40°C above the ambient temperature. A cool roof, by contrast, stays at or near the ambient temperature due to the characteristics of its outer layer. Cool roofing is defined by the radiative properties known as solar reflectance and thermal emittance, shown schematically in Figure (12).

Several phenomena occur to the incident solar radiation upon striking a roof's surface, as shown in Figure (12). Much of the solar radiation is reflected back toward the sky, but some is absorbed by the roof as heat. A portion of the retained heat will be emitted back to the sky in the form of infrared (IR) radiation. Some heat is also carried away from the roof surface through convection. The remaining heat flows through the roof. The amount of heat that reaches the conditioned space below the roof will be determined by the insulation property of the roof material, and by the difference in temperatures on either side of the roof.

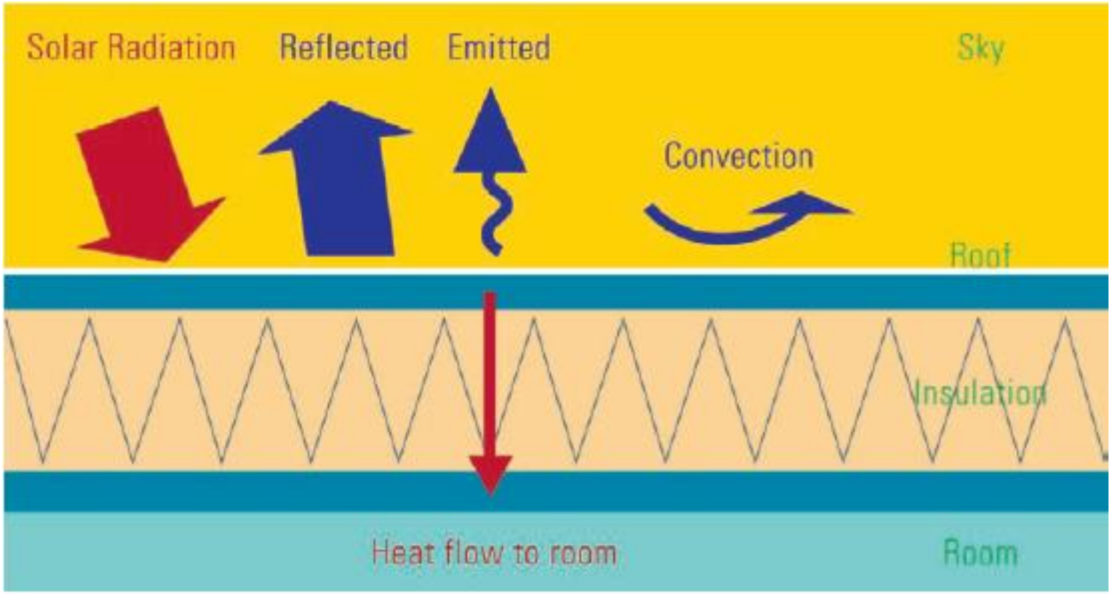



Figure 12: Heat Transfer through a Roof -Source: [15]

A cool roof has a higher solar reflectance and higher thermal emittance than a non-cool roof. High solar reflectance and high thermal emittance of a cool roof combine to keep the roof surface much cooler than a traditional roof, with peak temperature reductions up to 15°C. Achieving this type of drop in roof surface temperature will reduce the overall heat gain through the roof and reduce a building's annual cooling needs. Studies show that cool roofs can typically reduce summer air-conditioning energy use by 10%-20%.

Increasing the solar reflectance of the building roofs reduces its solar heat gain, lowers its temperatures, and decreases its outflow of thermal infrared radiation into the atmosphere. This process of "negative radiative forcing" effectively counters global warming. Most existing flat roofs are dark and reflect only 10 to 20% of sunlight. Resurfacing conventional dark roofs, with a cool white material that has a long-term solar reflectance of 0.60 or more increases its solar reflectance by at least 40%. Retrofitting 100 $m^2$ of roof has an effect on radiative forcing equivalent to a one-time offset of 10 tonnes of $CO_2$. The use of cool-colored roofs increases solar reflectance by about 0.20, yielding the equivalent of a one-time $CO_2$ offset of 5 t per 100 $m^2$, or about half that achieved with white surfaces. The solar reflectance of pavement can be raised on average by about 0.15, the equivalent of a 4 t reduction in $CO_2$ per 100 $m^2$ [16].

The comparison between radiative properties of a traditional and cool roof is shown in Table (20).

Table 20: Traditional and Cool Roof Properties

| Traditional roof | | |
|---|---|---|
| **Type** | **Reflectance** | **Emittance** |
| Dark gravel | 0.08-0.15 | 0.80-0.90 |
| Smooth asphalt | 0.04-0.05 | 0.85-0.95 |
| **Cool roof** | | |
| White gravel | 0.30-0.50 | 0.80-0.90 |
| Gravel and cementations | 0.50-0.70 | 0.80-0.90 |
| White roof coating | 0.75-0.85 | 0.85-0.95 |

Source: [15]

### 8.6 Potential of Active Renewable Energy Technologies

The renewable energy applications are designed to replace the conventional technologies with renewable energy technologies in generating energy for different purposes. As opposed to the existing technologies, the renewable will generate clean energy and use local resources for their energy generation.

Solar water heaters are one of the most commonly used renewable energy supplies in buildings and in these systems water is heated by the sun and the heat is stored until used. Similar systems can be used to heat the building but this increase the need for storage and sometimes even from one season to another.

In winter, for a location at 33.5 degrees latitude (Damascus city), assuming that the average solar radiation received is about 420 Watts/m$^2$. A typical household energy demand is around 3000 kWh per month or roughly 100 kWh per day. Assume the total surface area of flat-plate solar collectors is equal to the roof top area (100 m$^2$) and the collectors will receive about 6 hours of sunshine hours. So energy generated over this 6 hour period is:

$$420\ W/m^2 \times 100\ m^2 \times 6\ hours/day \approx 250\ kWh/day$$

At best, with a daily solar system efficiency of 20% this represents 1/2 of the typical daily energy usage (50kWh/day). With energy conservation and insulation and south facing windows, it is possible to lower the daily use of energy by about a factor of 2. In this case, if solar collectors become 20% efficient, then they can provide 100 % of the daily energy needs.

Photovoltaic (PV) is another example on active use of solar energy in buildings, where solar energy is transformed into electricity and used for the buildings supply of electricity. Solar energy can also be transformed directly into cooling and used as a cooling source. These systems will often require little storage, because they produce when needs for cooling are high.

## 8.7 Potential of Energy Efficient Technologies

Technological improvements and engineering experience can lead to marketing innovations, such as, tele-monitoring, guaranteed solar productivity and third party financing. These innovations encourage the growth of the market.

Many old technologies today are using more energy than they should. Smarter and more efficient choices are becoming available for everything that consumes energy- lighting, pumps, chillers, fans, motors, cooling coils etc.

### 8.7.1 HVAC Systems

HVAC systems maintain a building's comfortable indoor climate through Heating, Ventilation and Air Conditioning (Cooling). These systems profoundly influence energy consumption in buildings. Without heating, cooling and ventilation systems there would be no energy consumption in the building, since it would be totally dependent on outdoor conditions. There is an inverse correlation between the efficiency of the building and the need for HVAC systems: highly efficient building envelopes reduce the need for heating and cooling systems. Good and intelligent designed buildings can reduce or even avoid the need for heating and cooling and reduce the need for ventilation.

Efficiency improvements in HVAC systems can lead to substantial savings, but these savings will also depend on the efficiency of the building in general. If, for instance, energy efficiency is improved in a heating boiler or an air-conditioner, total saving will depend on the total need for heating or cooling in the building. Higher requirements for the building envelope might reduce the potential for saving in HVAC systems. Finally the HVAC systems need to be in a good balance with the buildings in general and they need to be of a proper size which fits with the actual heating, cooling and ventilation needs.

Installed systems other than HVAC systems can influence a building's energy performance in two different ways: through their own energy demand and through their production of waste heat which can result in increased cooling loads or decreased heating loads.

Converting energy to heat is significantly more efficient than converting energy to electricity. In the most energy efficient boiler systems, the energy efficiency of the system can exceed 90%. Conversely in the generation of electricity, only 30% to 50% of the energy inputted is converted to useable electricity. The remaining energy is lost through the smoke stack or through transmission and distribution of the electricity.

Many possible systems can heat a building. Collective heating can include a combined system based on a heating supply in the building such as a boiler or on an external supply in the form of district heating or heating from combined heat and power production. Buildings can also draw heat from individual systems such as electric heaters, heat pumps or individual ovens. Finally, heating can be integrated in the ventilation and air-conditioning systems.

Centralized heating systems include a distribution system in the building such as pipes, ducts, tanks, pumps, fans, or exchangers. The efficiency of the overall system depends on the efficiency of all its components, and an efficient boiler can become an inefficient heating system if parts are poorly connected and badly calibrated. In individual systems, the efficiency often depends alone on the efficiency in the heating source only.

To achieve optimum energy efficiency, designers should evaluate:

- Thermal comfort criteria.
- Load calculation methods.
- System characteristics.
- Equipment and plant operation (part-load).

Energy efficiency of many HVAC sub-systems and equipment has been improved gradually over the years, such as in air systems, water systems, central cooling and heating plants. Energy efficient HVAC design now being used or studied include:

- Variable air volume (VAV) systems to reduce fan energy use.
- Outside air control by temperature/enthalpy level.
- Heat pump and heat recovery systems.
- Building energy management and control systems.
- Natural ventilation and natural cooling strategies.

Opportunities for improving HVAC efficiency are:

- Improve efficiency of equipment when central plant equipment is replaced.
- Improve control and management of systems using direct digital controls.
- Use "free" cooling with outdoor air, which reduces mechanical cooling and improves indoor air quality.
- Add variable frequency drives that manage air and fluid flows to match actual building needs.
- Use high efficiency motors.

The electrical appliances candidate for EE measures in the residential, commercial and service sector include:

1. Refrigerators, home air conditioners,

2. Air-conditioners in commercial and government establishments,

3. Electric water heaters,

The rest of the electrical appliances are not considered due to their low contribution in mitigating GHG emissions.

### 8.7.2 Refrigerators and Freezers

Almost 100% of domestic refrigeration appliances sold around the world use a vapour compression refrigeration cycle to cool stored food. A small market share exists for gas absorption cooled appliances, which are used almost exclusively for hotel mini-bars, and a very small niche market exists for thermoelectrically cooled appliances for camping and mobile home use.

A typical refrigerator or freezer has a single compressor and condenser and one or two evaporators operating in series in a single cooling circuit. About 95% of European appliances use natural convective cooling to transfer heat to the evaporator and from the condenser, while almost all North American, Australasian and Japanese appliances use forced convection (i.e. use electrically powered fans) often called “no frost systems”.

Natural convective cooling is efficient, low cost and convenient for appliances with small to medium cooling capacities and which operate in low humidity conditions. In higher humidity, frosting on the evaporator is a problem for consumers and requires the use of a fan. Beyond a certain volume and height it is difficult to maintain appropriate internal temperature distribution without using a fan.

Whether the appliance is no-frost or cooled by natural convection, its efficiency is greatly influenced by the quality of insulation, the efficiency of the compressor and of the heat exchangers and the quality of the control system. All of these have improved significantly over recent years.

Quality of insulation depends first on the conductivity of the foam or whatever other insulating material is used. It also depends on the reduction of “thermal bridges” caused by discontinuities in the insulating layer, either due to bad insulation installation (poor design or poor manufacturing operation) or where structural or functional parts of the appliance have to penetrate the insulation. The latter can be reduced by better design (e.g. reduction of required holes’ surfaces, conductivity of the materials used). Vacuum panels are the latest development in insulation materials.

Efficiency of the compressor is related to efficient electric motors and pumps. Great deployment improvements have been made in recent years, but the most efficient models and technologies still have to penetrate the market.

The larger a refrigeration appliance, the easier it is to make it more “efficient” if efficiency is measured in terms of the inverse of the energy used per unit storage space at a given temperature. The reason for this is that the surface to volume ratio is lower for larger appliances thus the heat loss per unit volume is smaller, while the useful space available for insulation or cooling circuit components is larger, which has a bearing on their efficiency. Similarly, larger capacity compressors are inherently more effective than smaller capacity units and hence give an efficiency gain to appliances with inherently larger cooling capacities. However, this does not completely offset the additional energy use of bigger “cold” appliances, but the variations in energy use and volume are far from being proportional.

**Example 1:**

Table (21) is a real example from a recent analysis that was performed to establish minimum energy-performance standards for Thailand. The table begins with a row showing the annual electricity use of a baseline ("base case"): 255kWh/year. It then shows the cost and energy-efficiency improvements associated with additional technical measures that can be adopted to improve the refrigerator energy efficiency. Note that the first few measures are the most cost effective, with the highest benefit-cost ratios. Subsequent steps are still cost effective but have slightly lower benefit-cost ratios [17].

Table 21: Cost-Efficiency of a Refrigerator (176-liter, 1-door, manual defrost refrigerator freezer)

| Description | Annual kWh | Energy Saving (%) | Manufacturer Cost (US $) | Retail Cost (%) | Benefit/Cost Ratio | |
|---|---|---|---|---|---|---|
| | | | | | This Step | All Steps |
| Base case | 255 | – | – | – | – | – |
| Add 1 cm insulation to side walls | 234 | 8.4 | 1.3 | 1.5 | 2.9 | 2.9 |
| Add 1 additional cm to side walls | 227 | 11.1 | 2.6 | 3.0 | 1.1 | 2.3 |
| Add 2 cm insulation to back walls | 216 | 15.3 | 3.75 | 4.4 | 1.9 | 2.1 |
| Small "Good" compressor: 52.9 kCal/hr, 0.92 COP* (replacing 58 kCal/hr, 0.89 COP compressor) | 201 | 21.1 | 6.5 | 7.6 | 1.1 | 1.7 |
| Add run capacitor to small compressor: COP=1.01 | 183 | 28.5 | 9.9 | 11.6 | 1.1 | 1.5 |
| Improve door gasket design (reduce gasket heat loss by 25%) | 171 | 32.9 | 12.1 | 14.2 | 1.1 | 1.4 |

Source: [17]

• Each of the steps listed in this table is incremental to the previous step.
• The benefit/cost ratio is the ratio of the discounted net present values of the societal benefits to the societal costs.
• COP = Coefficient of Performance

**Example 2:**

The following improvements have been conducted on a 515-liter, top-mount, auto-defrost refrigerator-freezer [17]:

a. The compressor efficiency increases from a coefficient of performance (COP) of 1.37 to 1.60 [or an energy-efficiency ratio (EER) of 4.7 to 5.45],

b. Door insulation thickness is increased from 3.8 to 6.3 centimeters,

c. The evaporator and condenser fan motor efficiencies are improved so that their power consumption decreases from 9.1 Watts (W) and 12.0 W, respectively, to 4.5 W each.

d. Other design options shown are reduced gasket heat leak, adaptive defrost, and increased heat-exchanger area.

The consumption of the refrigerator is decreased from 700 to 420 kWh/year, while the manufacturing costs are increased from 260 to 325 U.S. dollars.

Figure (13) shows the results of the energy saving achieved by replacing all existing refrigerators- freezers in twenty houses in France with energy-saving refrigerators- freezers. The highest annual saving (1740 kWh) is achieved in the house no. /7/, while an annual saving of only 21 kWh is achieved in the house no. /11/. The average annual saving in energy consumption in all houses is 723 kWh.

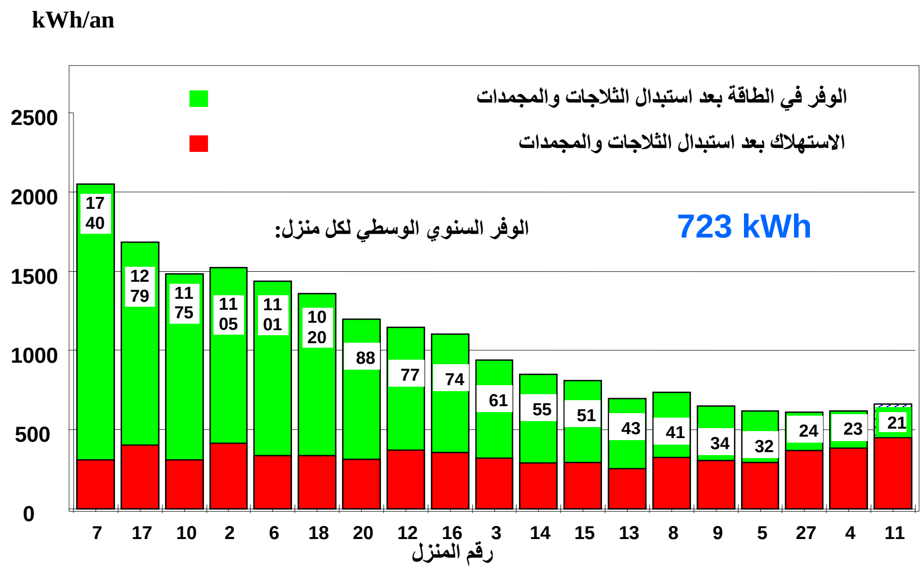



Figure 13: Measured Saving Achieved by Replacing all Existing Refrigerators- Freezers in Twenty Houses in France with Energy-Saving Refrigerators- Freezers - Source: [18]

According to a study conducted at the National Energy Research Center (NERC), a saving of 2% of the total production of electric power in Syria in 2004 (equivalent of 130 ktoe/yr) could be achieved if the average consumption of all existing refrigerators in Syria is reduced from 744 kWh/yr to 600 kWh/yr.

### 8.7.3 Air Conditioning

To maintain a comfortable and healthy indoor climate, the heat must be removed from overheated buildings.

There is only one category of air-conditioning system used in residential buildings: room air conditioner or ductless system or wall mounted **(**window or split).

Cooling systems can be centralized or decentralized into small units installed in every room for instance with small split units which are installed in each room. For split units, it is mostly the efficiency of the cooling device and the control system which are of importance for the overall efficiency. Within centralized systems, the dimensions and control of the system itself and the distribution ducts both determine energy efficiency. Air tightness is especially important for building cooling, as air leakage can substantially reduce the efficiency of mechanical cooling. Some buildings work with natural cooling or with night cooling, both of which reduce the need for active cooling.

Air-conditioning system types in commercial buildings are broken down into three broad categories: central, packaged, individual AC. Central systems are defined as those in which the cooling is generated in a chiller and distributed to air-handling units or fan-coil units with a chilled water system. Packaged systems include rooftop units or split systems which have direct-expansion cooling coils, with heat rejection remote from the cooled space. Individual AC systems involve self contained packaged cooling units, which are mounted in windows or on an external wall such that cooling occurs indoors and heat rejection occurs outdoors.

Home air conditioners (AC) usually dry air and therefore it is not recommended for use in tropical dry. Instead, the use of evaporative coolers preferably in such places permits humidifies the air.

Most air conditioners have their capacity rated in British Thermal Units (BTU). Generally speaking, a BTU is the amount of heat required to raise the temperature of one pound (0.45 kg) of water 1 degree Fahrenheit (0.56 degrees Celsius). Specifically, 1 BTU equals 1,055 joules. In heating and cooling terms, 1 "ton" equals 12,000 BTU.

The Energy Efficiency Rating (EER) of an air conditioner is its BTU rating over its wattage. For example, if a 10,000-BTU air conditioner consumes 1,200 watts, its EER is 8.3 (10,000 BTU/1,200 watts)

The correct choice of the capacity of the room air conditioner is necessary to avoid low or excessive cooling of the room. The capacity of an air conditioning depends on the area of the room (See Table 22). The values in this table are for thermally insulated room, have one window and normal ceiling. In addition, there is a need to take into account other factors to estimate the capacity, for example the geographical orientation of the room. Also, the thermal load differs for a single space between the kitchen, the bedroom and sitting room, and between the rooms exposed or not exposed to solar radiation. Finally the number of people present in the room plays an important role in identifying capacity.

To choose the correct capacity it is necessary to calculate the thermal load of the room based on building materials, level of thermal insulation, and size of the room ... etc. There are some web sites that provide such calculation free of charge. Many people working in the field of HVAC prefer to practice short hand calculation based on the experience gained in this area. Also, many customers turn to the advice of the neighbor who preceded them to the installation of air conditioner. As an approximate guide for sizing a room unit allows:

- 125 watts per square meter of floor area to be cooled in living areas;
- 80 watts per square meter of floor area in bedrooms.

Table 22: Estimated Capacity of the Room Air Conditioner

| Room area ($m^2$) | Capacity (BTU/h) | Capacity (ton refrigeration) |
|---|---|---|
| 14 −9 | 5000 | 5/12 |
| 23 −14 | 6000 | 1/2 |
| 28 − 23 | 7000 | 7/12 |
| 32 − 28 | 8000 | 8/12 |
| 37 − 32 | 9000 | 9/12 |
| 42 − 37 | 10000 | 10/12 |
| 51 − 42 | 12000 | 1 |
| 65 − 51 | 14000 | 1 and 1/6 |
| 93 − 65 | 18000 | 1.5 |
| 130 − 93 | 24000 | 2 |

Source: [19]

The comparison between the recommended values in Table (22) for the capacities of room air conditioners and the values of the capacities actually installed in Syria, we find that the difference is big and has more than doubled in many cases. This is due mainly to the fact that most of the air conditioned rooms are not thermally insulated. It is here shown the importance of thermal insulation to reduce heat load for heating and air conditioning.

Room air conditioners consume a large amount of electric power. In order to operate these air conditioners in an optimal way the following matters should be considered:

a. The Rotary type compressor consumes less energy and less noisy than Reciprocating type compressor. But the best compressor in terms of energy efficiency is the e-Scroll type newly developed,

b. The distance between the evaporator (interior unit) and the condenser (external unit) should be as short as possible,

c. The new air conditioners are usually filled with refrigerant in the factory, but in case of maintenance, the air conditioner must be filled with a charger which determine the necessary weight of refrigerant according to the value specified by the manufacturer,

d. Before filling the air conditioner with refrigerant the circuit should be cleaned from dirt by using nitrogen,

e. Avoid as possible the installation of a vertical pipe connecting the evaporator with the condenser. The long vertical pipe increases the compressor operation to reach the appropriate temperature adjustment,

f. The pipe connecting the evaporator with the condenser should be well insulated,

**Common mistakes**

1. First common mistake is turn the switch to the fan setting instead of the "cool" setting, by doing this warm air is blown around the coach.
2. The most common mistake made when installing a new central air conditioning system is buying a system that has a larger cooling capacity than is required. In order for an air conditioner to produce the required result, a feeling of comfort in the room that are being cooled, the system must not only lower air temperature, but it must lower the humidity.
3. Getting an air conditioner with either too high or too low a BTU rating for the space it needs to cool can be a problem. If it has too low a BTU rating, the unit will run continuously but still not cool the room adequately. This is noisy and consumes a lot of energy without getting much benefit because of the weak cooling. On the other hand, getting too strong an air conditioner can also be a problem. An air conditioner with too high a BTU rating will cool the space rapidly, but it will also tend to cycle on and off rapidly. This can waste energy, and it also lessens the effectiveness with which the air conditioner removes humidity from the air, since the space doesn't achieve optimum air circulation.
4. Thinking that lowering cooling temperature, for example from 26 to 24 °C, leads to accelerate the process of cooling is a common mistake. Lowering temperature to 24 °C does not lead to access to a temperature of 26 °C faster than maintaining the temperature at 26 °C.

Most air conditioners achieve a reverse cycle. The term reverse cycle means that the operation of the air conditioner can be internally reversed to provide indoor heating or cooling as required. There are two ways to produce warm air, either by the electric resistance heater or by heat pump. The Packaged Terminal Air Conditioner-PTAC is one-piece air conditioner with electric resistance heater, while the Packaged Terminal Heat Pump – PTHP is one-piece heat pump. The heat pump is more efficient than electric resistance heater at ambient temperatures greater than 5 °C. For one condenser the air conditioner may work with one evaporator (Single zone), or with two evaporators (Dual zone), or with three evaporators (Tri zone), or with four evaporators (Quad zone).

Research and development is still ongoing to improve the efficiency of air conditioning systems and to develop alternative refrigerants. Some of the R&D efforts in this area are:

- Develop high efficiency “Hermetic $CO_2$ Compressor”,
- Develop high efficiency and small size “DC twin-cylinder rotary compressor” with ‘Concentrated winding IPM - Interior Permanent Magnet”,
- Develop “Gas fired-absorption chiller/heater”,
- Develop a new mechanism by remote control with a view to clean or replace the filter of the air conditioner, while facilitating the process of cleaning the fan.

### 8.7.4 Lighting

Lighting requirements respond to a building's design. The need for lighting, especially during daytime, will depend on the size and placement of a building's windows, and the building's situation.

Indoor lighting systems produce heat, in form of waste energy depending on the actual type of installations, that can reduce energy demand for indoor heating in cold climates or during winter and raise demand for indoor cooling in hot climates or by summer.

Retrofitting lighting fixtures with energy efficient lamps or changing the entire fixture is a common energy saving practice in buildings. Lighting retrofits save significant energy and have rapid paybacks.

#### *a- Smart switching*

The need for lighting can be reduced by the use of automatic controls which depends on the orientation of buildings windows, the supply of daylight, use of the room etc.

The fastest saving can be achieved with "smart switching" of the lighting. Lighting is frequently switched on unnecessarily when e.g. there is sufficient daylight or there is nobody in the room. With hand operated systems especially, lights tend to be left burning needlessly. The advice is therefore to make the greatest possible use of automatic light regulating equipment. Examples include:

- Daylight sensors: daylight dimming controls for lights near windows
- Presence sensors or occupancy sensors
- Timers

#### *b- Efficient lighting*

Apart from the light source itself there are two important factors that influence the energy consumption of a lighting installation.

The first is the ballast or ballast used for the fluorescent tubes. There are two types of ballast: magnetic and electronic. Magnetic ballasts have the disadvantage that a large amount of energy is lost in the ballast itself, as much as 20% of the energy consumption of the light source. For a 58 W fluorescent tube, this means that about 13 W is lost in the ballast. Electronic ballasts on the other hand have losses of only 1 or 2%. Magnetic ballasts still tend to be used widely in Syria that are more than 10 or 15 years old.

The second factor that influences the energy consumption is the light fitting, in particular the optics, with the degree of reflectivity of the optics playing an important role. The higher the reflectivity of the fitting, the higher the light emission, and the greater the efficiency.

Standard, fluorescent tubes and incandescent light bulbs are common in Syria. Fluorescent tubes are not only efficient but also provide a good quality of light. Incandescent bulbs are extremely inefficient - most of the electricity they use produces heat, not light. The incandescent lamp yields only 5%. Not only are they inefficient, but they provide only 750 to 1,000 hours of light (at most). When used in fixtures burning for 12 to 20 hours a day, they must be replaced every two to three months. And, all of the heat they produce adds to the air conditioning load of the building.

Compact Fluorescent Light bulbs (CFLs) deliver the same amount of light as incandescent bulbs, but use one-third the energy. They also last for 8,000 to 10,000 hours. Their longer life reduces the replacement schedule for long-burning fixtures to once a year. CFLs emit a quarter of the heat of incandescent bulbs.

CFLs can replace incandescent bulbs of less than 150 watts in most applications: general lighting, down lighting, or decorative lighting such as pendants or wall sconces. Because the lamps are larger than most incandescent bulbs, make sure they fit the luminaries. CFLs are not recommended for ceilings higher than 4.5 meters, cold exterior locations, or most retail spotlighting. To apply fluorescent lamps successfully, carefully consider options for fixtures (direct versus indirect), lamps (diameter, length, intensity, and phosphor blend), and ballasts (electronic versus magnetic, rapid-start or programmed rapid-start versus instant-start).

Semi-conductor light sources or LEDs (Light Emitting Diodes) are solid light bulbs which are extremely energy-efficient and are expected to be even more efficient than fluorescent tubes in future. Until recently, LEDs were limited to single-bulb use in applications such as instrument panels, electronics, pen lights and, more recently, strings of indoor and outdoor.

Manufacturers have expanded the application of LEDs by "clustering" the small bulbs. The first clustered bulbs were used for battery powered items such as flashlights and headlamps. Today, LED bulbs are made using as many as 180 bulbs per cluster, and encased in diffuser lenses which spread the light in wider beams. Now available with standard bases which fit common household light fixtures, LEDs are the next generation in home lighting.

The high cost of producing LEDs has been a roadblock to widespread use. However, researchers at Purdue University have recently developed a process for using inexpensive silicon wafers to replace the expensive sapphire-based technology. This promises to bring LEDs into competitive pricing with CFLs and incandescent. LEDs may soon become the standard for most lighting needs.

***c- How to choose the right light***

Matching the right CFL to the right kind of fixture helps ensure that it will perform properly and last a long time. For example:

CFLs perform best in open fixtures that allow airflow, such as table and floor lamps, wall sconces, pendants, and outdoor fixtures.

For recessed fixtures, it is better to use a reflector CFL than a spiral CFL since the design of the reflector evenly distributes the light down to your task area.

Choose a qualified CFL that offers a shade of white light that works best for you. For example, while most CFLs provide warm or soft white light for your restaurant, you could choose a cooler color for task lighting.

To choose the qualified CFL with the right amount of light, find a qualified CFL that is labelled as equivalent to the incandescent bulb you are replacing. Light bulb manufacturers include this information right on the product packaging to make it easy for consumers to choose the equivalent bulb. Common terms include "Soft White 60" or "60 Watt Replacement."

You should also check the lumen rating to find the right CFL. The higher the lumen rating, the greater the light output. Table (23) will help you to determine what CFL wattage is best to replace your incandescent light bulb.

Table 23: Light Output Equivalency

| Incandescent bulbs (W) | Minimum light output (Lumens) | Common CFL bulbs (W) |
|---|---|---|
| 40 | 450 | 9-13 |
| 60 | 800 | 13-15 |
| 75 | 1100 | 18-25 |
| 100 | 1600 | 23-30 |
| 150 | 2600 | 30-52 |

Table (24) illustrates energy, lamp, and labor saving that result from replacing a 75-watt incandescent lamp with either a 19 watt spiral lamp or a 24 watt circline lamp. (These lamps come close to the 3:1 wattage ratio discussed below.) The annual saving for a $7 **CFL** is more than $10 in energy costs and about $10 in maintenance. Including labor for the installation, the **CFLs** in this application pay back in less than half a year.

Table 24: Energy, lamp, and labor saving that result from replacing a 75-watt incandescent lamp with either a 19 watt spiral lamp or a 24 watt circline lamp

| | **Baseline incandescent (75 W)** | **CFL spiral shape (19 W)** | **CFL circline (24 W)** |
|---|---|---|---|
| |  |  |  |
| **Performance** | | | |
| Initial light output (lm) | 1,180 | 1,200 | 1,100 |
| Design light output (lm) | 1,062 | 960 | 880 |
| Lamp lifetime (h) | 750 | 10,000 | 10,000 |
| Power input (W) | 75 | 19 | 24 |
| Initial efficacy (lm/W) | 15.70 | 63.00 | 45.83 |
| **Energy** | | | |
| Annual energy use (kWh/y) | 187.5 | 47.5 | 60.0 |

| | | | |
|---|---|---|---|
| Annual energy use ($/y) | 15.00 | 3.80 | 4.80 |
| Annual energy saving ($/y) | NA | 11.20 | 10.20 |
| **Maintenance** | | | |
| Lamp cost ($/lamp) | 1 | 7 | 7 |
| Relamping labor cost ($/lamp) | 2.5 | 2.5 | 2.5 |
| Annual lamp cost | 3.33 | 1.75 | 1.75 |
| Annual labor cost | 8.33 | 0.63 | 0.63 |
| Annual maintenance saving, lamp + labor ($/y) | NA | 10.42 | 10.42 |
| **Summary** | | | |
| Annual operating cost, energy + maintenance ($/y) | 26.67 | 6.18 | 7.18 |
| Annual operating cost saving ($/y) | NA | 20.49 | 19.49 |
| Payback on first CFL installed (y) | NA | 0.46 | 0.49 |

Source: [21]

Notes:

CFL = compact fluorescent lamp; h = hour; kWh = kilowatt-hour; lm = lumen; NA = not applicable; W = watt; y = year.

• Design light output for incandescent lamp based on 10% lumen depreciation at 40% of rated life.

• Design light output for CFLs based on 20% lumen depreciation at 40% of rated life.

• Annual operating time = 2,500 h. Electricity cost=$0.08/kWh.

Lighting in Syria consumes 20% to 25% of the total electricity consumption in buildings [20]. The most commonly used lamps are the fluorescent lamps (120 cm length). Despite the widespread of energy-saving lamps incandescent lamps are still used in Syria. The use of chandeliers in ceilings is a bad habit in Syria because of its large consumption of electricity.

### 8.7.5 Water Heating

Many buildings' occupants require hot sanitary water for hygiene, food preparation, cleaning and commercial purposes. The central heating system can provide this water, as can a separate system using electricity, oil, gas, solar thermal energy, heat pumps or district heating. Efficiency regulations often address hot sanitary water.

### 8.7.6 Ventilation

Well-insulated, airtight buildings often require active ventilation to remove used air and introduce fresh air for occupants. Natural ventilation, like the flow of air through open windows, and mechanical ventilation both circulate air. Ventilation can also be included in air-conditioners which combine simultaneous heating and cooling. There are many technologies to improve the efficiency of ventilation systems, including heat exchangers and heat pumps.

For ventilation systems there is a need to be aware of both the energy use in ventilation system itself for fans and preheating of the air etc. but there is also a need to take concern for the heat losses which comes with the exchange of the air. Ventilation systems should hence effectively ensure the necessary air exchange, not more and not less.

### 8.7.7 Dehumidification

In humid climates and in buildings producing much humidity, like swimming halls or other indoor bathing facilities, moisture may need to be removed from inside buildings. Itself an often energy-intensive process, dehumidification can be integrated into air conditioning systems. Building regulations in humid climates, should account for the energy involved in humidity control.

Dehumidification is as important, if not more important than the cooling ability of the system, as humidity generally supplies more personal discomfort than heat. For an air conditioning system to remove the humidity the fan must be running, in order for the fan to run the thermostat must be asking for cooling. A system that is oversized will not be circulating the air; hence it will reduce the temperature, but will not lower the humidity.

### 8.7.8 Automatic Control

Automatic controls of systems can largely determine or influence the efficiency of these systems. Individual systems as heating, cooling, ventilation or lighting systems can have individual automatics or the overall system can be controlled by one overall central system, which controls all the functions. If the systems are controlled by individual systems this can in some cases lead to conflicts between for instance the heating and the cooling systems. Good and efficient automatics can ensure the optimal use of the HVAC systems can be addressed.

## 8.8 Conclusions

The technologies of the household equipment are constantly evolving and thus improve the energy efficiency. The control and maintenance of such equipment has evolved from sophisticated tools to simple tools. The new and emerging technologies help the Engineers to rationalize energy consumption and thus reduce the cost.

The most successful programs in the application of energy saving adopted a coherent policy including “Minimum Energy Performance Standards” (MEPS) and awareness campaigns. Regardless of the policies and procedures for this purpose, they should be updated regularly in the light of technological progress achieved.

Despite the availability of the many opportunities to rationalize the consumption of energy, the energy policy is slowly beginning to taking shape in Syria, notwithstanding the institutional barriers that need to be surmounted. The characteristics of the energy sector itself with its links to the various economic activities will determine the long – term character of the energy policy adopted. A successful strategy for deployment and implementation of EE & RE plan depends first and foremost on the full cooperation and mutual support of various government agencies and institutions. The recommendations that could help Syria to adopt policies and strategies for energy conservation are:

1. Not only focus on investment in building new power plants, but must also focus on investment in energy conservation and energy efficiency because they tend to reduce the demand for electric power, thus eliminating the construction of new generating stations;
2. Design EE Labels and forcing them gradually;
3. Develop a clear and logical national standards for energy efficiency in the country;
4. Encourage and support RE&EE projects with funding from the international GHGs Reduction Funds;
5. Review the energy prices;
6. Adopt a clear strategy in this area.

# Calculation of Saving Gained from Proposed Energy Efficiency Measures in the Residential Sector

## 9.1 Thermal Insulation in Buildings

### 9.1.1 Assumptions

a. Number of dwellings in Syria:
   - 3.5 million in 2005;
   - 4.0 million in 2010;
   - 7.9 million in 2030;
   - 3.9 million dwelling are expected to be constructed between 2010 and 2030.

b. The average square area of a typical dwelling is 120 $m^2$.

### 9.1.2 Possible Saving Gained from Thermal Insulation in buildings

The study proposes the adoption of the U-values shown in Table (25).

Table 25: Summary of the Results of U-Values Calculations

| Element | ($W/m^2.K$) U-Value | |
|---|---|---|
| | Before insulation | After insulation |
| Roof (insulation thickness=2 cm) | 1.84 | 0.96 ≈ 1.0 |
| Wall (insulation thickness=3 cm) | 2.92 | 0.915≈ 1.0 |
| Façade (insulation thickness=3 cm) | 3.38 | 1.77 ≈ 1.8 |
| Al window, single glass | 5.2 | 5.2 |
| Floor | 2.03 | 2.03 |

Table (26) summarizes the results of the economic feasibility study of thermal insulation for a typical apartment having an area of 120 square meters.

Table 26: Results of the Feasibility Study for Insulating a Typical Flat with 120 $m^2$

| | Unit | Value |
|---|---|---|
| External walls (100$m^2$ for walls & 20 $m^2$ for windows) | | |
| Thermal losses in non-insulated walls (including windows) | W | 7436 |
| Thermal losses in insulated walls (including windows) | W | 3894 |
| Thermal energy saving resulted from insulating the walls | W | 3542 |
| | kcal/h | 3046 |
| | liter mazout/hr | 0.354 |
| Annual saving in diesel oil for space heating | liter mazout/yr | 450 |
| | SL/yr | 9225 |
| Annual saving in electricity for air-conditioning | kWh/yr | 1771 |
| | SL/yr | 4268 |
| Roof (120 $m^2$) | | |
| Thermal loss in non-insulated roof | W | 4858 |
| Thermal loss in insulated roof | W | 2534 |
| Thermal energy saving resulted from insulating the roof | W | 2324 |
| | kcal/h | 1999 |
| | liter mazout/hr | 0.232 |
| Annual saving in diesel oil for space heating | liter mazout/yr | 295 |
| | SL/yr | 6048 |
| Annual saving in electricity for air-conditioning | kWh/yr | 1162 |
| | SL/yr | 2800 |
| The flat | | |
| Sum of thermal losses in non-insulated walls & roof | W | 12294 |
| Sum of thermal losses in insulated walls & roof | W | 6428 |
| Sum of the thermal energy saving resulted from insulating the roof & walls | W | 5866 |
| | kcal/hr | 5045 |
| | liter mazout/hr | 0.587 |
| Sum of the annual saving in diesel oil for space heating | liter mazout/yr | 745 |
| | SL/yr | 15273 |
| Sum of the annual saving in electricity for air-conditioning | kWh/yr | 2933 |
| | SL/yr | 7068 |
| Sum of the total annual saving in diesel oil & electricity | SL/yr | 22341 |
| Initial cost for the thermal insulation | SL | 33000 |
| Payback period | years | 1.5 |

It is clear from Table (26) that the economic feasibility study shows that the thermal insulation is a cost effective measure with a payback period less than 2 years.

### 9.1.3 A Proposal for the Potential of the Thermal Insulation in the Residential Buildings up to 2030

To assess the potential for the use of thermal insulation, it is recommended to focus on the new residential buildings for the following two reasons:

1. The implementation of the thermal insulation in new buildings is much easier in comparison with old buildings,

2. The “Syrian Code of Thermal Insulation” addressed only the new buildings.

The present study suggests three scenarios (See Table 27). The surface area of each dwelling is assumed to be 120 $m^2$.

Table 27: Proposed Number of Dwellings to be Insulated in 2030 (120 $m^2$ for Each Dwelling)

| Scenario | Number of insulated dwellings per year | Total number of insulated dwellings in 2030 |
|---|---|---|
| Low | 10,000 | 200,000 |
| Medium | 30,000 | 600,000 |
| High | 50,000 | 1,000,000 |

### 9.1.4 Calculation of the Possible Saving Gained from the Proposed Insulated Dwellings up to 2030

Based on the following results of the study done on a typical apartment of 120 $m^2$:

-Total annual saving in diesel oil for the purpose of space heating is 745 liter/yr;

-Total annual saving in electricity for the purpose of air conditioning is 2933kWh/yr.

The calculated savings in diesel oil (for space heating) and electricity (for air conditioning) from the proposed insulated dwellings up to 2030 are presented in Table (28). Table (29) shows same saving but in term of kilo tones oil equivalent.

Table 28: Potential Savings in Fuel & Electricity from the Proposed Insulated Dwellings in 2030

| Scenario | Total number of insulated dwellings in 2030 | Saving in diesel oil ($10^6$ liter) | Saving in electricity (GWh) |
|---|---|---|---|
| Low | 200,000 | 149 | 587 |
| Medium | 600,000 | 447 | 1760 |
| High | 1,000,000 | 745 | 2933 |

Table 29: Potential of Total Saving from the Proposed Insulated Dwellings in 2030

| Scenario | Unit | Diesel oil | Electricity* | Total (%) |
|---|---|---|---|---|
| Low | ktoe | 128 | 147 | 275 |
| | % | 47% | 53% | 100% |
| Medium | ktoe | 384 | 440 | 824 |
| | % | 47% | 53% | 100% |
| High | ktoe | 641 | 733 | 1374 |
| | % | 47% | 53% | 100% |

* 1ktoe = 4 GWh, $\eta \approx 34\%$ (Power plants)

## 9.2 Solar Water Heating (SWH) Systems in the Residential Sector

### 9.2.1 Assumptions

- 3.5 million in 2005;
- 7.9 million in 2030;
- The total annual energy consumption for heating water in the residential sector in 2005 is 671 ktoe (Table 5),

### 9.2.2 Proposed Plan for Developing SWH Systems in the Residential Sector up to 2030

The annual consumption of final energy per dwelling for water heating is:

671,000 toe/3,500,000 = 192 kgoe/dwelling/year

= 2233 kWh/dwelling/year (1kgoe=11.63 kWh)

Assuming an annual consumption per dwelling of 192 kgoe or 2233 kWh/year, the final energy needed to heat the water in all dwellings in 2030 is:

192 kgoe x 7,900,000 = 1517 ktoe/year

Due to the lack of space for the installation of solar water heaters in all dwellings in 2030, it is assumed that the solar contribution is only 25% in 2030.

Based on the previous assumptions, Table (30) presents a proposed plan for developing SWH systems in the residential sector up to 2030.

Table 30: Proposed Plan for Developing SWH Systems in the Residential Sector up to 2030

| | Unit | Diesel oil | Electricity | Solar Energy | Other fuel | Total (%) |
|---|---|---|---|---|---|---|
| Breakdown of estimated hot water consumption in 2005 | ktoe | 436 | 188 | 1.8 | 45.2 | 671 |
| | % | 65% | 28% | 0.3% | 6.7% | 100% |
| Breakdown of expected hot water consumption in 2030 | ktoe | 683 | 303 | 379 | 152 | 1517 |
| | % | 45% | 20% | 25% | 10% | 100% |

The proposed plan showed in Table (30) assumes that the share of solar energy in heating water will increase from 0.3% in 2005 to 25% in 2030.

### 9.2.3 The Proposed Number of SWH Systems to be Installed in the Residential Sector up to 2030

Assuming that one typical SWH system produces 2233 kWh/year, the projected contribution of solar energy to heat water in the residential sector in 2030 (25%) corresponds to the following number of SWH systems:

$$379 \times 10^6 \text{ kgoe} \times 11.63 \text{ kWh/kgoe} = 4408 \times 10^6 \text{ kWh} = 4408 \text{ GWh}$$

$$4408 \times 10^6 \text{ kWh/ } 2233 \text{ kWh/Solar system} = 1{,}974{,}026 \text{ Solar systems}$$

This means that 25% of the number of occupied dwellings in 2030 (7.9 million dwellings) can be equipped with SWH systems.

#### 9.2.4 Potential Energy Saving Gained from SWH Systems in the Residential Sector in 2030

The potential energy saving gained from SWH Systems in the residential sector in 2030 are presented in Table (31).

Table 31: Potential Energy Saving from SWH Systems in the Residential Sector in 2030

| | Unit | Diesel oil | Electricity | Total (%) |
|---|---|---|---|---|
| Energy saving from 1,974,026 SWH systems in 2030 | ktoe | 303 | 76 | 379 |
| | % | 80% | 20% | 100% |

### 9.3 Solar Water Heating (SWH) Systems in the Commercial and Service Sectors

#### 9.3.1 Proposed Plan for Developing SWH Systems in the Commercial and Service Sectors up to 2030

In the commercial and service sectors, forced circulation SWH systems are required. A limited number of such SWH systems are successfully implemented in some hospitals, hotels and other locations.

Given the difficulty of knowing the number of commercial and service buildings for providing them with SWH systems, the study assumes that the number can be up to 2000 SWH systems in 2030 with an average capacity of 2500 liters a day per system.

Assuming a hospital in Damascus has a load of 2500 liters of hot water per day at a temperature of 60 degrees Celsius. The calculation done by RETScreen software gives the following results:

- An area of flat plate solar collectors: 50 $m^2$

- Thermal energy yield: 35 MWh / year

- Solar contribution: 76%

#### 9.3.2 Potential Energy Saving Gained from SWH Systems in the Commercial and Service Sectors up to 2030

Based on the calculated saving in the software RETScreen the total saving that can be achieved in 2030 from 2000 SWH systems is:

$$2000 \text{ x } 35 \text{ MWh/year} = 70 \text{ GWh/year}$$

It is expected that this number of SWH systems will replace diesel oil water heating systems. So, the results of calculation must be in terms of "liters of diesel oil" and "ton of oil equivalent".

The energy content of the diesel oil at 100% efficiency is:

$$1 \text{ liter} = 35.8 \text{ MJ} \approx 10 \text{ kWh} \approx 0.86 \text{ kgoe } (1\text{kgoe}=11.63 \text{ kWh})$$

Assuming the efficiency of diesel oil water heating systems of 50%, the energy content of diesel oil become:

$$1 \text{ liter} \approx 5 \text{ kWh} \approx 0.43 \text{ kgoe } (1\text{kgoe}=11.63 \text{ kWh})$$

The saving gained from 2000 SWH systems in terms of "liters of diesel oil" is:

$$70 \text{ x } 10^6 \text{ kWh/ } 5 \text{ (kWh/liter)} = 14\text{x}10^6 \text{ liter}$$

Or in terms of "ton of oil equivalent":

$$14\text{x}10^6 \text{ liter x } 0.43 \text{ (kgoe/liter)} = 6 \text{ ktoe}$$

Or:

$$70 \text{ x } 10^6 \text{ kWh / } 11.63 \text{ (kWh/kgoe)} = 6 \text{ ktoe}$$

Table (32) shows the potential saving from 2000 SWH systems in the commercial and service sectors in 2030.

Table 32: Potential Energy Saving from SWH Systems in the Commercial and Service Sectors in 2030

| | Unit | Diesel oil | Total (%) |
|---|---|---|---|
| Energy saving from 2000 SWH systems in 2030 | ktoe | 6.0 | **6.0** |
| | % | 100% | **100%** |

## 9.4 Photovoltaic Applications in Remote Area

Due to the lack of comprehensive and adequate survey of the potentials for wide spread dissemination of PV technology in rural areas of Syria, the potential PV applications are extracted from reference [22]. Table (33) summarized the proposed PV applications for implementation in remote area until 2030.

Table 33: Proposed PV Applications up to 2030

| Application | Proposed number of systems | System capacity Wp | Total capacity kWp |
|---|---|---|---|
| Electrification of individual residences | 2000 | 500 | 1000 |
| Electrification of health centers | 37 | 1500 | 55 |
| Electrification of schools | 34 | 1000 | 34 |
| Water pumping | 83 | 2000 | 166 |
| PV irrigation water pumping | 1000 | 6000 | 6000 |
| Water desalination | 30 | 5000 | 150 |
| Total | | | 7405 |

The total capacity of the proposed PV applications to be implemented until the year 2030 is about 7.4 MWp. Based on the conversion factor of PV systems the calculation of the electrical power that might be produced from the proposed PV applications is as follows:

7405 x 1.9 (MWh/y/kWp) = 14070 MWh/y = 14.07 GWh/y = 1.21 ktoe/y

For PV applications, it is normal to obtain this resulting saving which is relatively small compared with the saving gained from the proposed SWH systems.

Finally, Table (34) summarizes the total saving resulting from the proposed actions and possible measures to reduce energy consumption through the implementation of the solar thermal and PV technologies in the residential, commercial and service sectors up to 2030.

Table 34: Sum of Total Energy Savings from Renewable Energy Applications in Residential, Commercial and Service Sectors up to 2030

| | Unit | Diesel oil | Electricity | Total (%) |
|---|---|---|---|---|
| Energy saving gained from SWH systems in residential sector | ktoe | 303 | 76 | **379** |
| | % | 80% | 20% | **100%** |
| Energy saving gained from SWH systems in commercial & service sectors | ktoe | 6.0 | | **6.0** |
| | % | 100% | | **100%** |
| Energy saving gained from PV applications | ktoe | 1.21 | | **1.21** |
| | % | 100% | | **100%** |
| **Total** | ktoe | 310.21 | 76 | **386.21** |

## 9.5 Reflective Surfaces of Solar Radiation (Cool Roofs)

### 9.5.1 Assumptions

- The increase of solar reflectance of the roofs is 20%;
- The converting process from conventional dark roofs to cool roofs is estimated to be progressively implemented during the period between 2010 and 2030;
- The number of dwellings expected to be constructed during the period between 2010 and 2030 is 3.9 million dwelling;
- The average roof area of a typical dwelling is 120 $m^2$.

### 9.5.2 Potential Saving in 2030 by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings

Assuming a saving of 2.78 kWh/$m^2$/yr [16], Table (35) shows the total annual saving in 2030 resulting from reducing cooling load by converting 1% of the entire surface of existing buildings in Syria in 2010 and 2% of the entire surface of the residential buildings, expected to be constructed between 2010 and 2030, to cool roofs.

Finally, assuming a saving of 2.78 kWh/$m^2$/yr, Table (36) shows the total annual saving in 2030 resulting from reducing cooling load by converting 1% of the entire surface of existing buildings in Syria in 2010 and  2% of the entire surface of the residential buildings, expected to be constructed between 2010 and 2030, to cool roofs.

**Table 35: Total Annual Saving in 2030 Resulting from Reducing Cooling Load by converting 1% of the entire Surface of Existing Buildings in 2010 and 2% of the entire Surface of the Residential Buildings, Expected to be Constructed between 2010 and 2030, to Cool Roofs**

| Row | Item | Existing dwellings in 2010 | Expected dwellings to be constructed between 2010 and 2030 |
|---|---|---|---|
| 1 | Estimated residential roof area | 0.3 x$10^9$ $m^2$ | 0.47 x$10^9$ $m^2$ |
| 2 | Fraction of all buildings that are air conditioned | 1% | 2% |
| 3 | Average air conditioning saving | 2.78 kWh/$m^2$/yr | |
| 4 | Potential annual saving (Row 1 x Row 2 x Row 3) | 8.34 GWh/yr | 26.1 GWh/yr |
| 5 | $CO_2$ emission per kWh electricity generation | 0.521 kg $CO_2$/kWh* | |
| 6 | Annual avoided $CO_2$ emissions (Row 4 x Row 5) | 4.35 kt $CO_2$/yr | 13.6 kt $CO_2$/yr |

* Source: RETScreen Software

Table 36: Potential Saving in 2030 by Reducing Cooling Load by Installing Cool Roofs on Residential Buildings

| Measures | Unit | Electricity* |
|---|---|---|
| Potential saving in cooling load from transferring 1% of the roofs on residential buildings existing in 2010 to cool roofs | GWh/yr | **8.34** |
| | ktoe | **2.1** |
| Potential saving in cooling load from transferring 2% of the roofs on residential buildings expected to be constructed between 2010 & 2030 to cool roofs | GWh/yr | **26.1** |
| | ktoe | **6.53** |
| **Total** | GWh/yr | **34.44** |
| | ktoe | **8.63** |

* 1ktoe = 4 GWh, η≈34% (Power plants)

## 9.6 Lighting and Electrical Appliances

The results of DSM study [20] relating to the potential savings in lighting and electrical appliances in the residential and industrial sectors are shown in Table (37).

The study proposes the adoption of the measures proposed in the DSM study for the following reasons:

1. These procedures have not been implemented to date,

2. Surveys were based on good and reliable data,

3. A logical analysis of these measures,

For these reasons, the study suggests to maintain the same saving proposed in the DSM study until 2030 instead of 2020.

Table (38) summarizes the potential saving from EE measures in lighting and electrical appliances in the residential, commercial, service, and industrial sectors in 2030.

Table 37: Proposed Measures for DSM (Lighting & Electrical appliances)

| Measures | Saving in 2020 (GWh) |
|---|---|
| **Lighting** | |
| High-efficiency lighting for religion & industrial buildings | 477.3 |
| High-efficiency tube & CFL lamps in Households | 377.1 |
| High-efficiency lighting for commercial & governmental buildings | 374.6 |
| High-efficiency street lighting | 249.3 |
| **Electrical appliances** | |
| **Sub Total** | **1478.3** |
| High-efficiency AC in households | 197.3 |
| High-efficiency refrigerators in households | 82.1 |
| High-efficiency AC and load control for medium & large commercial customers | 76.8 |

| | |
|---|---|
| High-efficiency water heaters & water heaters control in households | 75.4 |
| High-efficiency motors for pumping applications | 71.9 |
| High-efficiency AC and load control for small commercial customers | 58.4 |
| High-efficiency AC and load control for governmental buildings | 11.2 |
| **Sub Total** | **573.1** |
| Total | 2051.4 |

Source: [20]

Table 38: Potential Saving from Energy Efficiency Measures in Lighting &Electrical Appliances in the Residential, Commercial, and Service Sectors in 2030

| Measure | Unit | Electricity* |
|---|---|---|
| Increasing energy efficiency in lighting and electrical appliances | GWh | **2051.9** |
| | ktoe | **512.9** |

* 1ktoe = 4 GWh, η≈34% (Power plants)

Table (39) shows the total potential saving resulting from the proposed RE&EE measures in the residential, commercial and service sectors in 2030.

Table 39: Total Potential Saving from the Energy Efficiency Measures in the Residential, Commercial, and Service Sectors in 2030 (ktoe)

| Measure | Diesel oil | Electricity | Total |
|---|---|---|---|
| Thermal insulation (low scenario) | 128 | 147 | **275** |
| Reducing cooling load from transferring 1% of the roofs on residential buildings existing in 2010 to cool roofs | - | 2.1 | **2.1** |
| Reducing cooling load from transferring 2% of the roofs on residential buildings expected to be constructed between 2010 & 2030 to cool roofs | - | 6.53 | **6.53** |
| Increasing energy efficiency in lighting and electrical appliances | - | 512.9 | **512.9** |
| **Total** | **128** | **668.53** | **796.53** |

## 9.7 Total Potential Saving Resulting from the Proposed RE&EE Measures in the Residential, Commercial and Service Sectors in 2030

Table (40) shows the total potential saving resulting from the proposed RE&EE measures in the residential, commercial and service sectors in 2030.

Table 40: Total Potential Saving from the RE&EE Measures in the Residential, Commercial, and Service Sectors in 2030 (ktoe)

| Measure | Unit | Diesel oil | Electricity | Total |
|---|---|---|---|---|
| Renewable energy measures | ktoe | 310.21 | 76 | **386.21** |
| Energy efficiency measures | ktoe | 128 | 668.53 | **796.53** |
| **Total** | ktoe | **438.21** | **744.53** | **1182.74** |
| | Tj* | **17529** | **29781** | **47310** |

*1ktoe = 40.0 Tj

## 9.8 Conclusion

The total saving in 2030 is: 1183 ktoe, which represents 6.0% of the primary energy consumed in Syria in 2005 (19.6 Mtoe), or 7.75% of the final energy consumed in Syria in 2005 (15.25 Mtoe). Also, the total saving represents 2.45% of the final energy consumed in Syria in 2030 48.359 Mtoe).

## 10. Economic and Environmental Impacts of Proposed Measures

To reach the goal of the study of economic and environmental impacts of the proposed plan for RE&EE applications in the residential sector, an analytical study for the implementation of the proposed measures should be undertaken. The results of this study should be presented in terms of economic feasibility and environmental and in terms of availability of the necessary funding to implement the plan. The expected direct and indirect impacts could be:

**Environmental Impacts**

- Reducing greenhouse gas carbon dioxide in 2030 by about 1735 kilotons, or 3% of the total emissions in 2005 (58350 kt).

- Improvement of environmental conditions by the use of clean renewable energy applications.

**Economic Impacts**

- Reduction in the consumption of fossil fuel, thereby reducing the import bill of diesel fuel,

- Reduction in electric power consumption, thereby reducing the electric peak demand,

- Increasing income resulting from the reduction of energy consumption,
- Promotion of opportunities for local manufacturing of the energy-saving tools and equipment,

- Creating new job opportunities.

To achieve this goal, a national model should be design to:

- Estimate the economic effects of direct and indirect impacts on various economic sectors,

- Study the impact of inputs and outputs with economic and demographic variables at the national level,

- Provide a framework to study the adverse impacts of the economic events between the various sectors of the economy.

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# 12. Annexes

### Annex 1: Statistical Data on Buildings

**الجدول (1): الأبنية المرخصة في القطاع السكني (الخاص والتعاوني)**

**Table (1): Licensed Buildings in the Residential Sector (Private& Cooperative)**

| إضافات لأبنية سكنية<br>Additions to Res. Bldg. | | الأبنيـة السـكنيـة<br>Residential Buildings | | | | السنة<br>Year |
|---|---|---|---|---|---|---|
| المساحة الطابقية<br>Floor Area (1000 m²) | عدد الرخص<br>No. of Licenses | المساحة الطابقية<br>Floor Area (1000 m²) | عدد الغرف<br>No. of Rooms | عدد وحدات السكن<br>No. of Dwelling Units | عدد الرخص<br>No. of Licenses | |
| 55 | 1952 | 1119 | 46638 | 14851 | 8115 | **1963** |
| 78 | 1897 | 1584 | 47599 | 14972 | 7888 | **1970** |
| 121 | 3082 | 2362 | 75468 | 22618 | 12388 | **1975** |
| 95 | 1946 | 3109 | 95724 | 27379 | 15838 | **1980** |
| 49 | 1038 | 5223 | 146229 | 38981 | 20595 | **1985** |
| 11 | 321 | 1933 | 61265 | 14896 | 6987 | **1990** |
| 24 | 729 | 5356 | 158039 | 39692 | 19902 | **1995** |
| 4 | 123 | 1183 | 33330 | 9253 | 4629 | **2000** |
| 55 | 1412 | 11841 | 329215 | 90579 | 45663 | **2005** |
| 29 | 733 | 12493 | 340165 | 97427 | 36623 | **2007** |
| 32 | 841 | 12147 | 334905 | 95664 | 39131 | **2008** |

Source: Statistical Abstract

الجدول (2): الأبنية المرخصة في القطاع السكني-التجاري والقطاع التجاري (الخاص والتعاوني)

**Table (2): Licensed Buildings in the Commercial-Residential & Commercial Sectors (Private & Cooperative)**

| الأبنية التجارية Commercial Buildings | | | الأبنية السكنية-التجارية Commercial-Residential Buildings | | | | | | | السنة Year |
|---|---|---|---|---|---|---|---|---|---|---|
| المساحة الطابقية Floor Area $(1000\ m^2)$ | عدد المحلات التجارية No. of Comm. Shops | عدد الرخص No. of Licenses | المساحة الطابقية Floor Area $(1000\ m^2)$ المجموع Total | تجاري Comm. | سكني Res. | عدد المحلات التجارية No. of Comm. Shops | عدد الغرف No. of Rooms | عدد وحدات السكن No. of Dwelling Units | عدد الرخص No. of Licenses | |
| 70 | - | 317 | 172 | 56 | 116 | - | 5518 | 1465 | 314 | **1963** |
| 69 | 1426 | 377 | 220 | 56 | 164 | 1388 | 5632 | 1577 | 305 | **1970** |
| 130 | 2517 | 609 | 418 | 101 | 317 | 3076 | 9860 | 2869 | 554 | **1975** |
| 136 | 3387 | 667 | 793 | 215 | 578 | 6016 | 17156 | 5815 | 1061 | **1980** |
| 149 | 3009 | 497 | 1120 | 280 | 840 | 8220 | 24779 | 7672 | 1439 | **1985** |
| 64 | 1513 | 270 | 619 | 144 | 475 | 3606 | 15739 | 4074 | 671 | **1990** |
| 309 | 5840 | 637 | 1369 | 326 | 1043 | 8558 | 38684 | 11022 | 1678 | **1995** |
| 102 | 1297 | 220 | 282 | 67 | 215 | 1866 | 7730 | 2522 | 353 | **2000** |
| 425 | 6148 | 1453 | 2217 | 529 | 1688 | 13956 | 48302 | 14498 | 2708 | **2005** |
| 525 | 6525 | 1483 | 2450 | 561 | 1889 | 15027 | 52169 | 16009 | 2702 | **2007** |
| 612 | 7335 | 1697 | 1905 | 459 | 1446 | 10214 | 42549 | 12570 | 2196 | **2008** |

Source: Statistical Abstract

الجدول (3): الأبنية المرخصة في القطاع الصناعي والأبنية المرخصة الأخرى

**Table (3): Licensed Buildings in the Industrial Sector & Other Licensed Buildings**

| أبنيـة أخرى<br>Other Buildings | | الأبنيـة الصناعية<br>Industrial Buildings | | | السنة<br>Year |
|---|---|---|---|---|---|
| المساحة الطابقية<br>Floor Area ($1000\ m^2$) | عدد الرخص<br>No. of Licenses | المساحة الطابقية<br>Floor Area ($1000\ m^2$) | عدد المنشآت الصناعية<br>No. of Commerce Shops | عدد الغرف<br>No. of Rooms | |
| 4 | 60 | 21 | - | 50 | **1963** |
| 6 | 58 | 28 | 387 | 149 | **1970** |
| 86 | 190 | 90 | 272 | 114 | **1975** |
| 169 | 259 | 59 | 446 | 225 | **1980** |
| 201 | 513 | 52 | 167 | 103 | **1985** |
| 54 | 205 | 94 | 369 | 216 | **1990** |
| 325 | 943 | 258 | 1483 | 666 | **1995** |
| 85 | 128 | 152 | 152 | 120 | **2000** |
| 744 | 1677 | 1088 | 1126 | 1019 | **2005** |
| 898 | 1777 | 1488 | 1381 | 1219 | **2007** |
| 734 | 1251 | 1356 | 1161 | 1152 | **2008** |

Source: Statistical Abstract

الجدول (4): الأبنيـة المرخصـة في القطاع السكني في الحضر (الخاص والتعاوني)

**Table (4): Licensed Buildings in the Residential Sector in Urban Areas (Private& Cooperative)**

| إضافات لأبنية سكنية<br>Additions to Res. Bldg. | | الأبنيــة الســكنيــة<br>Residential Buildings | | | | السنة<br>Year |
|---|---|---|---|---|---|---|
| المساحة الطابقية<br>Floor Area (1000 m$^2$) | عدد الرخص<br>No. of Licenses | المساحة الطابقية<br>Floor Area (1000 m$^2$) | عدد الغرف<br>No. of Rooms | عدد وحدات السكن<br>No. of Dwelling Units | عدد الرخص<br>No. of Licenses | |
| 23 | 930 | 933 | 38667 | 11368 | 4888 | **1963** |
| 33 | 903 | 1321 | 39464 | 11461 | 4751 | **1970** |
| 32 | 929 | 1832 | 58186 | 16112 | 6332 | **1975** |
| 20 | 471 | 1987 | 63244 | 16979 | 6525 | **1980** |
| 9 | 184 | 2777 | 80086 | 21727 | 7671 | **1985** |
| 2 | 33 | 1314 | 42307 | 9819 | 3141 | **1990** |
| 3 | 64 | 3059 | 94401 | 22987 | 6979 | **1995** |
| 1 | 10 | 755 | 20950 | 5625 | 1793 | **2000** |
| 4 | 107 | 5902 | 162315 | 43070 | 13637 | **2005** |
| 3 | 93 | 6569 | 174240 | 50769 | 11609 | **2007** |
| 4 | 126 | 5530 | 150485 | 42679 | 10674 | **2008** |

Source: Statistical Abstract

(الخاص والتعاوني) الجدول (5): الأبنية المرخصة في القطاع السكني-التجاري والقطاع التجاري في الحضر

**Table (5): Licensed Buildings in the Commercial-Residential & Commercial Sectors in Urban Areas (Private& Cooperative)**

| الأبنيـة التجارية Commercial Buildings | | | الأبنيـة السكنية-التجارية Commercial-Residential Buildings | | | | | | | السنة Year |
|---|---|---|---|---|---|---|---|---|---|---|
| المساحة الطابقية Floor Area (1000 m²) | عدد المحلات التجارية No. of Comm. Shops | عدد الرخص No. of Licenses | المساحة الطابقية Floor Area (1000 m²) | | | عدد المحلات التجارية No. of Comm. Shops | عدد الغرف No. of Rooms | عدد وحدات السكن No. of Dwelling Units | عدد الرخص No. of Licenses | |
| | | | المجموع Total | تجاري Comm. | سكني Res. | | | | | |
| 60 | - | 219 | 163 | 51 | 112 | - | 5313 | 1412 | 266 | **1963** |
| 59 | 1219 | 260 | 209 | 51 | 158 | 1264 | 5422 | 1524 | 259 | **1970** |
| 114 | 2105 | 424 | 399 | 96 | 303 | 2865 | 9476 | 2740 | 479 | **1975** |
| 118 | 2855 | 471 | 739 | 200 | 539 | 5610 | 16204 | 5580 | 952 | **1980** |
| 133 | 2540 | 348 | 1034 | 253 | 781 | 7358 | 22919 | 7163 | 1231 | **1985** |
| 53 | 1265 | 191 | 588 | 134 | 454 | 3363 | 15249 | 3946 | 608 | **1990** |
| 227 | 5117 | 436 | 1303 | 301 | 1002 | 7828 | 37507 | 10712 | 1531 | **1995** |
| 62 | 1124 | 148 | 260 | 59 | 201 | 1642 | 7283 | 2386 | 306 | **2000** |
| 260 | 3950 | 650 | 1914 | 427 | 1487 | 11357 | 43262 | 13055 | 2059 | **2005** |
| 366 | 4711 | 765 | 1977 | 427 | 1550 | 11638 | 43900 | 13534 | 1885 | **2007** |
| 381 | 5065 | 859 | 1465 | 324 | 1141 | 7099 | 34403 | 10178 | 1395 | **2008** |

Source: Statistical Abstract

الجدول (6): الأبنيـة المرخصـة في القطاع الصناعي والأبنيـة المرخصـة الأخرى في الحضر

**Table (6): Licensed Buildings in the Industrial sector & Other Licensed Buildings in Urban Areas**

| السنة Year | الأبنيـة الصناعية Industrial Buildings | | | أبنيـة أخرى Other Buildings | |
|---|---|---|---|---|---|
| | عدد الغرف No. of Rooms | عدد المنشآت الصناعية No. of Commerce Shops | المساحة الطابقية Floor Area (1000 $m^2$) | عدد الرخص No. of Licenses | المساحة الطابقية Floor Area (1000 $m^2$) |
| 1963 | 43 | - | 17 | 23 | 3 |
| 1970 | 129 | 304 | 22 | 22 | 5 |
| 1975 | 88 | 234 | 50 | 43 | 21 |
| 1980 | 183 | 355 | 55 | 95 | 92 |
| 1985 | 89 | 145 | 46 | 103 | 44 |
| 1990 | 181 | 328 | 81 | 30 | 8 |
| 1995 | 612 | 1415 | 199 | 225 | 79 |
| 2000 | 65 | 94 | 61 | 33 | 36 |
| 2005 | 707 | 784 | 736 | 443 | 210 |
| 2007 | 920 | 1043 | 1143 | 514 | 231 |
| 2008 | 860 | 865 | 1063 | 433 | 279 |

Source: Statistical Abstract

الجدول (7): الأبنيـة المرخصـة في القطاع السكني في الريف (الخاص والتعاوني)

**Table (7): Licensed Buildings in the Residential Sector in Rural Areas (Private& Cooperative)**

| إضافات لأبنية سكنية Additions to Res. Bldg. | | الأبنيـة السـكنيـة Residential Buildings | | | | السنة Year |
|---|---|---|---|---|---|---|
| المساحة الطابقية Floor Area (1000 $m^2$) | عدد الرخص No. of Licenses | المساحة الطابقية Floor Area (1000 $m^2$) | عدد الغرف No. of Rooms | عدد وحدات السكن No. of Dwelling Units | عدد الرخص No. of Licenses | |
| 32 | 1022 | 186 | 7971 | 3483 | 3227 | **1963** |
| 45 | 994 | 263 | 8135 | 3511 | 3137 | **1970** |
| 89 | 2153 | 530 | 17282 | 6506 | 6056 | **1975** |
| 75 | 1475 | 1122 | 32480 | 10400 | 9313 | **1980** |
| 40 | 854 | 2446 | 66143 | 17254 | 12924 | **1985** |
| 9 | 288 | 619 | 18958 | 5077 | 3846 | **1990** |
| 21 | 665 | 2297 | 63638 | 16705 | 12923 | **1995** |
| 3 | 113 | 428 | 12380 | 3628 | 2836 | **2000** |
| 51 | 1305 | 5939 | 166900 | 47509 | 32026 | **2005** |
| 26 | 640 | 5924 | 165925 | 46658 | 25014 | **2007** |
| 28 | 715 | 6617 | 184420 | 52985 | 28457 | **2008** |

Source: Statistical Abstract

**(الخاص والتعاوني) الجدول (8): الأبنية المرخصة في القطاع السكني–التجاري والقطاع التجاري في الريف**

**Table (8): Licensed Buildings in the Commercial-Residential & Commercial Sectors in Rural Areas (Private& Cooperative)**

| الأبنيـة التجارية<br>Commercial Buildings | | | الأبنيـة السكنية–التجارية<br>Commercial-Residential Buildings | | | | | | | السنة<br>Year |
|---|---|---|---|---|---|---|---|---|---|---|
| المساحة الطابقية<br>Floor Area ($1000\ m^2$) | عدد المحلات التجارية<br>No. of Comm. Shops | عدد الرخص<br>No. of Licenses | المساحة الطابقية<br>Floor Area ($1000\ m^2$) | | | عدد المحلات التجارية<br>No. of Comm. Shops | عدد الغرف<br>No. of Rooms | عدد وحدات السكن<br>No. of Dwelling Units | عدد الرخص<br>No. of Licenses | |
| | | | المجموع<br>Total | تجاري<br>Comm. | سكني<br>Res. | | | | | |
| 10 | - | 98 | 9 | 5 | 4 | - | 205 | 53 | 48 | **1963** |
| 10 | 207 | 117 | 11 | 5 | 6 | 124 | 210 | 53 | 46 | **1970** |
| 16 | 412 | 185 | 19 | 5 | 14 | 211 | 384 | 129 | 75 | **1975** |
| 18 | 532 | 196 | 54 | 15 | 39 | 406 | 952 | 235 | 109 | **1980** |
| 16 | 469 | 149 | 86 | 27 | 59 | 862 | 1860 | 509 | 208 | **1985** |
| 11 | 248 | 79 | 31 | 10 | 21 | 243 | 490 | 128 | 63 | **1990** |
| 82 | 723 | 201 | 66 | 25 | 41 | 730 | 1177 | 310 | 147 | **1995** |
| 40 | 173 | 72 | 22 | 8 | 14 | 224 | 447 | 136 | 47 | **2000** |
| 165 | 2198 | 803 | 303 | 102 | 201 | 2599 | 5040 | 1443 | 649 | **2005** |
| 160 | 1814 | 718 | 472 | 134 | 338 | 3389 | 8269 | 2475 | 817 | **2007** |
| 231 | 2270 | 838 | 439 | 135 | 304 | 3115 | 8146 | 2392 | 801 | **2008** |

Source: Statistical Abstract

الجدول (9): الأبنيـة المرخصـة في القطاع الصناعي والأبنيـة المرخصـة الأخرى في الريف

**Table (9): Licensed Buildings in the Industrial sector & Other Licensed Buildings in Rural Areas**

| أبنيــة أخرى<br>**Other Buildings** | | الأبنيــة الصناعية<br>**Industrial Buildings** | | | السنة<br>**Year** |
|---|---|---|---|---|---|
| المساحة الطابقية<br>**Floor Area (1000 m$^2$)** | عدد الرخص<br>**No. of Licenses** | المساحة الطابقية<br>**Floor Area (1000 m$^2$)** | عدد المنشآت الصناعية<br>**No. of Commerce Shops** | عدد الغرف<br>**No. of Rooms** | |
| 1 | 37 | 4 | - | 7 | **1963** |
| 1 | 36 | 6 | 83 | 20 | **1970** |
| 65 | 147 | 40 | 38 | 26 | **1975** |
| 77 | 164 | 4 | 91 | 42 | **1980** |
| 157 | 410 | 6 | 22 | 14 | **1985** |
| 46 | 175 | 13 | 41 | 35 | **1990** |
| 246 | 718 | 59 | 68 | 54 | **1995** |
| 49 | 95 | 91 | 58 | 55 | **2000** |
| 534 | 1234 | 352 | 342 | 312 | **2005** |
| 668 | 1263 | 345 | 338 | 299 | **2007** |
| 455 | 818 | 293 | 296 | 292 | **2008** |

Source: Statistical Abstract

**الجدول (10): الأبنية المرخصة (سكنية وغير سكنية) حسب الحضر والريف في الجمهورية العربية السورية خلال السنوات: 1963، 1970 – 2007 (المساحة: ألف م$^{2}$)**

**Table (10): Licensed buildings (Residential & non Residential) in Urban & Rural Areas (1000m$^{2}$)**

| الأبنية غير السكنية Non - Residential Buildings | | | | | | الأبنية السكنية Residential Buildings | | | | | | | | | | | | السنة Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| * المساحة الطابقية Floor Area | | | مساحة الأرض Land Area | | | عدد الغرف No. of Rooms | | | عدد وحدات السكن No. of Dwellings | | | المساحة الطابقية Floor Area | | | مساحة الأرض Land Area | | | |
| مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | |
| 151 | 20 | 131 | 153 | 23 | 130 | 55054 | 9963 | 45091 | 16458 | 4616 | 11842 | 1290 | 222 | 1068 | 1572 | 269 | 1303 | **1963** |
| 159 | 22 | 137 | 167 | 13 | 154 | 55829 | 9802 | 46027 | 16550 | 3566 | 12984 | 1826 | 314 | 1512 | 2380 | 625 | 1755 | **1970** |
| 410 | 127 | 283 | 388 | 171 | 217 | 89324 | 20536 | 68788 | 25487 | 6635 | 18852 | 2799 | 633 | 2166 | 2982 | 1276 | 1706 | **1975** |
| 556 | 114 | 442 | 667 | 312 | 355 | 115463 | 35444 | 80019 | 33194 | 10635 | 22559 | 3782 | 1236 | 2546 | 7025 | 3375 | 3650 | **1980** |
| 682 | 206 | 476 | 453 | 232 | 221 | 171893 | 68957 | 102936 | 46436 | 17664 | 28772 | 6112 | 2545 | 3567 | 6546 | 3746 | 2800 | **1985** |
| 358 | 81 | 277 | 184 | 77 | 107 | 76786 | 19425 | 57361 | 18833 | 5139 | 13694 | 2419 | 650 | 1769 | 1729 | 673 | 1057 | **1990** |
| 1217 | 411 | 806 | 977 | 563 | 414 | 196882 | 65068 | 131814 | 50485 | 16952 | 33533 | 6423 | 2358 | 4065 | 5281 | 3022 | 2260 | **1995** |
| 406 | 188 | 218 | 334 | 248 | 86 | 41154 | 12910 | 28244 | 11775 | 3764 | 8011 | 1402 | 446 | 956 | 883 | 494 | 494 | **2000** |
| 2097 | 1167 | 930 | 2684 | 1101 | 1583 | 379012 | 173339 | 205673 | 105077 | 48952 | 56125 | 13141 | 6191 | 6950 | 8389 | 4264 | 4125 | **2005** |
| 3157 | 1233 | 1924 | 2271 | 1067 | 1204 | 354842 | 147074 | 207768 | 98329 | 41161 | 57168 | 12553 | 5205 | 7349 | 6432 | 3128 | 3303 | **2006** |
| 3473 | 1307 | 2166 | 2355 | 1170 | 1185 | 393161 | 174947 | 218214 | 113434 | 49131 | 64303 | 14411 | 6289 | 8122 | 6974 | 3596 | 3378 | **2007** |

* تتضمن المساحة الطابقية التجارية من البناء السكني التجاري

الجدول (11): الأبنيـة السكنية المنفذة في الأعوام 1963، 1970 . 2008 (في القطاعين الخاص والتعاوني )

)1000m²(

**Table (11): Accomplished Residential Buildings in 1963, 1970 - 2008**
**(Private & Cooperative Sectors) (1000m²)**

| الأبنيـة السـكنية Residential Buildings | | | | | | | | | السنة Year |
|---|---|---|---|---|---|---|---|---|---|
| مسـاحـة الأراضـي Land Area | | | عدد وحدات السـكن No. of Dwellings | | | المسـاحة الطابقية Floor Area | | | |
| مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | |
| 1479 | 230 | 1249 | 14596 | 3163 | 11433 | 1339 | 171 | 1168 | **1963** |
| 2473 | 718 | 1755 | 11328 | 2454 | 8874 | 1449 | 247 | 1202 | **1970** |
| 4094 | 1986 | 2108 | 18830 | 4902 | 13928 | 2056 | 532 | 1524 | **1975** |
| 9478 | 5828 | 3650 | 30407 | 12209 | 18198 | 3425 | 1476 | 1949 | **1980** |
| 6886 | 4187 | 2699 | 36097 | 9733 | 26364 | 4226 | 1177 | 3049 | **1985** |
| 1728 | 672 | 1056 | 19650 | 6840 | 12810 | 2552 | 843 | 1709 | **1990** |
| 5282 | 3022 | 2260 | 49172 | 16397 | 32775 | 5789 | 2125 | 3664 | **1995** |
| 997 | 503 | 494 | 15995 | 4104 | 11891 | 1862 | 513 | 1349 | **2000** |
| 8390 | 4265 | 4125 | 80930 | 33637 | 47293 | 9900 | 4070 | 5830 | **2005** |
| 6974 | 3596 | 3378 | 103393 | 37366 | 66027 | 13153 | 5052 | 8101 | **2007** |
| 6304 | 3553 | 2751 | 105493 | 59715 | 45778 | 13333 | 7306 | 6027 | **2008** |

**الجدول (12): الأبنية غير السكنية المنفذة في الأعوام 1963، 1970 . 2008 (في القطاعين الخاص والتعاوني )**

**(1000$m^2$)**

**Table (12): Accomplished Non-Residential Buildings in 1963, 1970 - 2008**
**(Private & Cooperative Sectors) (1000$m^2$)**

| الأبنية غير السكنية Non - Residential Buildings | | | | | | | | | | | | السنة Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| مساحة الأراضي Land Area | | | المساحة الطابقية للأبنية الأخرى Other Building Floor Area | | | المساحة الطابقية الصناعية Industrial Floor Area | | | المسحة الطابقية التجارية Commercial Floor Area | | | |
| مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | |
| 88 | 11 | 77 | – | – | – | 6 | 3 | 3 | 83 | 8 | 75 | **1963** |
| 167 | 13 | 154 | 5 | 3 | 2 | 14 | 1 | 13 | 83 | 5 | 78 | **1970** |
| 775 | 194 | 581 | 48 | 35 | 13 | 24 | 2 | 22 | 175 | 20 | 155 | **1975** |
| 827 | 472 | 355 | 67 | 49 | 18 | 78 | 7 | 71 | 275 | 43 | 232 | **1980** |
| 454 | 233 | 221 | 91 | 79 | 12 | 30 | 2 | 28 | 313 | 30 | 283 | **1985** |
| 181 | 75 | 106 | 47 | 38 | 9 | 74 | 17 | 57 | 241 | 28 | 213 | **1990** |
| 1078 | 664 | 414 | 216 | 169 | 47 | 256 | 45 | 211 | 593 | 92 | 501 | **1995** |
| 337 | 247 | 90 | 97 | 66 | 31 | 141 | 85 | 56 | 189 | 52 | 137 | **2000** |
| 2096 | 1167 | 929 | 589 | 458 | 161 | 739 | 440 | 299 | 850 | 208 | 642 | **2005** |
| 2354 | 1169 | 1185 | 937 | 722 | 215 | 1022 | 272 | 750 | 903 | 245 | 658 | **2007** |
| 1982 | 856 | 1126 | 605 | 414 | 191 | 729 | 201 | 528 | 807 | 236 | 571 | **2008** |

**الجدول (13): المساكن المعتادة والغرف والمساحة الطابقية ومعدل التزاحم (حضر وريف ) في الأعوام 1970، 1981، 1994، 2004، 2007، و 2008**

**Table (13): Conventional Dwellings (Occupied & Vacant), Rooms, Floor Areas and no. of Persons per Room (Urban & Rural) in years: 1970, 1981, 1994, 2004, 2007 and 2008**

| No. of Dwellings | No. of Rooms | Floor Area (1000m$^2$) | No. of rooms per dwelling unit | No. of persons per room(1) | Average floor area per capita (m$^2$) (2) | Urban or Rural | Year |
|---|---|---|---|---|---|---|---|
| 405289 | 1261920 | 35334 | 3.11 | 2.26 | 12.37 | Urban | **1970** |
| 584647 | 1210161 | 36305 | 2.07 | 3.13 | 9.59 | Rural | |
| **989936** | **2472081** | **71639** | **2.50** | **2.67** | **10.83** | **Total** | |
| 756897 | 2513424 | 75403 | 3.32 | 2.03 | 14.56 | Urban | **1981** |
| 782049 | 2091246 | 69011 | 2.67 | 2.56 | 12.47 | Rural | |
| **1538946** | **4604670** | **144414** | **2.99** | **2.28** | **13.46** | **Total** | |
| 1326173 | 4534053 | 132097 | 3.42 | 1.83 | 15.86 | Urban | **1994** |
| 1131730 | 3459891 | 103468 | 3.06 | 2.30 | 12.97 | Rural | |
| **2457903** | **7993944** | **235565** | **3.25** | **2.04** | **14.41** | **Total** | |
| 1911901 | 7285610 | 192036 | 3.80 | 1.50 | 17.90 | Urban | **2004** |
| 1456441 | 5379200 | 144112 | 3.70 | 1.80 | 15.30 | Rural | |
| **3368342** | **12664810** | **336148** | **3.80** | **1.60** | **16.70** | **Total** | |
| 2144651 | 8141822 | 221813 | 3.80 | 1.26 | 21.63 | Urban | **2007** |
| 1596014 | 5879040 | 160958 | 3.68 | 1.52 | 18.05 | Rural | |
| **3740665** | **14020862** | **382771** | **3.75** | **1.37** | **19.97** | **Total** | |
| 2207032 | 8385349 | 229810 | 3.80 | 1.20 | 22.88 | Urban | **2008** |
| 1663504 | 6107204 | 169011 | 3.67 | 1.57 | 17.60 | Rural | |
| **3870536** | **14492553** | **398821** | **3.74** | **1.36** | **20.30** | **Total** | |

* (1): For occupied & vacant, (2): For occupied dwellings and their persons
Note: 1970, 1981, 1994 & 2004 data housing censuses

**الجدول (14): الأبنية المنفذة من المرخصة (سكنية وغير سكنية) حسب الحضر والريف في الجمهورية العربية السورية خلال السنوات 1963، 1970–2007 (المساحة: ألف م$^2$)**

**Table (14): Accomplished buildings from the licensed buildings (residential & non residential) in Urban & Rural Areas (Area in 1000m$^2$)**

| الأبنية غير السكنية Non - Residential Buildings | | | الأبنية السكنية Residential Buildings | | | | | | | | | السنة Year |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | عدد الغرف No. of Rooms | | | عدد وحدات السكن No. of Dwellings | | | المساحة الطابقية Floor Area | | | |
| مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | مجموع Total | ريف Rural | حضر Urban | |
| 89 | 11 | 78 | 50321 | 6787 | 43534 | 14596 | 3163 | 11433 | 1329 | 172 | 1157 | **1963** |
| 136 | 15 | 121 | 44227 | 7764 | 36463 | 11328 | 2454 | 8874 | 1428 | 243 | 1185 | **1970** |
| 247 | 57 | 190 | 68420 | 19413 | 49007 | 18830 | 6291 | 12539 | 2056 | 532 | 1524 | **1975** |
| 570 | 117 | 453 | 108116 | 43667 | 64449 | 30407 | 12209 | 18198 | 3425 | 1476 | 1949 | **1980** |
| 433 | 110 | 323 | 126733 | 34506 | 92227 | 36097 | 9733 | 26364 | 4225 | 1177 | 3048 | **1985** |
| 363 | 84 | 279 | 76393 | 24791 | 51602 | 19650 | 6840 | 12810 | 2553 | 843 | 1710 | **1990** |
| 1065 | 306 | 759 | 181057 | 61476 | 119581 | 49172 | 16397 | 32775 | 5789 | 2125 | 3664 | **1995** |
| 425 | 203 | 222 | 58325 | 14515 | 43810 | 15995 | 4104 | 11891 | 1863 | 512 | 1351 | **2000** |
| 2209 | 1106 | 1103 | 279195 | 111544 | 167651 | 80930 | 33637 | 47293 | 9901 | 4070 | 5831 | **2005** |
| 2377 | 1000 | 1377 | 300066 | 141715 | 158351 | 84743 | 39410 | 45333 | 10960 | 4966 | 5994 | **2006** |
| 2863 | 1240 | 1623 | 363185 | 133267 | 229918 | 103393 | 37366 | 66027 | 13153 | 5052 | 8101 | **2007** |

* تتضمن المساحة الطابقية التجارية من البناء السكني التجاري

**Annex 2:** ***Electric Energy Tariff in Syria (SL/kWh)***

<table>
<tr><th colspan="2"></th><th>Peak<br>17h00-<br>22h00</th><th>Diurnal<br>07h00-<br>17h00</th><th>Nocturnal<br>22h00-<br>07h00</th><th>Average</th></tr>
<tr><td rowspan="3">High Voltage</td><td>230 kV</td><td>3.00</td><td>2.00</td><td>1.50</td><td>2.0</td></tr>
<tr><td>66 kV</td><td>3.76</td><td>2.50</td><td>1.80</td><td>2.5</td></tr>
<tr><td>20 kV</td><td>4.50</td><td>2.80</td><td>1.85</td><td>2.80</td></tr>
<tr><td>Industrial</td><td rowspan="2">20/0.4 kV</td><td>5.00</td><td>3.36</td><td>2.45</td><td>3.36</td></tr>
<tr><td>Agriculture</td><td>2.54</td><td>1.80</td><td>1.40</td><td>1.80</td></tr>
<tr><td rowspan="3">Commercial<br>20/0.4 kV</td><td>1-400 kWh/month</td><td colspan="4">2.50</td></tr>
<tr><td>401-1000 kWh/month</td><td colspan="4">3.50</td></tr>
<tr><td>> 1000 kWh/month</td><td colspan="4">4.00</td></tr>
<tr><td rowspan="9">Residential<br>0.4 kV</td><td>1-50 kWh/month</td><td colspan="4">0.25</td></tr>
<tr><td>51-100 kWh/month</td><td colspan="4">0.35</td></tr>
<tr><td>101-200 kWh/month</td><td colspan="4">0.50</td></tr>
<tr><td>201-300 kWh/month</td><td colspan="4">0.75</td></tr>
<tr><td>301-400 kWh/month</td><td colspan="4">2.00</td></tr>
<tr><td>401-500 kWh/month</td><td colspan="4">3.00</td></tr>
<tr><td>501-1000 kWh/month</td><td colspan="4">3.50</td></tr>
<tr><td>> 1000 kWh/month</td><td colspan="4">7.00</td></tr>
<tr><td colspan="5">Average tariff (subsidised category) (1-300 kWh): 0.52 SL/kWh<br>Average tariff (301-400 kWh): 0.89 SL/kWh<br>Average tariff (401-500 kWh): 1.31 SL/kWh<br>Average tariff (1-1000 kWh): 2.41 SL/kWh</td></tr>
<tr><td>Religious Buildings</td><td colspan="5">Free of Charge</td></tr>
</table>

## Annex 3: Analysis of Imported Solar Materials Data

**Table (1): Imported SWH systems in 2005**

| Item: 8419.19 (SWH systems) | | |
|---|---|---|
| **Country** | **Weight [kg]** | **Value [S.P]** |
| China | 33851 | 753500 |
| Turkey | 1688 | 217000 |
| South Korea | 840 | 244800 |
| Jordan | 12084 | 3372050 |
| USA | 110 | 300000 |
| **TOTAL** | **48,573** | **4,887,350** |

**Table (2): Imported Solar Collectors & SWH systems in 2006**

| **Country** | **8419.90.90 (collectors)** | | **8419.19.00 (SWH systems)** | |
|---|---|---|---|---|
| | **Weight [kg]** | **Value [S.P]** | **Weight [kg]** | **Value [S.P]** |
| European Market | 99427 | 69168956 | 72 | 4050 |
| China | 29834 | 2184000 | 56551 | 2910075 |
| Germany | 1005 | 2196732 | 2556 | 1105520 |
| Italy | 67807 | 95182858 | | |
| Taiwan | 5755 | 201200 | | |
| Turkey | 69777 | 6697544 | 14160 | 362000 |
| South Korea | | | 70 | 57700 |
| Jordan | 9423 | 2891934 | 4100 | 951700 |
| UAE | 714 | 61500 | | |
| Lebanon | | | 800 | 35500 |
| **TOTAL** | **283,742** | **178,584,724** | **78,309** | **5,426,545** |

**Table (3): Imported Solar Collectors & SWH systems in 2007**

| **Country** | **8419.90.20 (collectors)** | | **8419.19.00 (SWH systems)** | |
|---|---|---|---|---|
| | **Weight [kg]** | **Value [S.P]** | **Weight [kg]** | **Value [S.P]** |
| European Market | 346512 | 103730476 | | |
| China | 154499 | 7452831 | 75930 | 5005062 |
| Germany | 177486 | 22501637 | | |
| Greece | 78125 | 12536222 | | |
| Italy | 16668 | 16288579 | 578 | 75000 |
| Taiwan | | | 2910 | 726537 |
| Turkey | 90811 | 7025961 | 11404 | 851000 |
| South Korea | | | 510 | 342097 |
| Spain | | | 4216 | 5712875 |
| UK | 244 | 157000 | | |
| Austria | 1600 | 71078 | | |
| Japan | 6 | 4100 | | |
| Switzerland | 6868 | 7335360 | | |
| France | 270 | 98500 | | |
| Lebanon | 18489 | 1406000 | | |
| **TOTAL** | **891,578** | **178,607,744** | **95,548** | **12,712,571** |

**Table (4): Imported Solar Collectors & SWH systems in 2008**

| Country | 8419.90.10 (collectors) | | 8419.19.00 (SWH systems) | |
|---|---|---|---|---|
| | Weight [kg] | Value [S.P] | Weight [kg] | Value [S.P] |
| European Market | 214866 | 63546979 | 1780 | 746916 |
| China | 2141173 | 136992241 | 202211 | 15163889 |
| Germany | 44046 | 2462838 | | |
| Greece | 20080 | 3131000 | | |
| Italy | 20 | 9000 | | |
| Taiwan | 33 | 22000 | 3401 | 659258 |
| Turkey | 660892 | 67185403 | 26139 | 3528572 |
| South Korea | 97012 | 9485072 | 3369 | 527848 |
| Spain | | | 989 | 44513 |
| Portugal | 5000 | 131299 | | |
| India | 5855 | 9479014 | | |
| Jordan | | | 2086 | 6327 |
| Czech Republic | | | 10500 | 128954 |
| **TOTAL** | **3,188,977** | **292,444,846** | **250,475** | **20,806,277** |

**Table (5): Breakdown by year of Imported Solar Collectors & SWH systems (2005-2008)**

| Year | Collectors | | Systems | |
|---|---|---|---|---|
| | Weight [kg] | Value [S.P] | Weight [kg] | Value [S.P] |
| **2005** | - | - | 48,573 | 4,887,350 |
| **2006** | 283,742 | 178,584,724 | 78,309 | 5,426,545 |
| **2007** | 891,578 | 178,607,744 | 95,548 | 12,712,571 |
| **2008** | 3,188,977 | 292,444,846 | 250,475 | 20,806,277 |
| **TOTAL** | **4,364,297** | **649,637,314** | **472,905** | **43,832,743** |

**Table (6): Breakdown by Country of Imported Solar Collectors & SWH systems (2005-2008)**

| Country | Collectors | | Systems | | Total Weight [kg] | Total Value [S.P] |
|---|---|---|---|---|---|---|
| | Weight [kg] | Value [S.P] | Weight [kg] | Value [S.P] | | |
| EU | 660805 | 236446411 | 1852 | 750966 | 662657 | 237197377 |
| China | 2325506 | 146629072 | 368543 | 23832526 | 2694049 | 170461598 |
| Italy | 84495 | 111480437 | 578 | 75000 | 85073 | 111555437 |
| Turkey | 821480 | 80908908 | 53391 | 4958572 | 874871 | 85867480 |
| Germany | 222537 | 27161207 | 2556 | 1105520 | 225093 | 28266727 |
| Greece | 98205 | 15667222 | | | 98205 | 15667222 |
| South Korea | 97012 | 9485072 | 4789 | 1172445 | 101801 | 10657517 |
| India | 5855 | 9479014 | | | 5855 | 9479014 |
| Switzerland | 6868 | 7335360 | | | 6868 | 7335360 |
| Jordan | 9423 | 2891934 | 18270 | 4330077 | 27693 | 7222011 |
| Spain | | | 5205 | 5757388 | 5205 | 5757388 |
| Taiwan | 5788 | 223200 | 6311 | 1385795 | 12099 | 1608995 |
| Lebanon | 18489 | 1406000 | 800 | 35500 | 19289 | 1441500 |
| USA | | | 110 | 300000 | 110 | 300000 |
| UK | 244 | 157000 | | | 244 | 157000 |
| Portugal | 5000 | 131299 | | | 5000 | 131299 |
| Czech Rep. | | | 10500 | 128954 | 10500 | 128954 |

| | | | | | | |
|---|---|---|---|---|---|---|
| France | 270 | 98500 | | | 270 | 98500 |
| Austria | 1600 | 71078 | | | 1600 | 71078 |
| UAE | 714 | 61500 | | | 714 | 61500 |
| Japan | 6 | 4100 | | | 6 | 4100 |
| **TOTAL** | **4,364,297** | **649,637,314** | **472,905** | **43,832,743** | **4,837,202** | **693,470,057** |

**Table (7): Specifications of some evacuated tubes available in the local market**

| **Heat pipes imported from:** | | | | | |
|---|---|---|---|---|---|
| | **Germany** | | **China** | | |
| Number of vacuum tubes | 20 | 30 | 10 | 20 | 30 |
| Weight (inc. support frame), kg | 100 | 150 | 35 | 71 | 109 |
| **SWH system (evacuated tubes) imported from China** | | | | | |
| Number of vacuum tubes | 20 | | | | |
| Weight (inc. support frame), kg | 51 | | | | |

**Table (8): Extracted Total Number & Total Square Meter of Imported Flat-Plat Collectors & SWH Systems between 2005 and 2008**

| **Country** | **Collectors** | | | **Systems** | | | **Total $m^2$** |
|---|---|---|---|---|---|---|---|
| | **Total Number** | **Total $m^2$** | **Cost per Collector [S.P]** | **Total Number** | **Total $m^2$** | **Cost per system [S.P]** | |
| **EU** | 13216 | 26432 | 17890 | 9 | 36 | 81100 | 26468 |
| **Italy** | 1690 | 3380 | 65969?? | 3 | 12 | 25950 | 3392 |
| **Turkey** | 16430 | 32860 | 4925 | 267 | 1068 | 18574 | 33928 |
| **Germany** | 4451 | 8902 | 6103 | 13 | 52 | 86504 | 8954 |
| **Greece** | 1964 | 3928 | 7977 | | | | 3928 |
| **Switzerland** | 137 | 274 | 53402 | | | | 274 |
| **Jordan** | 188 | 376 | 15345 | 91 | 364 | 47400 | 740 |
| **Spain** | | | | 26 | 104 | 221225 | 104 |
| **TOTAL** | **38076** | **76152** | **24515*** | **409** | **1636** | **80125*** | **77788** |

*** Average value**

**Table (9): Extracted Total Number & Total Square Meter of Imported Solar Evacuated Tubes & SWH Systems between 2005 and 2008**

| **Country** | **Collectors** | | | **Systems** | | | **Total $m^2$** |
|---|---|---|---|---|---|---|---|
| | **Total Number of tubes** | **Total $m^2$** | **Cost per tube [S.P]** | **Total Number Of systems** | **Total $m^2$** | **Cost per system [S.P]** | |
| China | 775170 | 116275 | 189 | 6142 | 18426 | 3880 | 134701 |
| South Korea | 32337 | 4850 | 293 | 80 | 240 | 14690 | 5090 |
| India | 1952 | 293 | 4857?? | | | | 293 |
| Taiwan | 1929 | 289 | 116 | 105 | 315 | 13175 | 604 |
| Lebanon | 6163 | 924 | 228 | 13 | 39 | 2663 | 963 |
| **TOTAL** | **817551** | **122631** | **1137*** | **6340** | **19020** | **8602*** | **141651** |

*** Average value**