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Improving the Energy Efficiency of the Residential Buildings in Jordan

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Global Green Growth Week 2019
Unlocking Renewable Energy Potential
GREEN GROW Knowledge Partner

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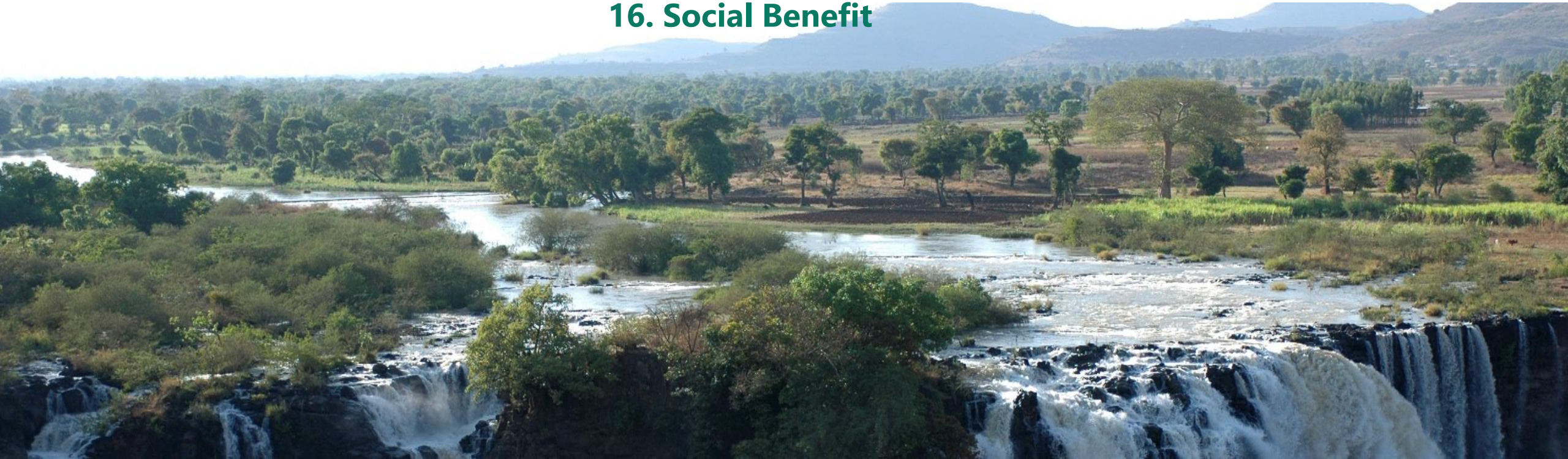

Introduction

- Jordan energy situation is extremely hard due to many reasons. Some of these reasons are listed below

a) High-energy demand rates. The demand for primary energy has increased from 2.4 million ton of oil equivalent (Toe) in 1982 to 7.5 million Toe in 2011

b) Lack of mineral and natural recourses. Jordan depends on imported fuel to meet its energy demand. Jordan's annual bill exceeds 20% of its GDP

c) Public debt that reaches 34 billion US $.

d) Refuges migration from surrounding countries because of armed conflicts.

Solutions

- Renewable energy projects consider as a solution to cover the energy demand.

- However, these projects are not effective as there are losses through the buildings. Heat gains and heat losses through the building envelope cause such high energy consumption.

- Improving energy efficiency of the building reduces both gains and losses through the envelope.

Energy Efficiency

- The objectives of improving the energy efficiency in building will result in

A) Less energy consumption while maintaining comfort level

B) saving energy and money.

Minimizing harmful emissions.

Jordanian Residential Sector

- the household sector accounts for the largest portion of the energy consumption.
- Therefore, it considered a promising field to reduce the total energy consumption.
- Applying efficiency measures on the buildings will reduce the wasted energy.
- Which in turn will reduce the reliance on the imported fossil fuel and reduce the energy bill.

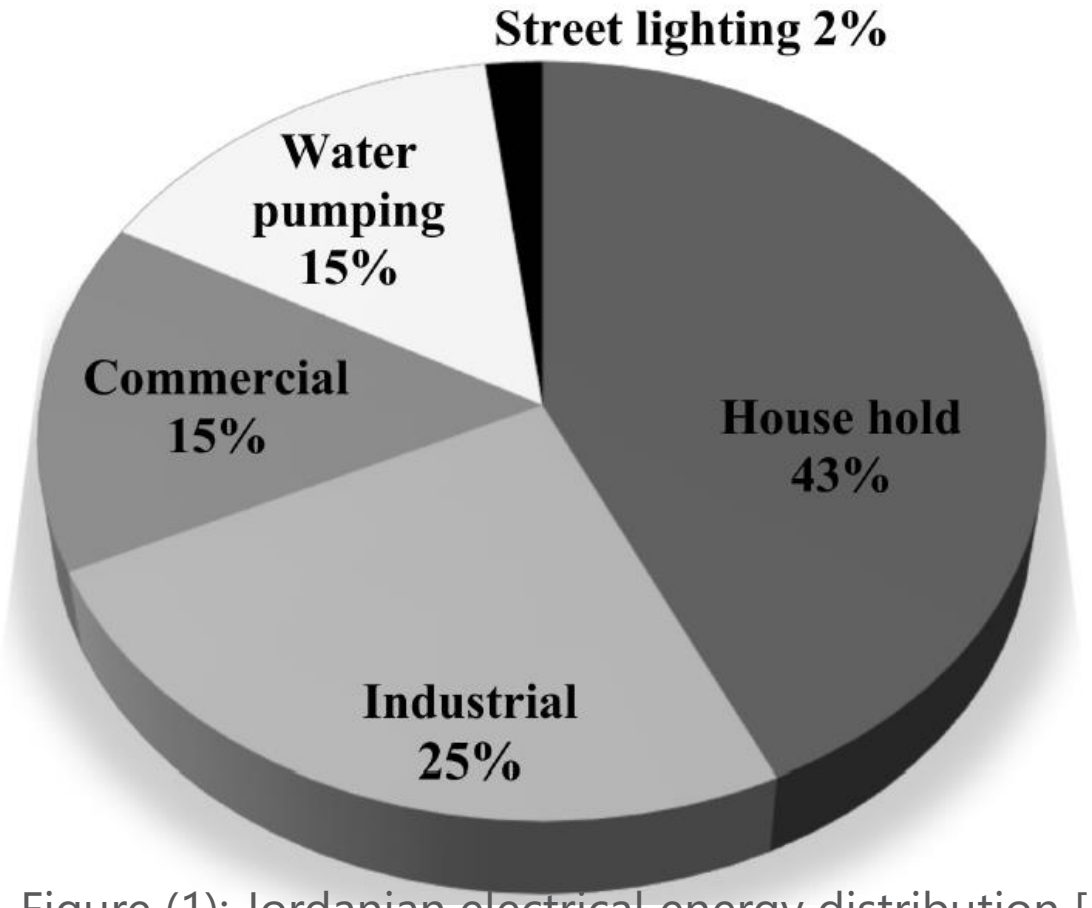

Figure (1): Jordanian electrical energy distribution [1]

Research Objective

- propose several effective energy conservation measures that reduce the total energy consumption of typical residential buildings under Jordanian climate conditions.
- Determine the energy consumption saving, peak demand saving, and harmful emission reduction.
- Determine the energy consumption profiles for each of the proposed measures.
- Determine The savings for each level to determine the cost-effectiveness of each stage.
- the total number of the job creation potential for each stage will be determined.

Methodology

- Three typical, existing residential building types were selected as case studies for this work.

- The energy used within the building was analyzed using DesignBuilder software.

- The simulation uses measured hourly weather data for various locations across Jordan.

Simulation models

- Simulation models for three typical existing residential building types are built according to current construction details, materials, and systems in the considered regions.

- These models are; traditional family house, five-story apartment with ten housing units, and two-story villa.

Table 1. Jordanian housing statistics [1]

Housing Type	Traditional Family House	Apartment	Two Story Villa
Number of houses	489,364	48,081	17,094
Floor area percentage	43.2%	54.3%	2.52%

The Building Characteristics

Table 2. Baseline buildings characteristics [1]

Building Model	Traditional House	Apartment	Villa
Number of floors	1	5	2
Total floor area	144 m^2	368 m^2	240 m^2
Wall (U value)	2.51	1.85	1.54
Roof (U value)	2.36	2.36	2.36
Glazing	Single clear	Single clear	Double clear
WWR	30%	30%	30%
Infiltration	1 ACH	0.6 ACH	0.5 ACH
Heating set point	21 °C	21 °C	21 °C
Cooling set point	23.5 °C	23.5 °C	23.5 °C
COP for cooling	2	2	2
COP for heating	1	0.8	0.8

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Energy-Efficient Retrofitting Strategies

- To improve energy efficiency in the three building types studied, retrofit programs that are divided into three levels were proposed.

- The idea behind dividing energy efficiency measure into levels is that the Money saved from each level will cover a reasonable portion from the cost of the measures in the next level.

These levels are divided based on their cost, the higher the level the more expensive it will be.

Retrofit program levels

Table 3. Proposed efficiency measures [1].

	EEM	Traditional House	Apartment	Villa
Level 1	Cooling set point temperature	24.5 °C	24.5 °C	24.5 °C
	Heating set point temperature	20 °C	20 °C	20 °C
	Lighting	60% reduction	60% reduction	60% reduction
Level 2 (level 1 retrofit program is included)	Roof insulation	6 cm polystyrene layer	6 cm polystyrene layer	6 cm polystyrene layer
	Shading	Overhang 1.5 m	Overhang 1.5 m	Overhang 1.5 m
	Wall insulation	4 cm polystyrene layer	4 cm polystyrene layer	4 cm polystyrene layer
Level 3 (level 1 and level 2 are included)	Glazing	Double, LOE, clear, 13 mm air	Double, LOE, clear, 13 mm air	Triple, LOE, clear, 13 mm air
	Heating COP		0.95	0.95
	Cooling COP	3.5	3.5	3.5

Individual measures impact

- To determine the impact of the individual efficiency measures on the total energy consumption, comprehensive parametric analyses have been performed.

- Table 6 shows the saving achieved from each measure for a villa located in Irbid, which is a mild climate region.

Table 6. Total energy saving for the individual measures.

Saving	Traditional House (%)	Villa (%)
Wall insulation	6.2	3.8
Roof insulation	11	6.3
Glazing	2.9	6
Shading	−0.4	3.7
HVAC COP	5	18.7
Lighting	12.7	10.9
Cooling set point temperature	3.4	1.6
Heating set point temperature	8.4	3.5

Insulation thickness impact

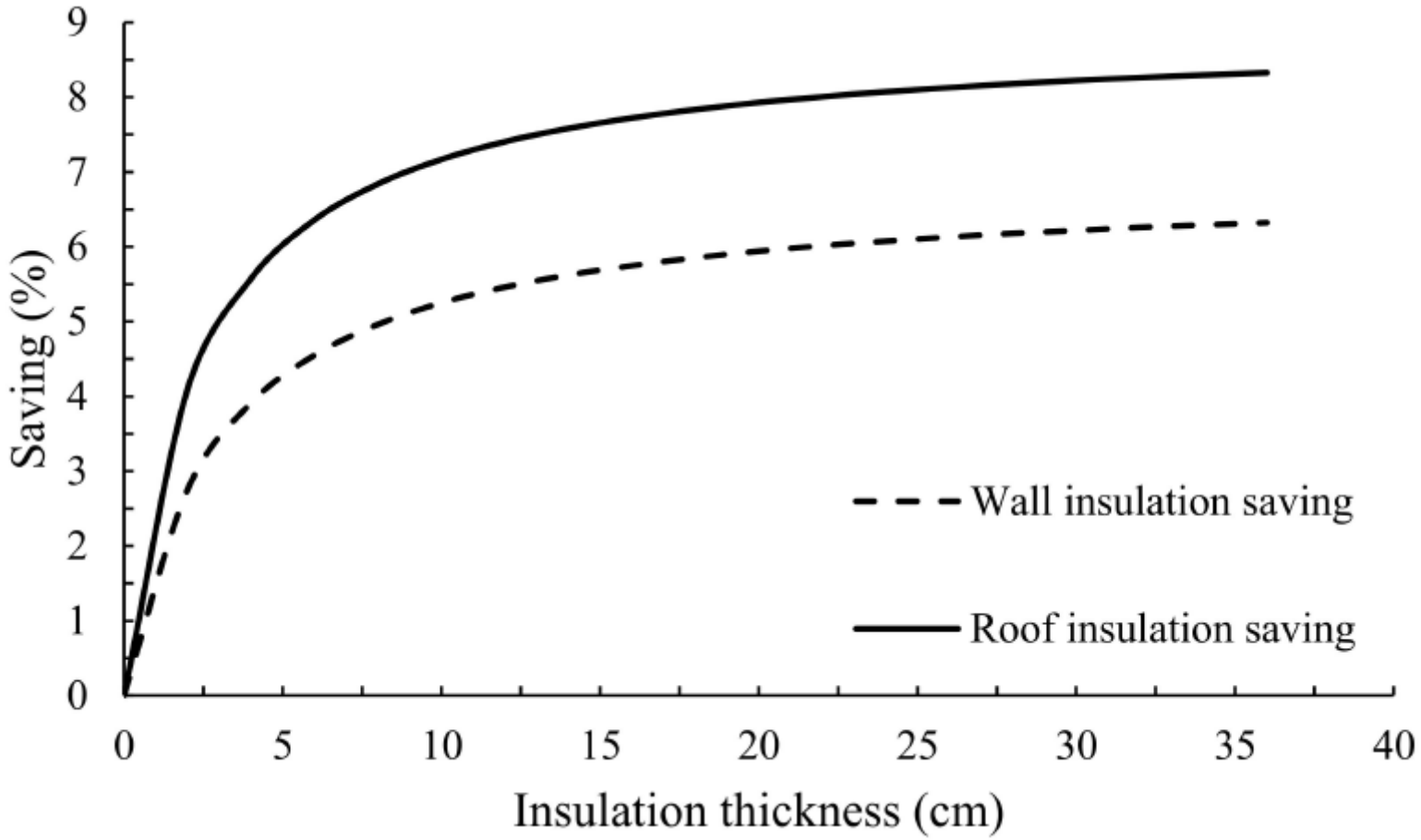

Figure 3. Insulation thickness effect (villa model) [1].

Economic and environmental evaluation

Table 7. Economic and environmental benefits for the suggested energy retrofit program [1].

Building Type	Base Level Energy Consumption (GWH)	Level 1	Level 2	Level 3	Saving (%)
		Retrofit Program Annual Energy Saving (GWH/year)			
Traditional family house	3353	764	1117	1169	34.8
apartment	3795	1099	1600	1932	50.9
Villa	562	92	183	266	47
Total	7710	1955	2901	3368	43.6
		Peak demand saving (MW)			
Traditional family house	838	191	279	292	34.8
apartment	949	274	400	483	50.9
Villa	140	23	46	66	47
Total	1927	489	725	842	43.6
		Annual CO_2 savings (Kilo-tons/year)			
Traditional family house	2152	523	766	801	37
apartment	2300	738	1050	1226	53
Villa	334	59	115	162	48
Total	4787	1321	1931	2190	46

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Cost effectiveness analysis

levels one and two of the retrofit program are highly cost-effective when implemented on buildings. Payback periods for level three are found to
be long for the traditional house due to the high estimated costs of the energy efficiency measures.
Such a high payback period is due to capital investment with low money saved in the traditional
house. Low money saved is due to low energy consumption in the model compared to the other
models (3-story apartment and 2 story villa).

Table 9. Cost effectiveness analysis for the suggested levels in Jordan.

Retrofit Program	Level 1	Level 2	Level 3
Payback period (year)			
* Traditional family house	0	13.9	18.58
* 5 store apartment	0	4	9.4
* 2 store villa	0	3.3	13.9

Social Benefit

An average of 17 jobs will be created per 1 million of investment in energy efficient buildings

Table 10. Number of job creation [1].

	Job Opportunities		
	Level 1	Level 2	Level 3
Traditional house	1877	28,593	40,896
Apartment	2598	8682	33,303
Villa	218	1391	6570
Total	4693	38,667	80,769

Thank You

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