Civil Engineering Research

SUSTAINABILITY AND ZERO ENERGY BUILDING

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Content of this Research

WHAT IS SUSTAINABILITY?

➢ Abstract

The impact of existing buildings on the environment is on the rise; thus, to achieve environmental sustainability requires sustainable upgrade (SU) of existing built facilities. Over the years, SU has focused on technologies with little attention given to the nature and conditions of existing buildings. The purpose of this paper is to identify existing building characteristics that impact SU. A detailed literature review on the nature and characteristics of existing buildings, as well as energy and environmental performance was undertaken. A survey questionnaire with all the determinants of existing buildings was administered to sustainability and construction professionals in Kurdistan. The results show that size of building, age of building, U-value of wall, U-value of ceiling, area of external wall, thickness of insulation materials, occupancy, size of window opening, life span of sustainable technologies, and the type of building impact sustainable upgrade of existing buildings for energy efficiency.

➢ What is the Sustainability?

The ability to meet the needs of the present without compromising the ability of future.

The Sustainable Concept will be using the following terms:

1. Green Principle - 3Rs – Reduce, Reuse, Recycle
2. Recycle
3. Carbon Footprint - (GHGs), Carbon dioxide CO2,
4. Methane (CH4) and Nitrous oxide (N2O)
5. Renewable Energy
6. Eco-Labeling - standard setting, certification, and marketing

➢ Carbon Footprints

Climate change is increasingly a health emergency. This has been recognized by the NHS which aims to be carbon net zero by 2040. Most of the carbon footprint of radiotherapy is due to patient travel. Here we investigate if satellite centers can help reduce this impact. The carbon footprint of construction was estimated using two different methods. The post codes for 49 patients and 21 staff were collected and the distance to the satellite center and main center determined. The carbon footprint from each of these aspects was combined to determine how many years it would take for the reduced patient travel to offset the construction of the satellite center. The mean carbon footprint of travel to the satellite center and main center were 116.0 kgCO2e and 176.2 kgCO2e respectively. The carbon footprint of building the satellite center was between 1103 tCO2e and 618 tCO2e, meaning it would take 5.6 – 10.0 years to offset the embedded carbon footprint of the new building. For the first time this study has estimated the carbon footprint of building a satellite radiotherapy center and how this, through reducing patient travel can lower the carbon footprint of the service within a decade. This work may help those wishing to sustainably improve service provision.

Problem Statement

How to Reduce Energy Consumption at our Homes?

Mitigating building energy use and carbon emissions in the buildings sector is a globally recognized goal. This is being pursued through the adoption of zero-energy building (ZEB) targets, with formal government regulations and policies actively embraced in domestic marketplaces.
However, building assessment methods used for the ZEB certification system have garnered substantial critique from building energy engineers and practitioners for their practical applicability. This study investigated energy consumption patterns of single-family residential buildings, focusing on two major energy end-use categories: lighting- and plug-loads.
Empirical analyses and field measurement data were used to construct representative profiles of lighting and plug loads, as well as power density values, based on data from existing residential buildings.
These distinct profiles of lighting and plug loads were used as input data for a residential ZEB evaluation.
A whole-building energy simulation model was developed to conduct annual building energy analyses and assess ZEB certification based on the set and applied load profiles.
Results showed that building energy consumption could vary by up to 23% based on different lighting load patterns and by as much as 58% for differing plug load patterns.
These findings underline the importance of refining the current domestic ZEB certification process by considering the influence of diverse domestic load profiles on energy consumption and building certification grades.

- Scope of the study

To Build Home and other living facility using more Insulation technique.

- Relevance of the study

The Long-term advantages will impact the Energy Consumption

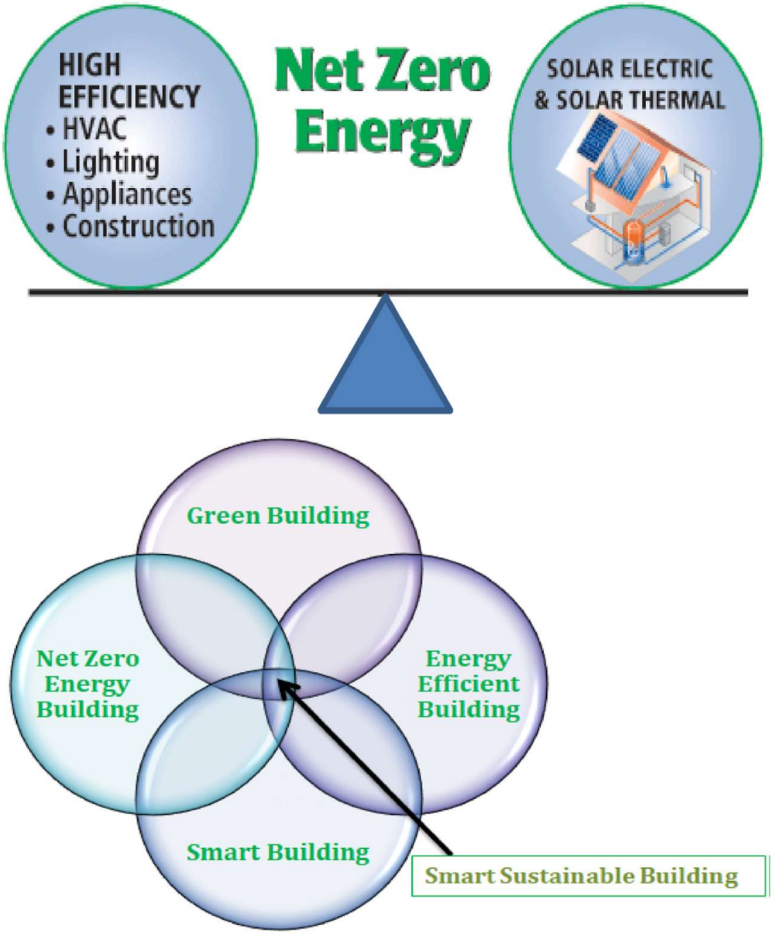
- Research Questions

How to construct Building Walls, Roofs and etc.?

Framework

Zero Energy Building - Engineering Solution

The absence of traditional sources of energy currently promotes the development of Net Zero Energy Buildings (NZEBs). The general definition of net zero energy construction is very critical to grasp. The aim of the paper is to overview the literature on the existing NZEB to make them self-sustaining and net zero in order to improve energy efficiency of the buildings. If enough renewable energy could be used, NZEB could potentially be achievable with power production. Furthermore, different building-service systems utilizing renewable energy sources have been extensively investigated for possible uses in NZEB. The paper gives the detail of its climatic condition in various part of the world along with their consequences and its impacts. The NZEB concept will significantly define the demand and supply strategies for renewable energies and conversion accounting to achieve a NZEB target along with its renewable energy evaluation. Buildings account for a large proportion of the world's total energy and carbon emissions, and play an important role in formulating strategies for sustainable growth. To this end, smart systems implement applications with numerous and interdisciplinary features. Here, the paper gives a detailed literature review on NZEB.



Zero Energy Building - Engineering Solution

- What is Zero energy building?

The term net zero refers to the balance between the amount of produced greenhouse gas and the amount removed from the atmosphere.
The term Net Zero Energy Building (NZEB) are characterized as zero net energy consumption buildings i.e. the total sum of energy used annually by the buildings is approximately equal to the total sum of the renewable energy produced on site. Recently, the idea of NZEBs, has changed from the study to practice. There are only a limited number of highly productive builders at present. The construction of NZEBs is becoming more and more feasible owing to advancements in building technology, renewable energy systems and academic research.
It is hard to locate a building that can be considered the first NZEB.
One of the explanations may be that NZEBs might not be a new idea for a building, but just a modern term for houses.

However, few publications appeared in the late 70s and early 80s, in which phrases 'A zero energy home or an autonomous energy house' or an "energy-independent house" has been used. This was the moment when the oil crisis had its consequences, the problem of fossil fuel sources and energy usage has
begun to be discussed.

A net zero energy building can be defined as a building:

1. In which total amount of energy used is equal to amount of renewable energy created on the site.
2. Means to reduce carbon emissions.
3. Reduce dependence on fossil fuels.
4. Buildings that produce a surplus of energy over the year are called "Energy Surplus Buildings".

Zero Energy Building - Engineering Solution

- VARIOUS RENEWABLE ENERGY ARE USED

SOLAR ENERGY

WIND ENERGY

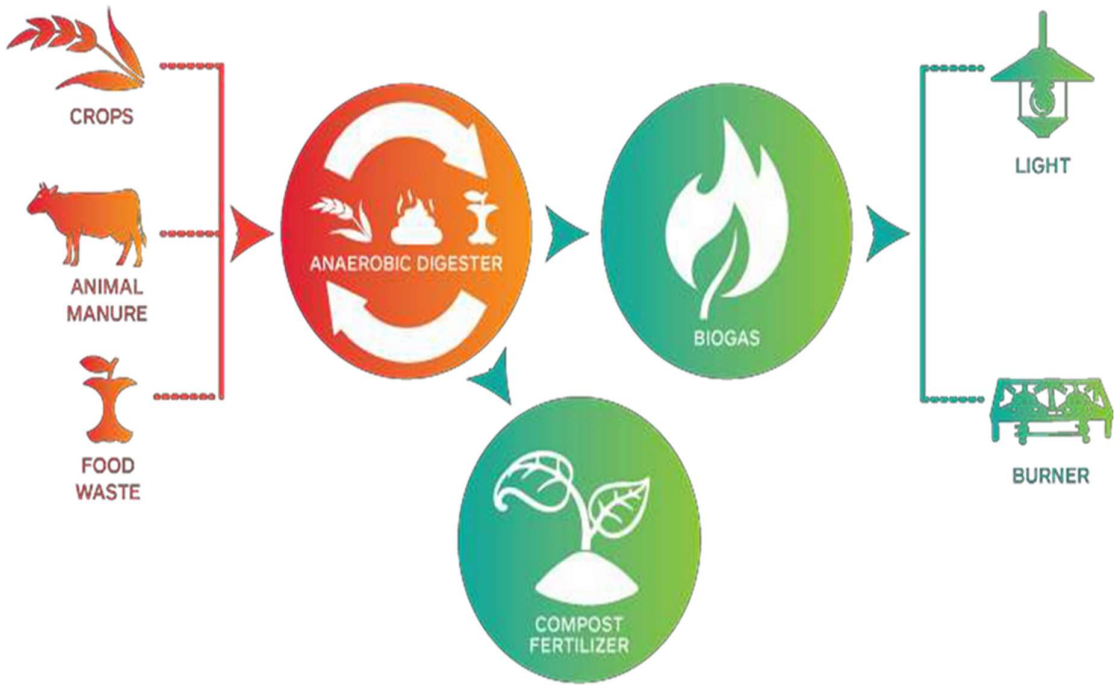
Zero Energy Building - Engineering Solution

- VARIOUS RENEWABLE ENERGY ARE USED

- What is Biogas?

Biogas is fuel gas made from biomass, either by decomposition or chemical processes. Biogas is 50% to 75% methane, while the remaining percentage is carbon dioxide and traces of other compounds.1
When it is reduced to nearly pure methane, biomethane can replace fossil fuel-based "natural gas" for electricity generation, transportation, heating, and home cooking. In the United States, nearly all biogas is produced for use in electricity generation.2

Natural organic matter such as crop residues, animal manure, as well as forestry and wood processing waste, are broken down in biodigesters, which use anaerobic (oxygen-free) digestion to produce biogas. Biogas can also come from recovering methane from landfills and from wastewater treatment plant sludge.

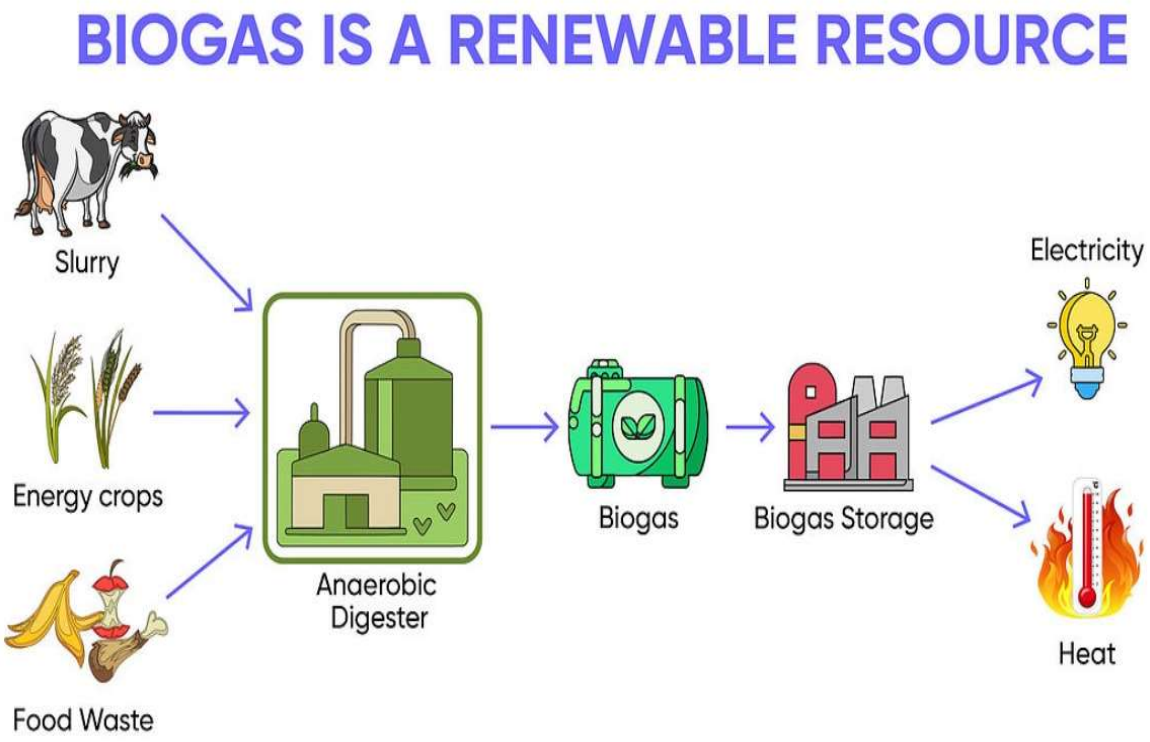


Zero Energy Building - Engineering Solution

➢ VARIOUS RENEWABLE ENERGY ARE USED

Biogas

- It is the most suitable energy resource as per environmental concern.
- Suitable for rural areas where plenty of organic and inorganic wastes are available, no proper discharging channel is not available.

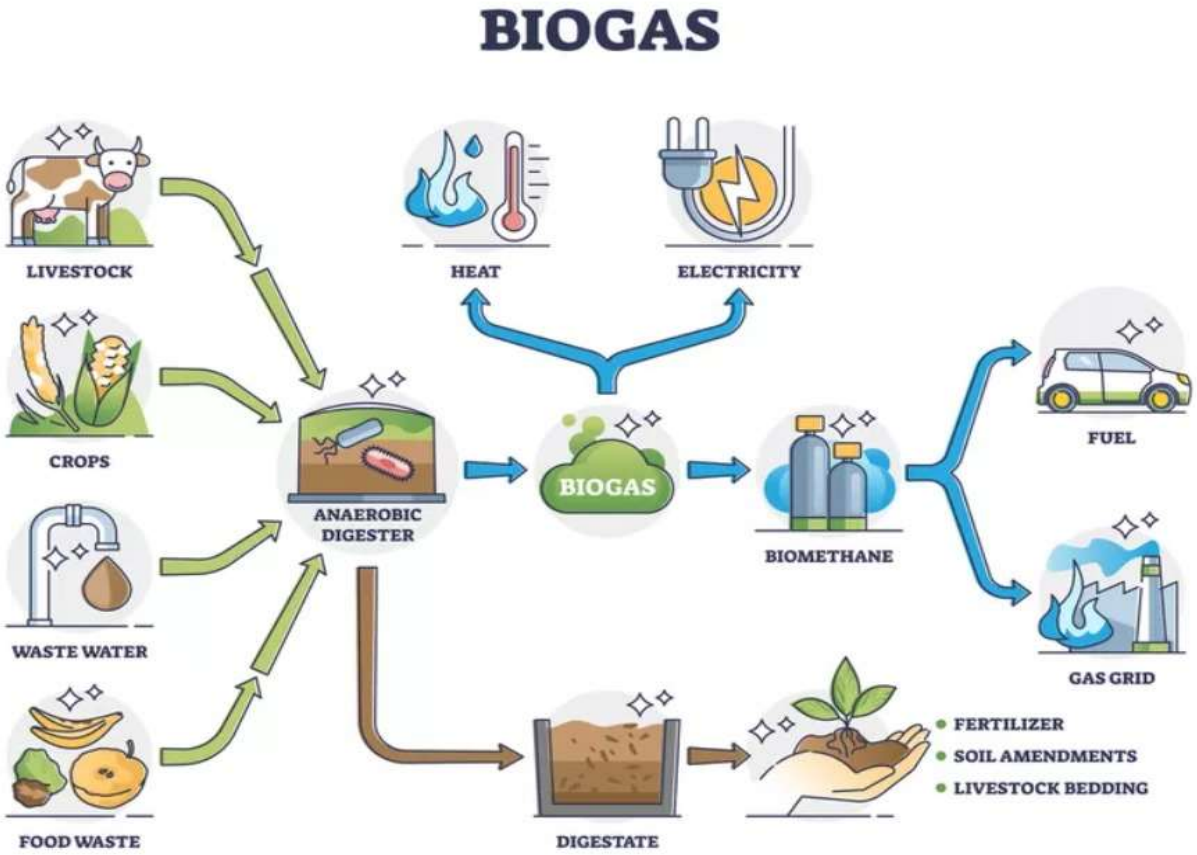


Zero Energy Building - Engineering Solution

- VARIOUS RENEWABLE ENERGY ARE USED

- What Is Anaerobic Digestion?

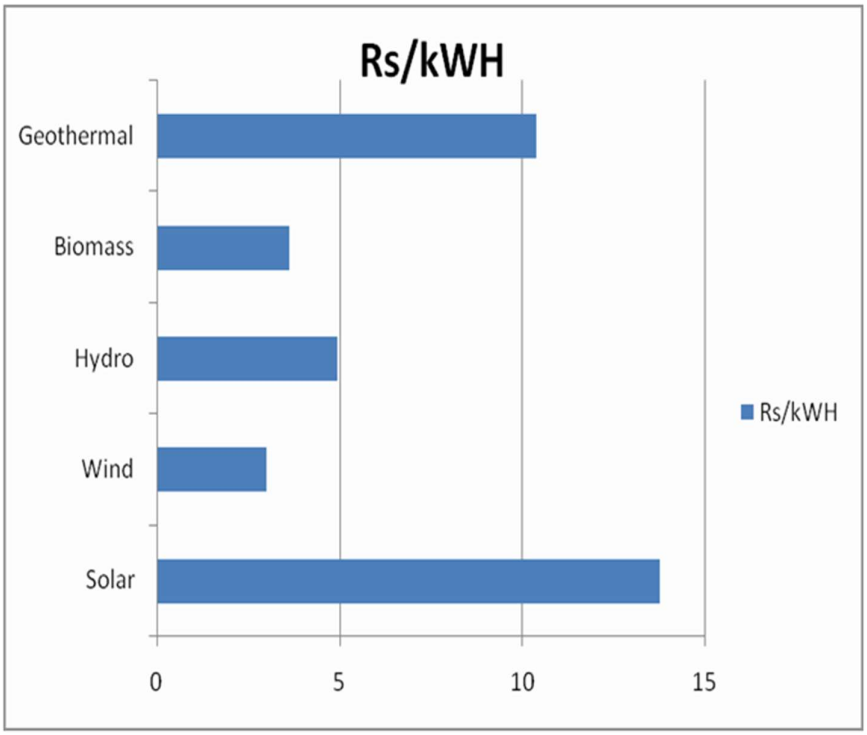
Anaerobic digestion uses microorganisms to break down biological material without oxygen. It is a multi-step process: Bacteria turn organic material into soluble derivatives, which are broken down by other bacteria into simple sugars, amino acids, and fatty acids. Then, they are converted further into acetic acid, ammonia, hydrogen, carbon dioxide, and other compounds, then finally into methane, carbon dioxide, and other trace compounds.



Zero Energy Building - Engineering Solution

- VARIOUS RENEWABLE ENERGY ARE USED

COMPARISON BETWEEN VARIOUS RENEWABLE ENERGY SOURSES

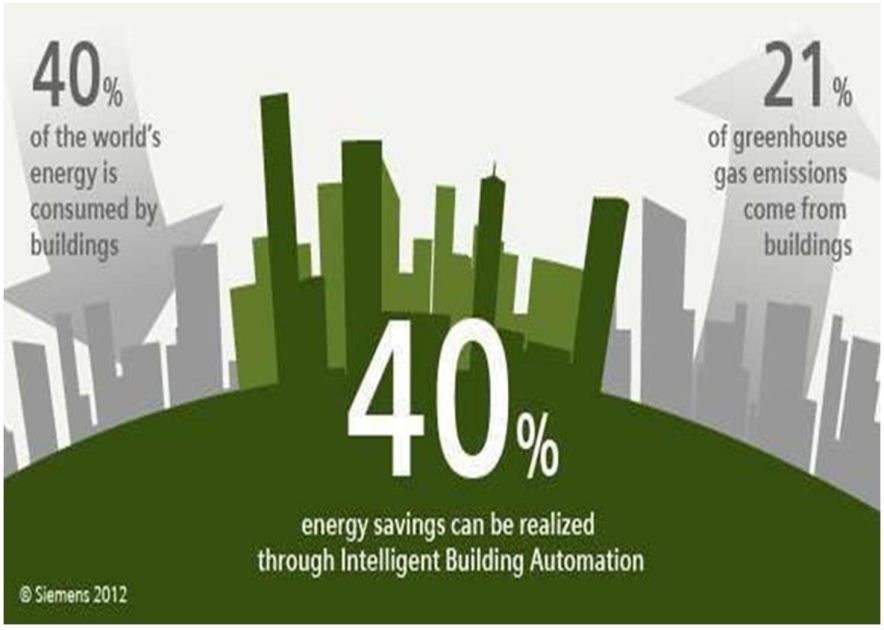


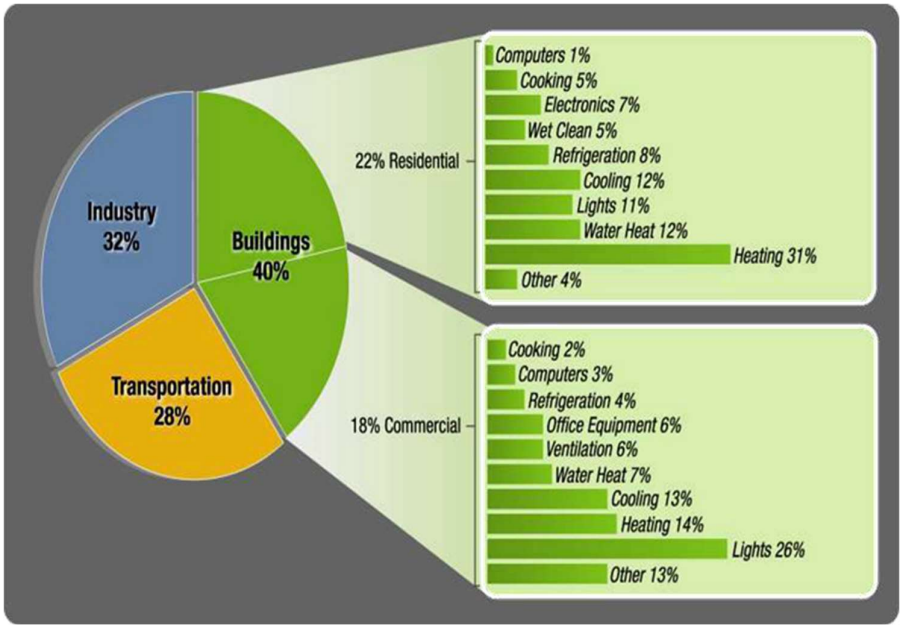
- ✓ Economical comparison shows that wind energy is most economical amongst all renewable resources mentioned in the graph.

Methodology

Building is the largest energy consumer

Buildings are a major primary energy consumer in the world energy sector, with a value of about 40% of total energy consumption.





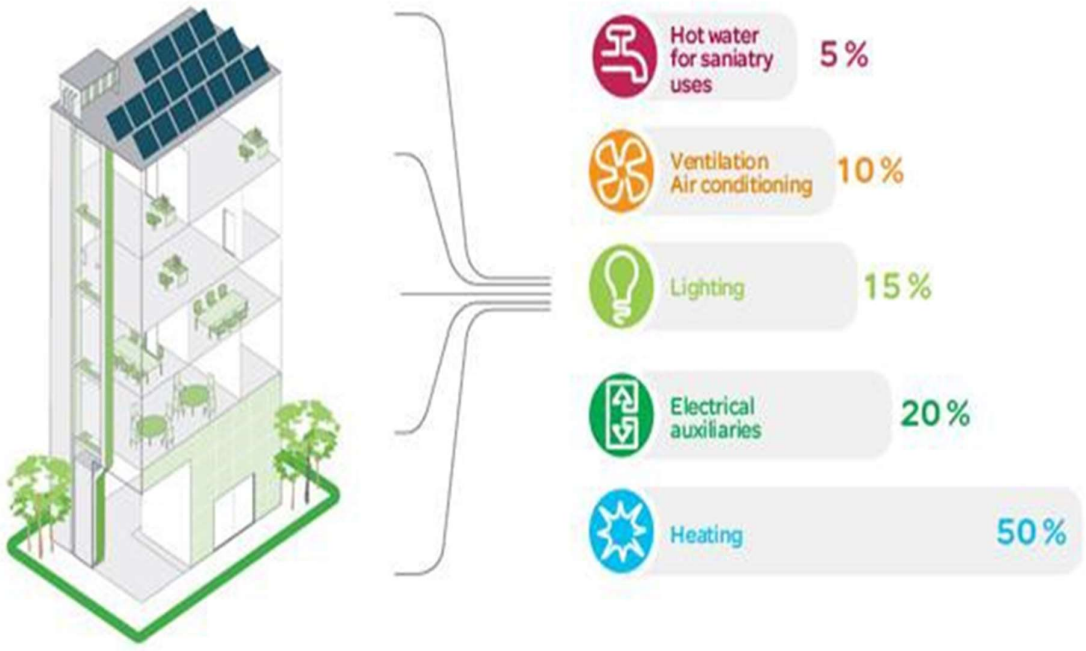
Building is the largest energy consumer

Buildings are a major primary energy consumer in the world energy sector, with a value of about 40% of total energy consumption.

- Building Envelope & Energy

Glazing and Facade Systems have:

- Large impacts on all aspects of building performance.
- Building shell, fabric or enclosure >> boundary between the conditioned interior of a building and the outdoors.

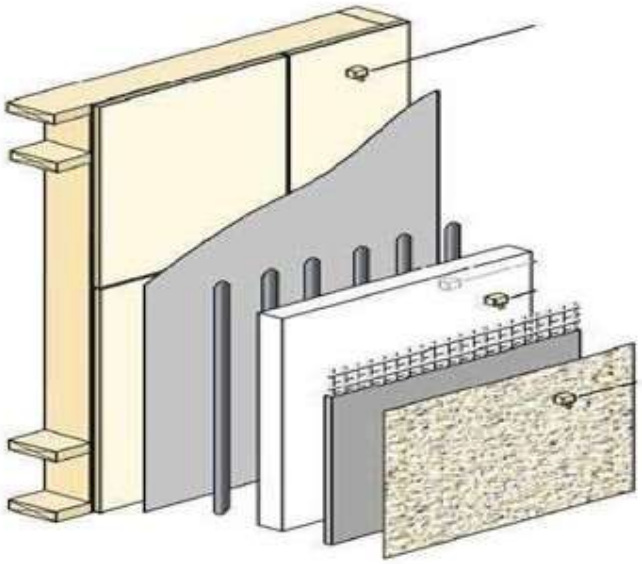


Building is the largest energy consumer

- Ways to Save Energy

There are several ways to reduce energy consumptions of the building, the most effective parts will be that included in the design of building at the start or the modification can be applied for the existing homes.

ROOF GARDEN



THERMAL INSULATION OF WALLS

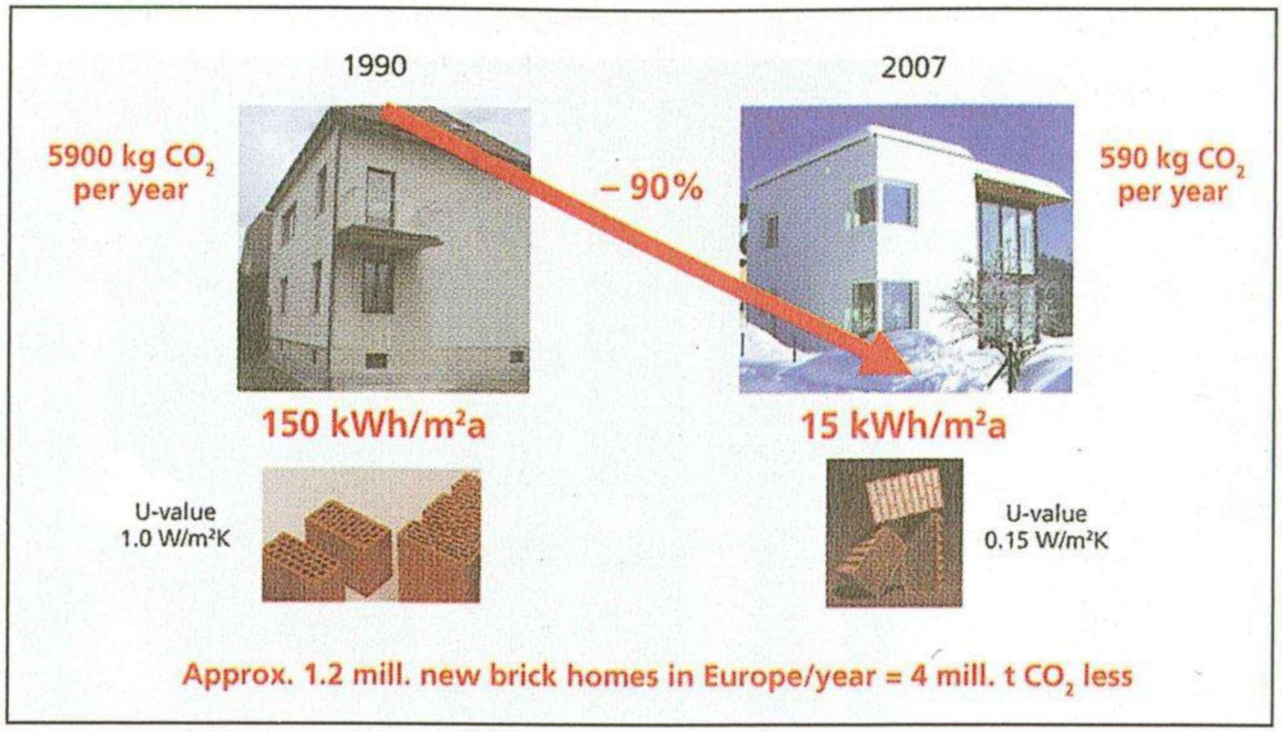
Building is the largest energy consumer

➢ The trend in thermal insulation

In the last 20 years the demand for thermal insulation of the building in Europe has been drastically reduced and apply ENERGY CERTIFICATES for HOUSING. Class A-B-C-D.
New products have been introduced with higher thermal insulating properties.
Globally the focus is on Zero-Energy Buildings (ZEB)-Requiring zero energy consumption.

As shown in the below picture in year 1990 by using clay brick have thermal conductivity value (U-value of 1.0 W/m²K) for walls, the house will consume 150kWh/m²a of energy and 5900 kg of CO_2 emission per year.

While the improving of thermal conductivity value (U-value) for 0.15 W/m²K have impact of 90%.

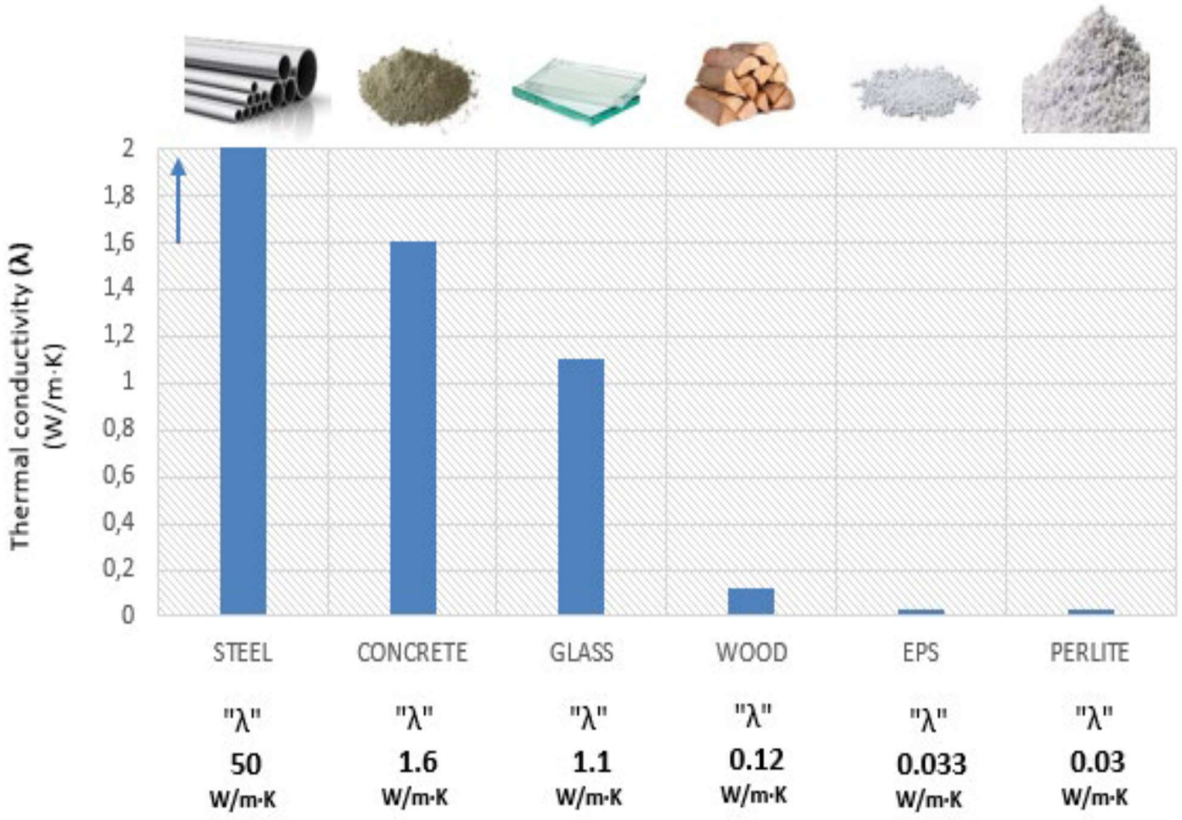


The Picture shows a study from GREECE (SABO Brick Company)

https://www.sabo.gr/

Building is the largest energy consumer

- Insulation parameters



1. Lambda value/ Thermal conductivity coefficient – λ (W/m·K)
2. Thermal conductivity – U (W/m2·K)
3. Thermal Resistance – R (m2·K /W)

- High Insulation requires:

1. Low λ or K-Value:
   Lambda value - thermal conductivity coefficient –λ (W/m.K)
2. Low U: Thermal conductivity –U (W/m2·K)
3. High R: Thermal Resistance –R (m2·K /W)

Building is the largest energy consumer

➢ Thermal Conductivity of Materials

The heat transfer characteristics of a solid material are measured by a property called the thermal conductivity, k (or λ), measured in W/m.K. It is a measure of a substance's ability to transfer heat through a material by conduction. Note that Fourier's law applies for all matter, regardless of its state (solid, liquid, or gas), therefore, it is also defined for liquids and gases.

The thermal conductivity of most liquids and solids varies with temperature. For vapors, it also depends upon pressure

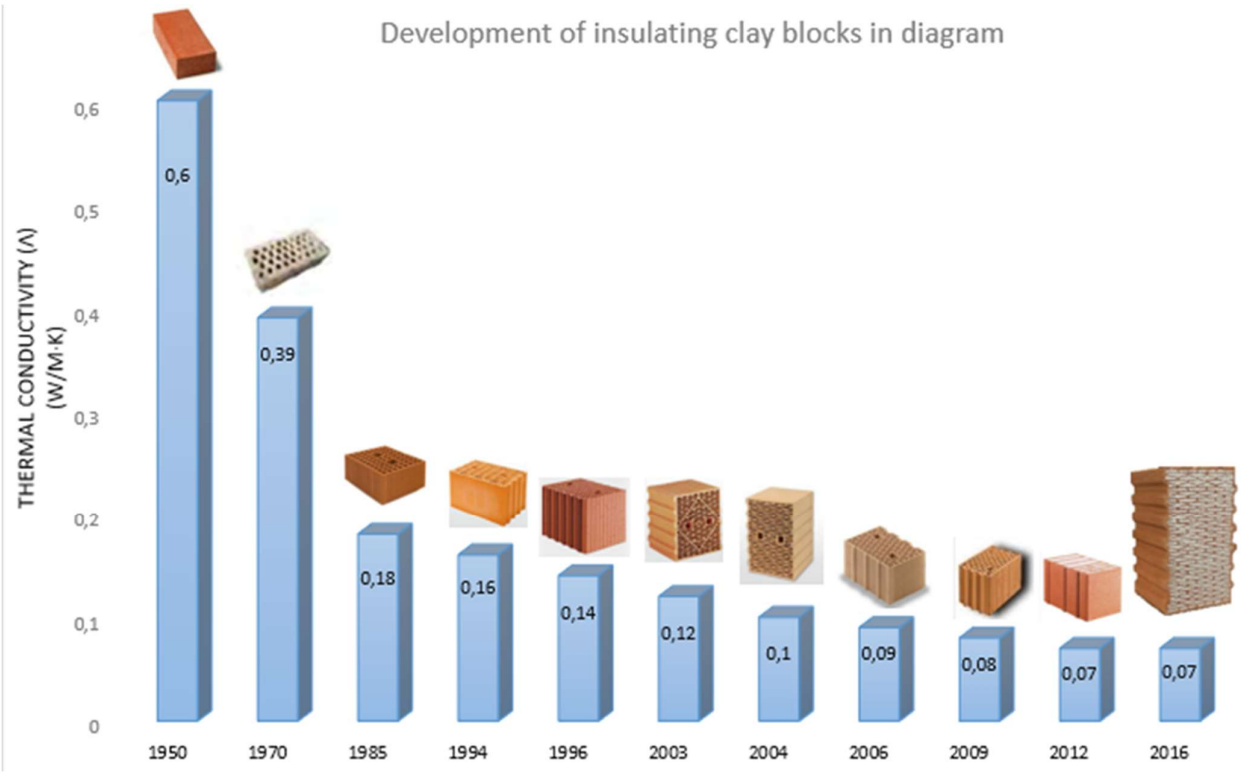
Thermal conductivity of materials

Material	Thermal Conductivity (W/m K)
Brickwork	0.77
Concrete - high density	1.93
Concrete block - lightweight aggregate	0.57
Glass	1.022
Plaster lightweight	0.18
Insulation mineral wool batt	0.038
Insulation polyurethane board	0.025
Steel - mild structural	60
Timber - softwood	0.13
Tiles - clay roof	1.0

https://material-properties.org/thermal-conductivity-of-materials/

THERMAL INSULATION OF WALLS

- The development of insulating blocks

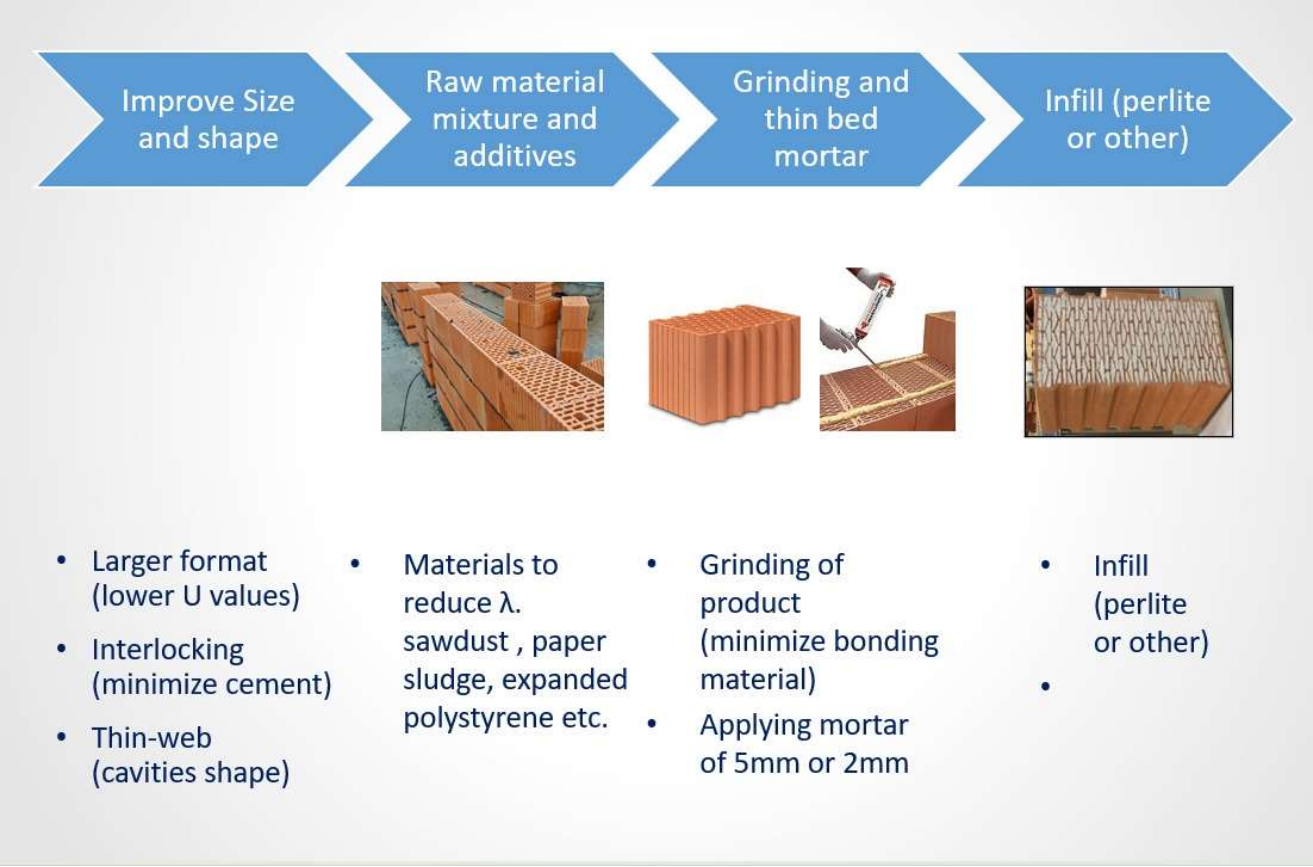


- Clay Blocks are good thermal insulation option for Walls

- Concrete blocks provide very little insulation. Concrete blocks have poor thermal resistance. Therefore, they do not effectively trap heat. As a result, concrete blocks without any other forms of insulation will not provide sufficient insulation for most structures.

THERMAL INSULATION OF WALLS

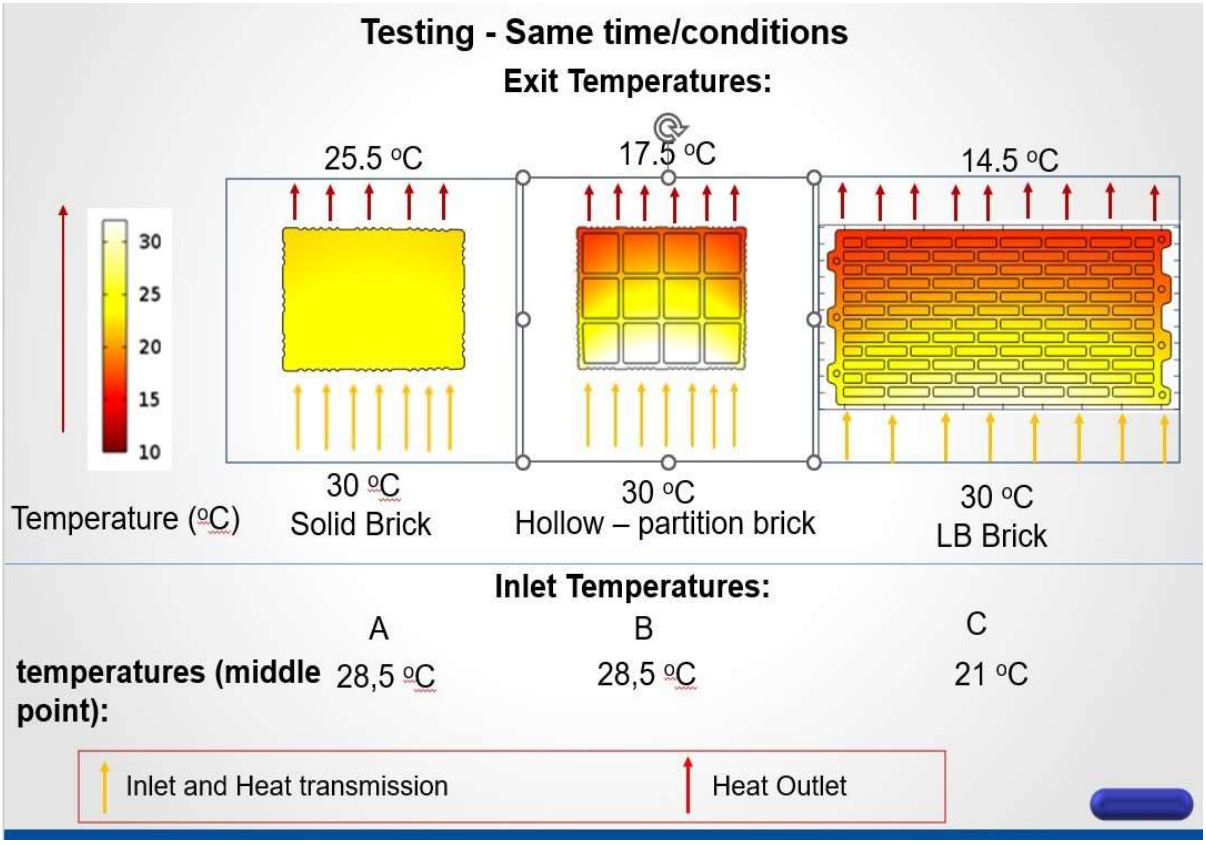
➢ Steps for improving energy saving

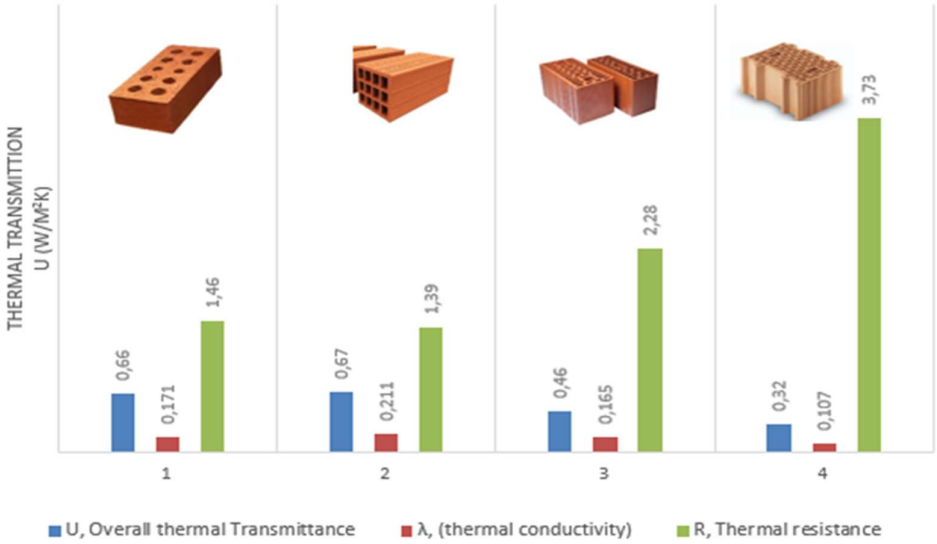


Sustainable Energy Fund (SEF) office building Schnecksville, Pennsylvania.

THERMAL INSULATION OF WALLS

- Design & shape has Impact on thermal transmissions





THERMAL INSULATION OF WALLS

➢ What Can We do in Kurdistan to save Energy?

1. Improving Traditional way in the Building Construction
2. (Replacing Old Building Materials)
3. External & Internal Wall:
4. At least the External Wall need improvements
5. (It is better to include Internal Wall also)
6. Concrete Block leads to more Energy Loss when it is used as an essential item in the building construction

➢ Masonry wall Alternatives:

1. Clay Brick Block
2. Light Weight Concrete Block
3. Thermo-stone Block
4. Ponzza Block

Practical Solution to save Energy in Kurdistan

- At least the External Wall needed improvements

Construction of New Building (**Practical Case Study**)

Clay Brick Blocks used for external walls, while concrete blocks used for Internal walls.

Practical Solution to save Energy in Kurdistan

- At least the External Wall needed improvements

Construction of New Building (**Practical Case Study**)

Clay Brick Blocks used for external walls, while concrete blocks used for Internal walls.

Practical Solution to save Energy in Kurdistan

- Steps for improving energy saving

Rehabilitation of Existing Building (**Practical Case Study**)

Clay Brick Blocks used for wall over existing plastered concrete block for walls.

Practical Solution to save Energy in Kurdistan

- Steps for improving energy saving

Rehabilitation of Existing Building (**Practical Case Study**)

To improve the energy consumption of the house, insulation gypsum board (KNAUF) plus Styropor foam (Flin) are the materials used for finishing of the walls.

Practical Solution to save Energy in Kurdistan

- Steps for improving energy saving

Rehabilitation of Existing Building (**Practical Case Study**)

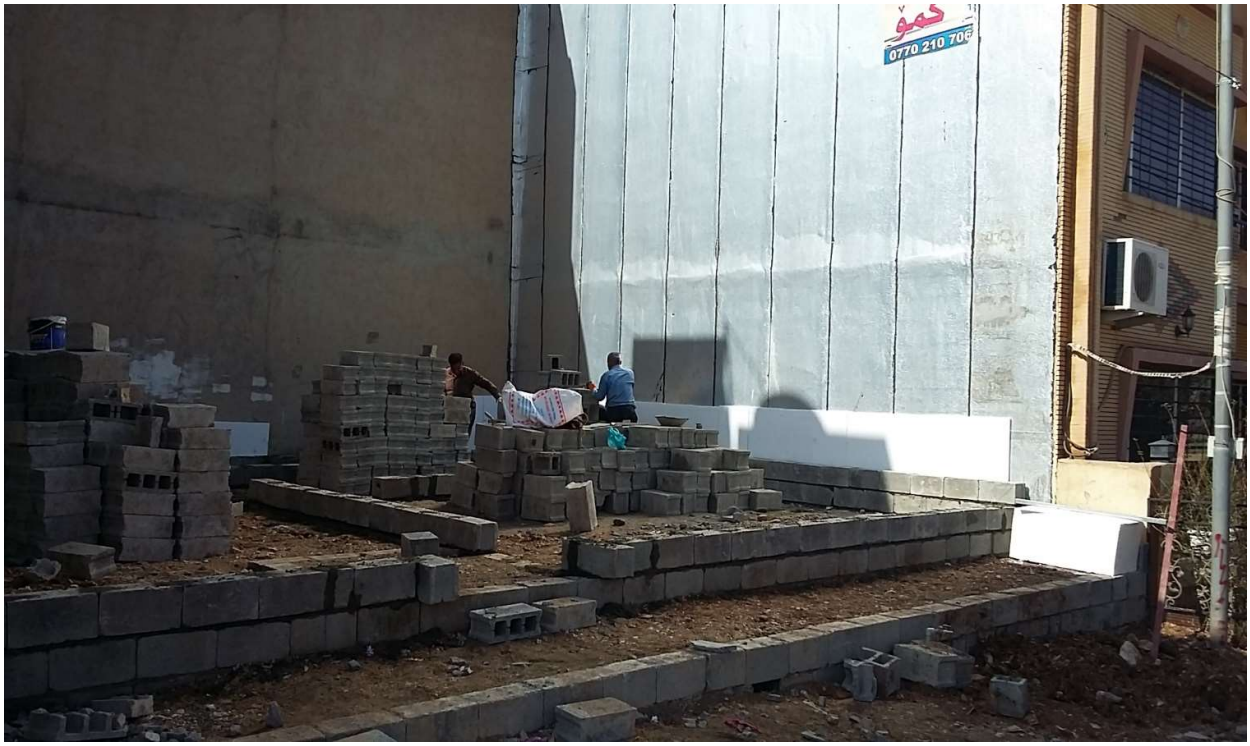
To improve the energy consumption of the house, insulation gypsum board (KNAUF) plus Styropor foam (Flin) are the materials used for finishing of the walls built by Concrete blocks.

Practical Solution to save Energy in Kurdistan

- Steps for improving energy saving

Keeping Adjacent Buildings Isolated During Construction

The Importance of Expansion Joints in two Adjacent Buildings are useful for isolation purpose and have very impact on insulation property of the house.



Insulation Techniques for new Building Construction
(**Practical Case Study**)

To improve the energy consumption of the house, insulation Styropor foam (Flin) used for isolation of the walls in the two adjacent buildings built by Concrete blocks.

Practical Solution to save Energy in Kurdistan

- Steps for improving energy saving

Insulation Techniques for new Building Construction
(**Practical Case Study**)

Practical Solution to save Energy in Kurdistan

- Steps for improving energy saving

Using Extruded Polystyrene (**XPS**) foam
for insulation from outside of the building

THERMAL INSULATION OF ROOFS

➢ Improving Traditional way in the Building Construction

- Solid Slab System (Concrete material is poor insulation properties)

Concrete slabs are a common feature in modern buildings, used as foundations, floors, and even walls. However, conventional concrete slabs lack proper insulation, leading to energy loss and increased heating or cooling costs. To address this issue, innovative thermal break designs have emerged, revolutionizing the efficiency of concrete slabs and promoting sustainable building practices.

The Problem with Conventional Concrete Slabs

Traditional concrete slabs without thermal breaks have limited capacity to resist heat transfer. This causes energy to escape through the slab, leading to unnecessary energy consumption and increased carbon footprint. With the rising focus on sustainable building practices, it has become crucial to find effective solutions to enhance energy efficiency in concrete slabs.

Practical Solution to save Energy in Kurdistan

➢ Thermal insulation for Slab Construction

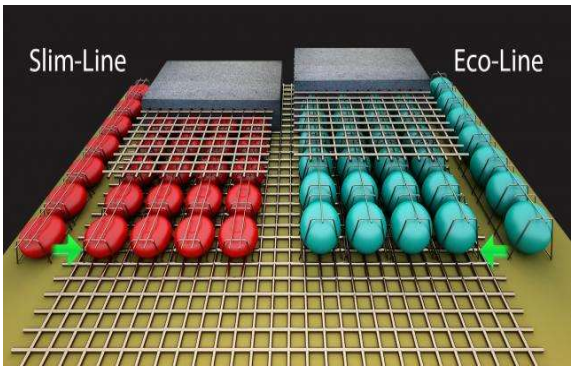
- Hollow Block Slab System

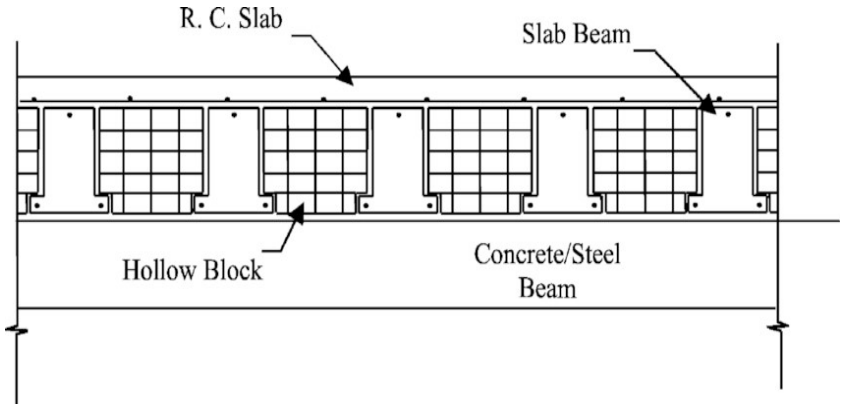
Hollow block slab is the most common type of ceiling in building systems around the world. Its most important features are that it provides sound and thermal insulation and is easy to implement.

It is used in halls and large rooms, as the distances between columns can reach 8 meters or more depending on the thickness of the ceiling and the depth and width of the fallen or hidden bridges.
It is the ideal choice for residential homes.

- Solid Slab Alternatives:

1. Hollow Slab System (Brick or Block).
2. Waffle Slab
3. Precast Concrete (Hollow-core slab)
4. COBIAX-Eco slab





Practical Solution to save Energy in Kurdistan

- Using Extruded Polystyrene (XPS) foam

Extruded Polystyrene (**XPS**) board easy to install during slab construction without any work cost

Practical Solution to save Energy in Kurdistan

- Using Extruded Polystyrene (XPS) foam

Practical Solution to save Energy in Kurdistan

- Hollow Slab System using Brick

  - This is where innovative thermal break designs come into play.

Hollow Block Slab System using clay brick blocks will prevents heat loss from the slab to the outside of the building, in the same time act as thermal break to cut away from entering heat or cold to the inside of the building.

Practical Solution to save Energy in Kurdistan

- Hollow Slab System using Brick

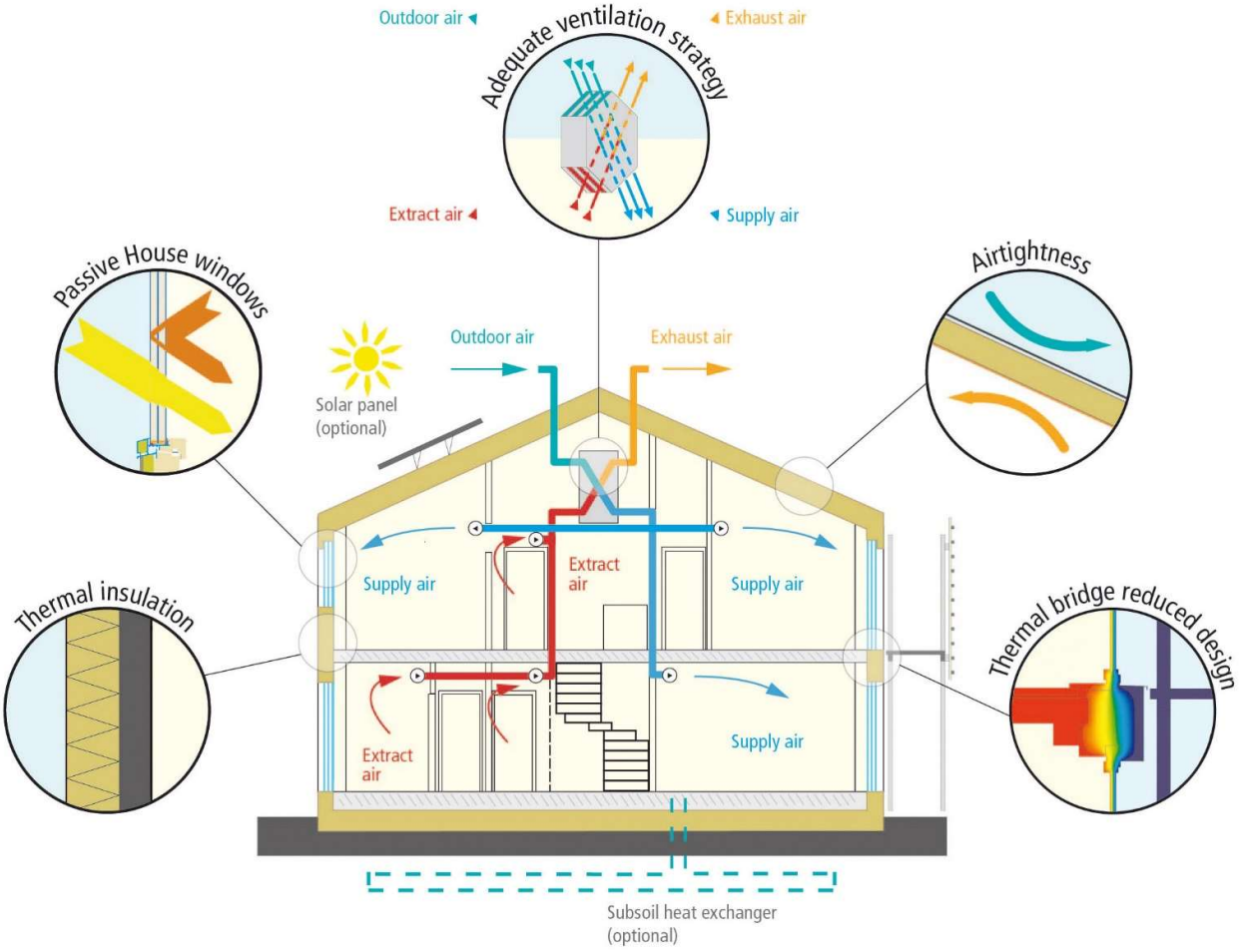
Practical Solution to save Energy in Kurdistan

Administration Building of Ashur Brick Company in Chamchamal district
External and Internal walls built by Iraqi standard Brick (Common Brick 24x11.5x7.5cm), Hollow block slab with bricks used in construction of Slabs

Proposed Solutions

Changing Traditional Building System

➢ Passive House Building System



Passive House Principles (Passive Elements)

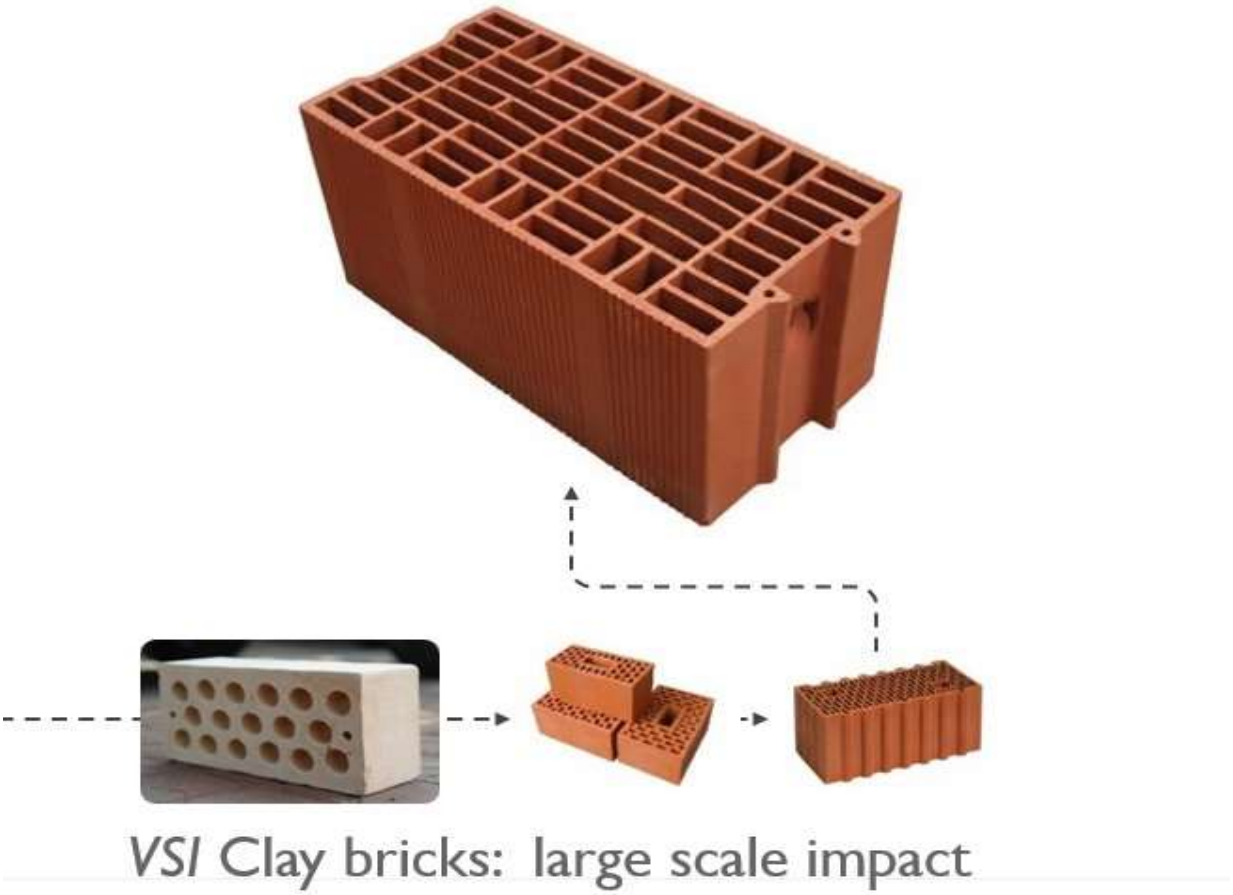
- Continuous Insulation
- No Thermal Bridges
- High Performance Windows + Doors
- Fresh Air with Heat Recovery
- Orientation + Form
- Daylighting + Solar Gain
- Moisture Management
- Efficient Water Heating + Distribution
- Shading + Airtight

Changing Traditional Building System

- Modern VSI Clay Bricks System

"Building Better" with modern VSI clay bricks, VSI clay bricks offer more comfortable housing and reduces construction cost and schedule, whilst helping the environment.

VSI: Vertical holes - Structural (load bearing) - heat Insulating



Use of modern VSI clay bricks reduces the consumption of steel, cement and formwork, can be used for five floors without concrete structure

Changing Traditional Building System

- Modern VSI Clay Bricks System

Research Analysis

➢ How to achieve the aim of this Research

- **Engineering Consultant Committee**

  This committee will be the higher authority in the city to develop new standard and regulation for building construction.

- **Rules and Obligation from Municipality**

  The Long-term plan to improve the new building construction, and modification for the existing houses will impact the Energy Consumption.

- **Real Estate Loan or Small funds**

  Through supports from Local government, peoples can build their homes by using better construction materials, this can be achieved by long duration loan “Real Estate Loan” or partial support by small funds to construct residential homes that stand with new developments in the world.

References and Resources

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- Personal Practical Experience more than 20 years in the field of Engineering Construction in the Kurdistan Region.

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