CONTENTS

INTRODUCTION

The most problems which face the world and the global earth we live on now days are energy, water and food resources. The reasons are the continue population growth, the limited energy resources and the global climate change due to global warming effect and also the change of the live style and human needs. The involved researchers and exports are busy to find alternatives for energy resources other than oil and natural gas such as sun energy, wind and green energy which produce less pollution than the first ones to be used in energy centrals.

This report deals with one of these issues which have more and absolute connection to the work of the planners and architects and the involved parties in the area of urban and buildings design and production. In the well-developed lands they started in the begin of the years seventies to enter recommendations and compulsory decisions and norms in the form of technical and engineering specifications to force the architects, contractors etc. to use insulation in all external walls and roofs, later they went further to use also more natural and sustainable building materials to reduce pollution which again results from materials which needs very long time to be dissolved and analyzed in nature.

If we take the economical aspect although it will add more initial cost to the building execution budget but at the end and through duration of time will bring more benefits by less consumption of energy and then not running up energy bills.

To achieve this goal engineers generally and architects specially have to take in consideration:

- *Orientation of the building by design*
- *Compact building , as much as possible less exposed surfaces*
- *Drawings and details, using good building materials, insulation, ventilation*

It is the duty and role of architects and engineers to create a good and a functional environment for the users of that space to live in comfortable and also economical in the aspect of energy consumption.

THE SCOPE AND REASON OF THIS RESEARCH

Since 2003 Kurdistan Region has seen an urban renaissance a lot of buildings and projects have been achieved. An renaissance with Massa production of residential projects as well as utilities projects but the problem is that there is no control without any engineering and technical specifications by the concerned parties and even by the engineers and the architects, the whole operation is irrational and abstractive happens, no planning, drawings and details, engineering and technical specifications, using new materials which are friendly to the nature. Simply this urban renaissance occurs not parallel to neither the normal procedure of achieving these projects and nor to capacity of the concerned parties.

I expect a lot of problems as a consequence of bad qualities of execution of these projects and maintenance of them.

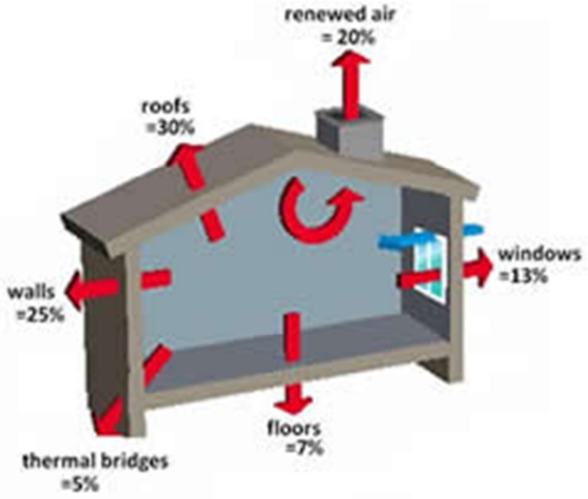
In this research and in the context of architectural interest, we will address the energy efficient building and rationalizing it as content.

ENERGY EFFICIENCY IN BUILDINGS

Buildings account for 40% of energy consumption in most countries, yet their potential for energy efficiency is huge. By using adapted insulation and energy savings techniques, up to 80% of a building's energy consumption for heating or cooling can be saved.

Reducing energy consumption in buildings through their better thermal insulation

In a building that is insufficiently or not insulated, heat flows through the roof or the façades thus leading to increased energy needs for heating (in winter) or for cooling (in summer).



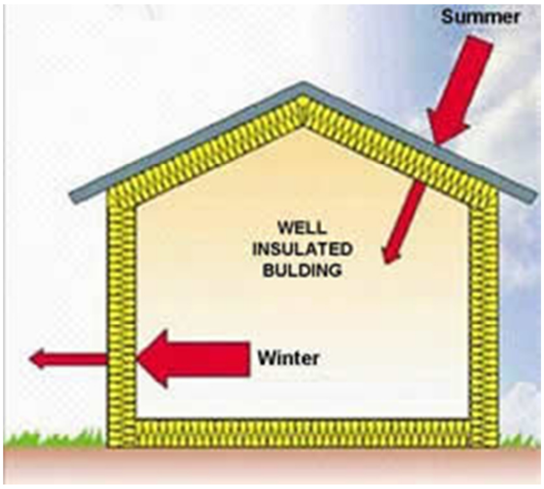


Figure 1

Figure 2

% of heat losses in a non insulated house

Properly fitted insulation helps provide a pleasant and stable indoor temperature both during cold winters and hot summers. In summer, good installed insulation will both keep out the cold and prevent the building from turning into a sweatbox. In winter, insulation will stop the heat losses through the roof or the façade and thereby reduces the energy need for heating.

WHERE TO INSULATE?

To obtain a thermally homogenous home and reduce heat losses properly, provide comfort in winter and summer, all surfaces in contact with the outside (roof, wall, loft) must be insulated.

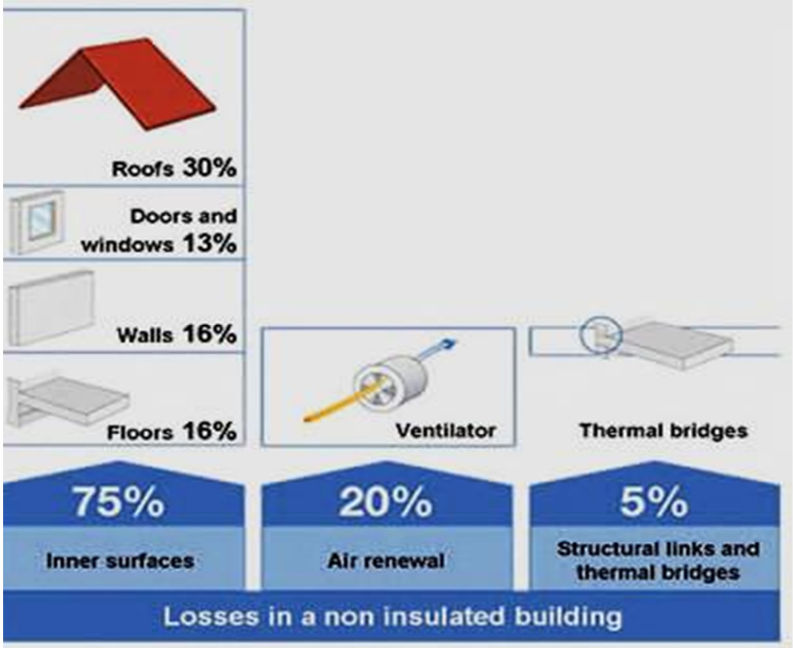
All walls and the roof in particular must be insulated

The thermal performance of insulation must be very high in the roof. In winter and summer, strong thermal resistance in the loft is essential.
In winter, losses are at their maximum through all opaque and glazed surfaces and structural links.
In the summer, direct sunlight on the walls and roofs - particularly exposed - can overheat the interior temperature.
The same goes for windows which need outside shutters, blinds, awnings, etc to deflect direct sunlight from the house

In a properly insulated home, heat transfers are reduced on all surfaces, both in summer and winter. Controlled mechanical ventilation optimises air renewal to keep losses down to a minimum.

Depending on the orientation, the size of windows and the occupiers' lifestyle, free energy through sunlight can represent up to 20% of energy consumption and reduce the heating bill accordingly.

Figure 3



THERMAL CAPACITY BEHAVIOR

Masses of masonry or water can be used to accumulate heat from solar collectors for release at night or on cloudy days. They can also serve to accumulate heat from electric resistance elements during off-peak hours when electric rates are lower, for use in heating the house during the rest of the day. Consider an exterior wall of a building that is constructed of a thick layer of a high-capacity material such as adobe, stone, brick, or concrete and is subjected to a difference in temperature between the outdoors and the indoors (Figure 4). The wall is warmed only slowly by the heat penetrating from the warmer side, as heat is absorbed in turn by each internal layer of the wall. Eventually a stable condition is reached in which the temperature of the colder side of the wall approaches the cold-side air temperature; the warmer side approaches the warm-side air temperature; and a straight-line gradient of temperature exists through the thickness of the wall. Until this stable condition prevails, the wall transmits heat from the one side to the other at a rate lower than what would be predicted solely from the thermal resistance of the wall. Once a stable condition is achieved, however, heat is transferred at the predicted rate. Because materials of high thermal capacity are characterized by low thermal resistances, this rate is quite rapid compared with that of a well-insulated wall.

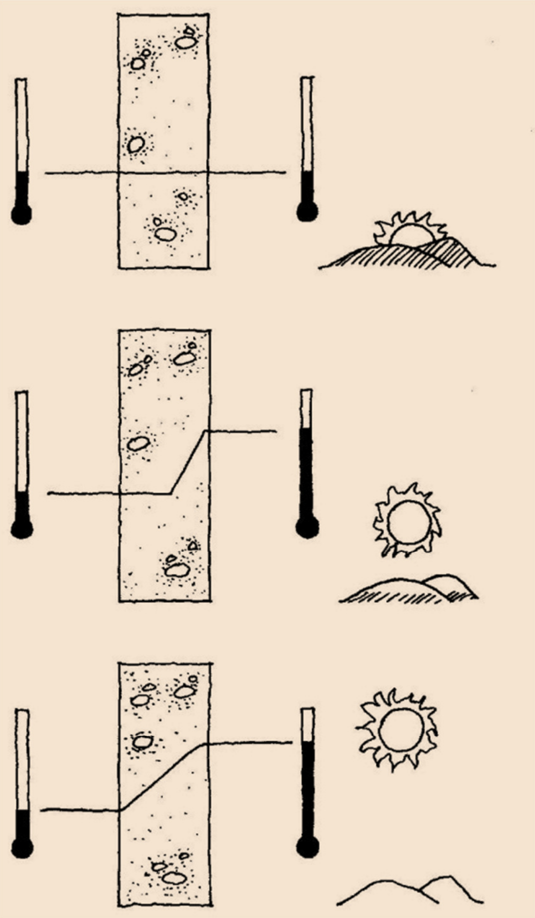


Figure 4

Materials of high thermal resistance can often be combined with materials of high thermal capacity to help achieve a desired pattern of thermal behavior in a building enclosure. Heavy, warm-climate buildings can be made to function even more effectively by the addition of a layer of insulation outside the masonry enclosure. The insulation reduces the amplitude of the temperature fluctuations to which the masonry is exposed, making the indoor temperature extremely stable (Figure 5). The same amount of insulation applied inside the masonry enclosure is considerably less effective. In this configuration the mass of the structure is still fully exposed to solar heat gain and to variations in outdoor air temperature. The insulation on the interior is virtually wasted in dealing only with the small temperature swings of the interior surfaces of the masonry. External insulation offers the additional advantage of protecting the building, particularly the roof structure, from extreme stresses of thermal expansion and contraction.

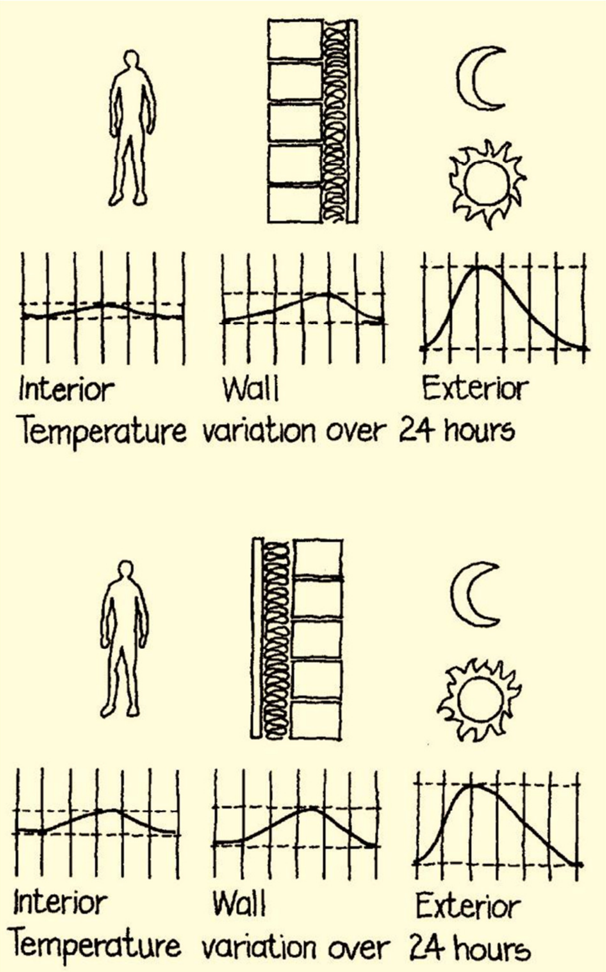


Figure 5

HOW TO DESIGN AND BUILD AN ENERGY EFFICIENT BUILDING?

Energy efficient buildings (new constructions or renovated existing buildings) can be defined as buildings that are designed to provide a significant reduction of the energy need for heating and cooling, independently of the energy and of the equipments that will be chosen to heat or cool the building.

This can be achieved through the following elements:

1. bioclimatic architecture: shape and orientation of the building, solar protections, passive solar systems
2. high performing building envelope: thorough insulation, high performing glazing and windows, air-sealed construction, avoidance of thermal bridges
3. high performance controlled ventilation: mechanical insulation, heat recovery

Only when the building has been designed to minimise the energy loss, it makes sense to start looking at the energy source (including renewable energy) and at the heating and cooling equipments. We designate this approach as the Trias Energetica concept.

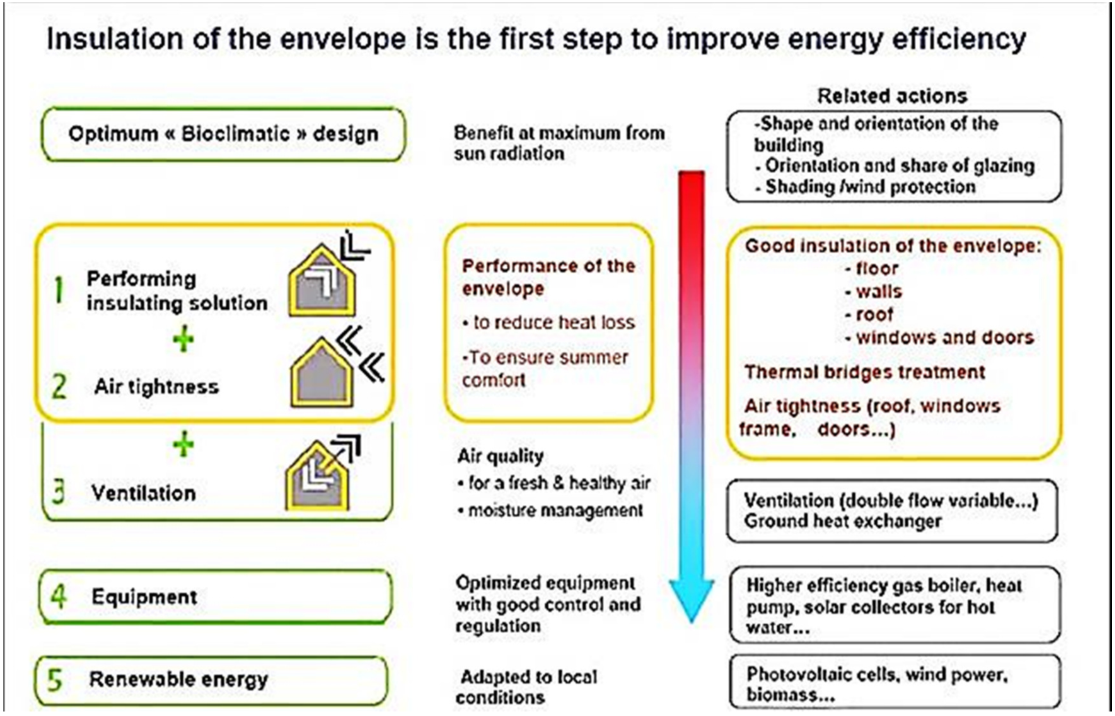


Figure 6

Bioclimatic architecture takes into account climate and environmental conditions to help achieve thermal and visual comfort inside. Bioclimatic design takes into account the local climate to make the best possible use of solar energy and other environmental sources, rather than working against them. Bioclimatic design includes the following principles:

- The shape of the building has to be compact to reduce the surfaces in contact with the exterior; the building and especially its openings are given an appropriate orientation (preferably towards the south); interior spaces are laid out according to their heating requirements ;
- Appropriate techniques are applied to the external envelope and its openings to protect the building from solar heat in winter as well as in summer; passive solar systems collect solar radiation, acting as “free” heating and lighting systems; the building is protected from the summer sun, primarily by shading but also by the appropriate treatment of the building envelope (i.e. use of reflective colours and surfaces).

Thermal insulation is a low-cost, widely available, proven technology that begins saving energy and money, and reducing emissions the moment it is installed. Well installed insulation ensures **energy efficiency** in every part of the building envelope including ground decks, roofs lofts, walls and facades. It is also well suited for pipes and boilers to reduce the energy loss of a building’s technical installations. Insulation is as relevant in cold regions as in hot ones. In cold/cool regions, insulation keeps a building warm and limits the need for energy for heating whereas in hot/warm regions the same insulation systems keep the heat out and reduce the need for air conditioning.

- An exterior wall is well insulated when its thermal resistance (R value) is high, meaning the heat losses through it are small (reduced U value). Insulation is a key component of the wall to achieve a high R value (or a low U value) for the complete wall. The thermal resistance R of the installed insulation products has to be as high as possible.
- To limit the thickness of the insulation within acceptable dimensions, Saint-Gobain Isover constantly improves the thermal conductivity of its materials (lower lambda value) thus allowing increased thermal resistance within the same space.

Air tightness reduces air leakage – the uncontrolled flow of air through gaps and cracks in the construction (sometimes referred to as infiltration, exfiltration or draughts). Air leakages need to be reduced as much as possible in order to create efficient, controllable, comfortable, healthy and durable buildings With more stringent building regulations requiring better **energy efficiency**, air tightness is an increasingly important issue.

- Details that are vital to achieving good air tightness need to be identified at early design stage. The next and equally important step is to ensure these details are carried over into the construction phase. Careful attention must be paid to sealing gaps and ensuring the continuity of the air barrier. It is far simpler to design and build an airtight construction than to carry out remedial measures in a draughty home.
- Saint-Gobain Isover has developed systems with innovative accessories that allow appropriate installation of the insulation while guaranteeing excellent air tightness and allowing proper moisture management (see the Vario system presentation).

Consequences of air leakages : cold outside air may be drawn into the home through gaps in the walls, ground floor and ceiling (infiltration), resulting in cold draughts. In some cases, infiltration can cool the surfaces of elements in the structure, leading to condensation. Warm air leaking out through gaps in the dwelling's envelope (exfiltration) is a major cause of heat loss and, consequently, wastedenergy. Most existing buildings, even those built recently, are far from being airtight and because of unwanted air infiltration generate huge costs to owners and occupants,in environmental,financial and healthterms.
A leaky dwelling will result in higher CO2 emissions. The additional heat loss will mean that a correctly sized heating system may not be able to meet the demand temperature. Draughts and localised cold spots can cause discomfort. In extreme cases, excessive infiltration may make rooms uncomfortably cold during cooler periods. Excessive air leakage can allow damp air to penetrate the building fabric, degrading the structure and reducing the effectiveness of the insulation. Air leakage paths often lead to dust marks on carpets and wall coverings that look unsightly.

Ventilation is the intended and controlled ingress and egress of air through buildings, delivering fresh air, and exhausting stale air through purpose-built ventilators in combination with the designed heating system and humidity control, and the fabric of the building itself.

- If you do not insulate properly and ventilate too little, you can risk warm humid air condensing on cold, poorly insulated surfaces which will create moisture that allows for moulds and fungi to grow.
- A **controlled ventilation** strategy will satisfy the fresh air requirements of an airtight building. Air infiltration or opening of the window cannot be considered an acceptable alternative to designed ventilation.
- As the saying goes: 'build tight, ventilate right.'

ENERGY EFFICIENT BUILDINGS – Experiences in USA

Energy conservation and economic development can go hand in hand.
Efficiently designed homes and offices will slash energy bills, liberate investment capital and avoid the expense of building new power plants.

Since the oil shocks of the early 1970's Americans have enjoyed a 35 percent rise in the gross national product without increasing their energy consumption.
The main reason is that the services energy can provide-comfort, mobility, a cold beer on a hot day-are generated much more efficiently today than they were back in 1973.
Much of the decline in energy consumption is due to the more efficient use of energy in homes and offices. In buildings, new technologies and better management of lighting, heating and ventilation systems have cut $45 billion from the nation's energy bills

Profiting from Conservation

Energy conservation has already made more energy available to the U.S. economy than any other single source. Yet there is room for even larger gains. In 1985 this country spent $440 bill\ion on energy, which amounts to $5,000 per household or 11 percent of the C.N.P. If all cost-effective conservation measures were taken and the U.S. became as energy efficient as, say, Japan, this country would consume half as much energy as it does today and save $220 billion per year. The annual cost of achieving this goal would be only about $50 billion per year.

Moreover, by slowing the growth in demand for new energy capacity, conservation could liberate 10 percent of U.S. industrial investment capital for other uses. Already the rate of capital investment in new power plants has fallen sharply owing to energy conservation. In 1982 utilities spent $50 billion, 14 percent of the total U.S. investment in industrial plant and equipment. In 1985 the amount dropped to $30 billion. By 1991 it is forecast to fall to $17 billion.

The electric industry predicts that investment will eventually rebound to 545 billion, but if the measures discussed in this article are adopted by 1990, the need for new capacity can be delayed and attenuated.

Many players in the energy market, from oil companies to regulators, now recognize the importance of investing in end-use efficiency. This has not always been the case. In 1975, for example, California's utilities predicted an annual growth rate for electrical demand of about 5 percent, even though one of us (Rosenfeld) warned that rising energy costs would cause consumers to improve their end-use efficiency so that the growth rate would be much lower, about 2 percent. By now the difference between these two projections is about 15,000 megawatts, the output of 15 large power plants.

As it turned out, demand grew at only 2 percent, and the 15 plants were never built-testimony to the market forces that led people to use energy more efficiently when the price rose, and to the foresight of regulators who imposed standards on appliances and buildings and also prevented the construction of the new plants.

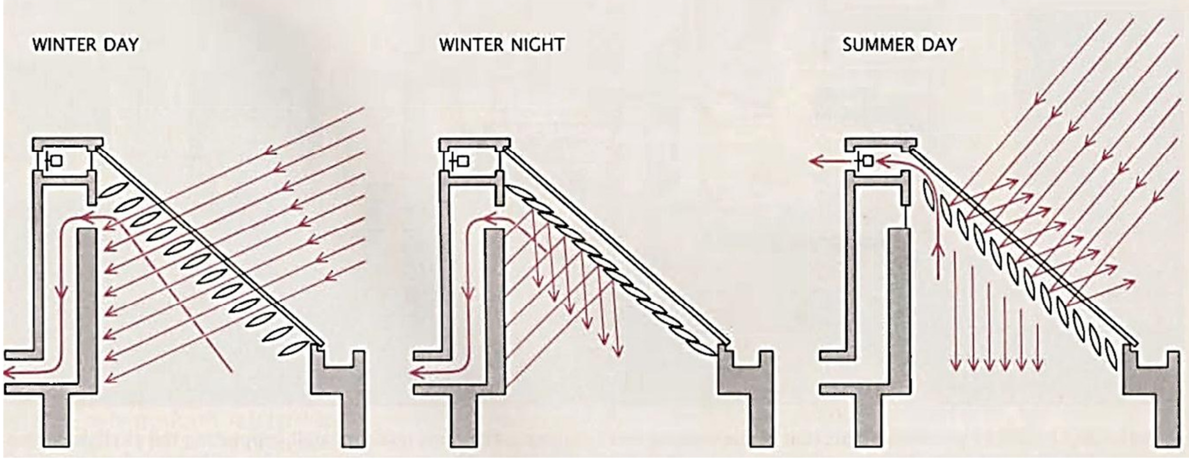


Figure 7

COMPUTER-CONTROLLED LOUVERS at the Albany County Airport regulate sunlight entering through the skylight *(see illustration on preceding page).* On a bright winter day sunlight heats the back wall. Warmed air is drawn into a space behind the wall and recirculated through the building. At night the louvers, which are filled with foam insulation, are shut to trap heat. In summer the louvers reflect direct sunlight but admit diffuse light. Warm air collects under the skylight and is vented by exhaust fans.

Figure 8

SKYLIT SOLAR COURT provides 40 percent of the lighting and 20 percent of the heating in the new passenger terminal at the Albany County Airport in Colonie, N.Y. A microcomputer, programmed with the solar altitude and azimuth angles until the year 2000, continuously gauges the indoor and outdoor environment and selects the most energy-efficient position for the louvers. The dark masonry wall supporting the skylight stores solar heat. The stone floor provides additional thermal mass.

When daylight is available, photoelectric controls dim the artificial lighting supplied by efficient fluorescent and mercury vapor lights. Einhorn Yaffee Prescott designed the terminal, and the energy consultant was W. S. Fleming & Associates, Inc.

Office Buildings

Efficient building design has had a particularly dramatic impact on heating needs. Because heat in large buildings comes mainly from internal sources-heat from people, appliances, lighting fixtures and so forth-it is possible to manage heating requirements by exploiting the thermal mass of the building, for example by storing excess daytime heat and using it to warm the building during the night.

The worst of the early-1970's buildings required 170,- 000 B.t.u. per square foot for heating alone.

The average 1979 buildings consumed 72,000 B.t.u. With yet more energy-efficient designs, heating needs will fall to less than 10,000 B.t.u., or six cents per square foot.

The decline for electricity is not as striking because new, improved equipment takes time to develop and install. For air conditioning, however, electric bills can be reduced through simple systems of thermal storage, which make it possible to move from 40 to 50 percent of electrical demand into off-peak hours. In 1979 annual electricity consumption was 27 kilowatt-hours per square foot in the worst office buildings and 18 kilowatt-hours in typical ones. New energy-efficient offices get by on between 10 and 15 kilowatt-hours.

Remarkably, it costs no more to construct an energy-efficient office building than it does to construct an inefficient one.

The reason is that by reducing the size of air-conditioning systems and getting rid of single glazed windows and excess lighting, one can pay for insulation, smaller double-glazed windows and automated thermostat and lighting controls.

Fifty years from now, when these improvements have been fully adopted for commercial buildings (assuming the same total floor-space area as today), this country will have liberated 85 power plants, costing two to three billion dollars each, and eliminated fuel needs equivalent to two Alaskas-not bad for an efficiency investment of zero.

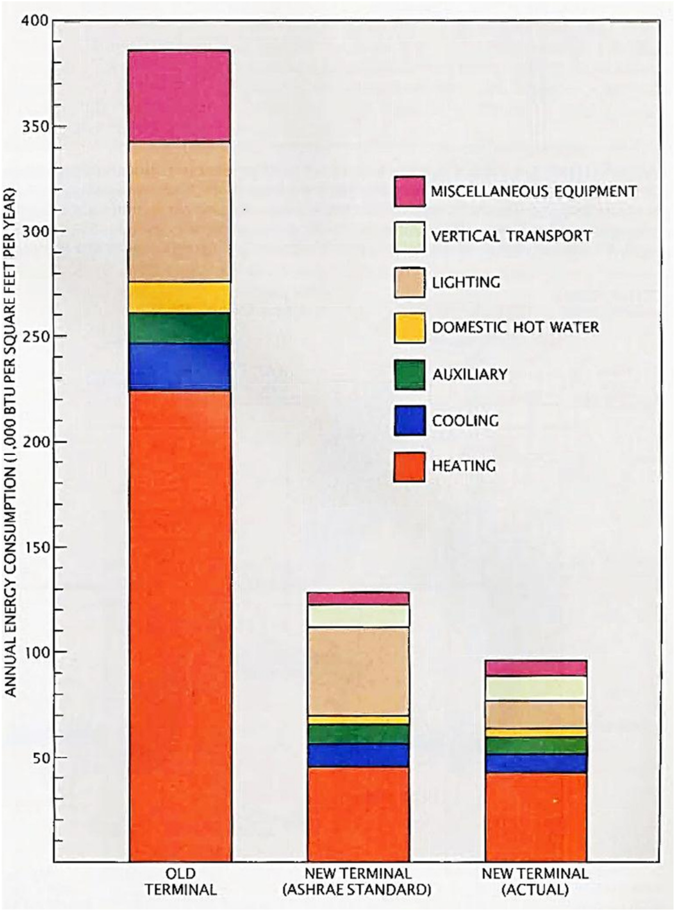


Figure 9

COMPUTER PROGRAM is a powerful tool in the design of energy-efficient buildings. The program's analysis of annual energy requirements in the old and new terminals at the Albany County Airport is shown here. The simulation was based on the local climate and the building's thermal mass, internal heat gains, solar gains and airconditioning and ventilation systems. The old terminal was a gas-guzzler. In 1975 the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) set standards for materials, lighting, ventilation and so on, which called for the new terminal to be markedly more efficient. Actually the final design performed even better than the standard. DOE-2 was developed for the Department of Energy by the Lawrence Berkeley Laboratory. It is now the national reference tool for building-energy analysis.

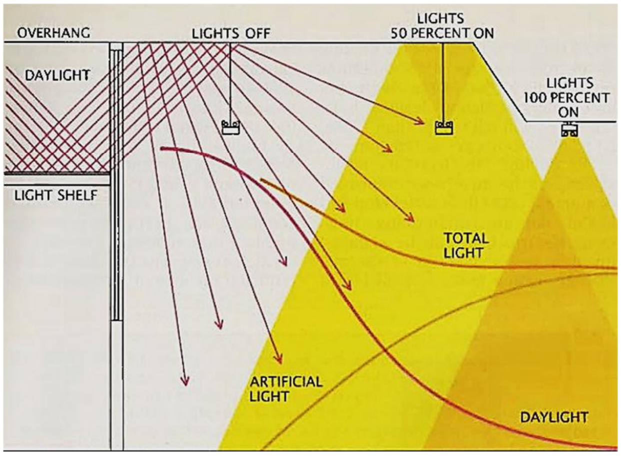


Figure 10

DAYLIGHTING can reduce lighting bills by up to IS percent in commercial buildings.

Overhangs and light shelves shade the windows from direct summer sunlight and reflect daylight into the work space. Systems actuated by photocells and controlled by microprocessors dim artificial lights in proportion to available daylight. The controls combine natural and artificial light to provide even lighting throughout the building.

Super Insulated Houses

New "superinsulated" houses reduce fuel needs by more than 75 percent. These houses are built with heavily insulated walls and ceilings, tight-fitting components and, often, ventilation systems that recover heat from the exhaust air. The walls and ceilings have extremely high insulation values, or R values.
(The R value is a measure of resistance to heat flow; a standard four inch- thick insulated wall is R-11 and a standard attic ceiling is R-19.) A superinsulated house would have walls and ceilings rated up to R-30 and R- 60 respectively. By investing from $2,000 to $7,000 to superinsulate a house it is possible to reduce annual heating costs to between $20 and $300, even in climates as cold as Minnesota and Saskatchewan. The remarkably low heating bills result because superinsulated houses store the "free" heat from people, lighting, appliances and passive solar heating through windows. Even ordinary houses tend to "float" about five degrees Fahrenheit above the outdoor temperature because of the internal free heat. Therefore when the thermostat in a conventional house is set at 70 degrees, the furnace will not go on until the outdoor temperature falls below 65 degrees, the "balance point" of the house. The five-degree difference is called the free temperature rise of the building. In a superinsulated house the free temperature rise can be as much as 30 degrees, so that if the thermostat is set for 70 degrees, the furnace will not go on until the outside temperature drops below 40 degrees; moreover, below 40 degrees it takes less fuel to heat the house. In a typical U.S. climate such as that of New York City, if the thermal resistance of a house is doubled, annual energy consumption is cut by about two-thirds.

The U.S. has the means to reduce its energy costs by $220 billion per year, above and beyond the $150 billion it is already saving as a result of conservation. For the buildings sector the potential annual savings are from $50 to $100 billion. In order to achieve these goals it will be necessary to remove the market barriers we have described. This will require the concerted efforts of utilities and government. The penalty for not doing so is severe: money will continue to be wasted, remaining reserves of cheap energy will be squandered, the U.S. will wane in competitiveness with Europe and Japan, the country will remain dependent on foreign sources and the environment will continue to be degraded. The nation should take advantage of the opportunities at hand without delay.

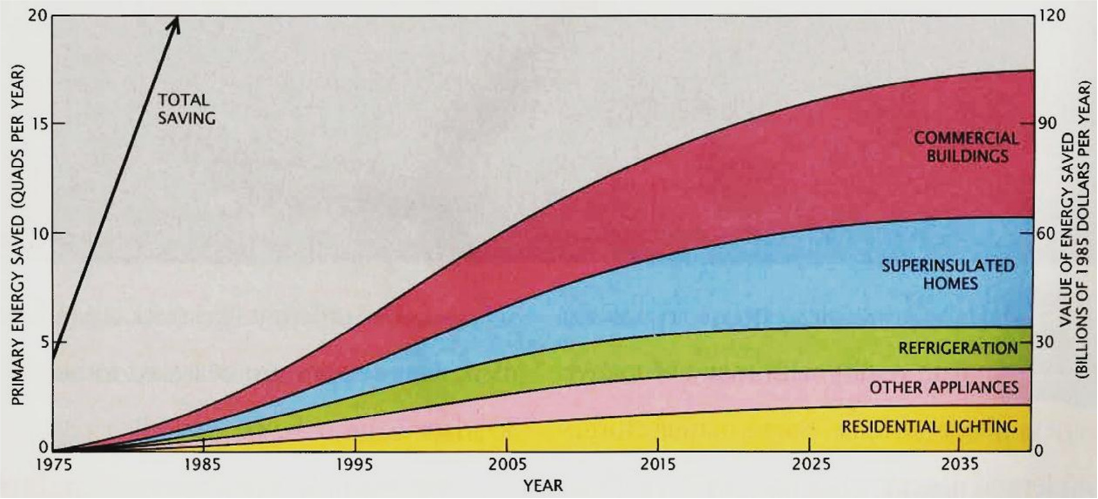


Figure 11

ENERGY SAVINGS from previous examples described above, save only a few billion dollars per year today (year 1975), but 50 to100 years from now, when the new technologies saturate the marketplace, they will save more than $100 billion per year. The savings shown are for commercial buildings (including most of the savings from improved lighting), superinsulated homes (including windows), refrigeration, other appliances and residential lighting. Thermal storage is not included because it saves peak power, not energy. The total savings line shows all U.S. energy saving . The calculations are based on figures fixed at 1985 levels for the total number of households and area of commercial floor space in the U.S.

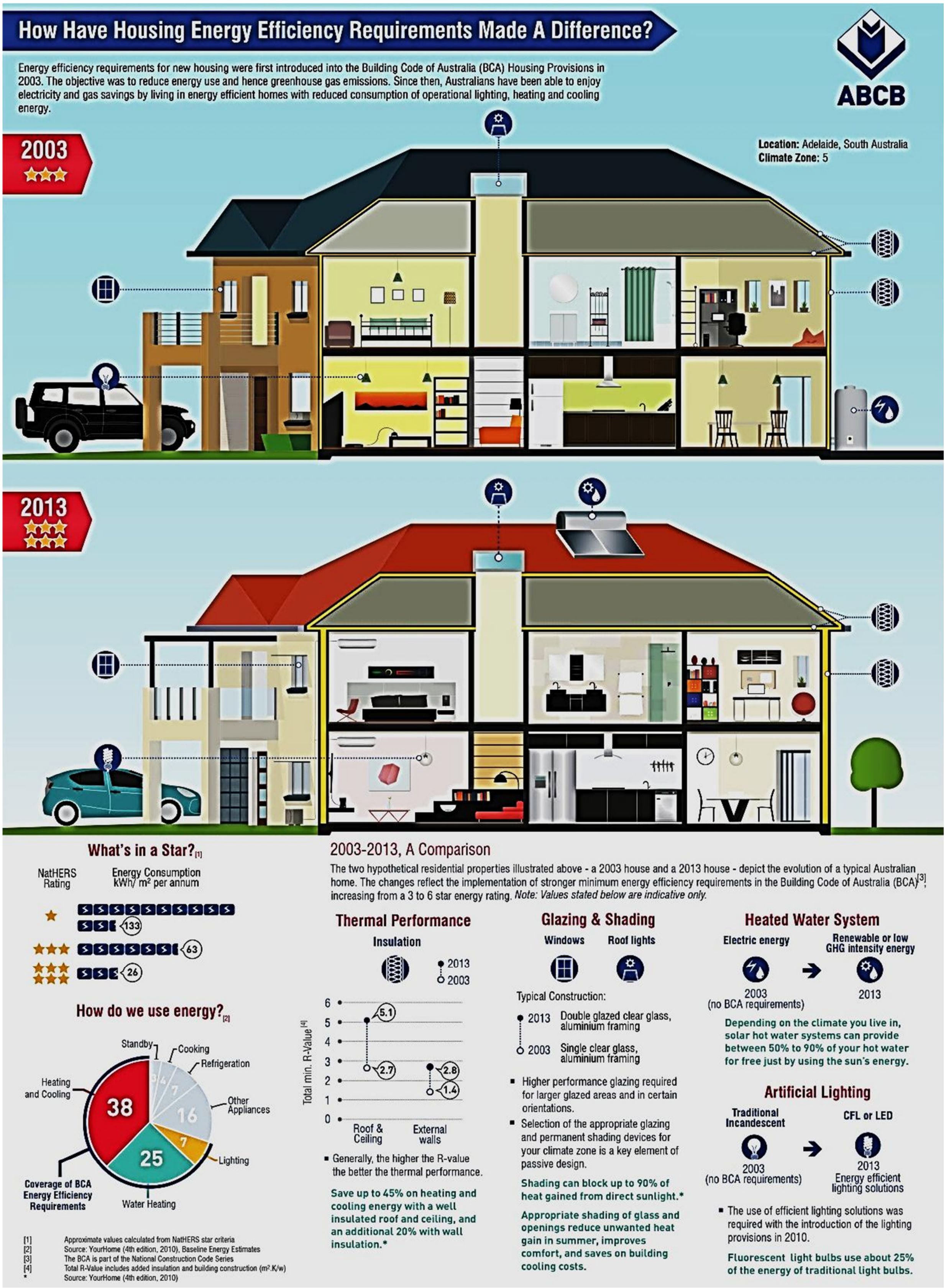
ENERGY EFFICIENT BUILDINGS – Experiences in Australia

How Have Housing Energy Efficiency Requirements Made a Difference?

Energy efficiency requirements for new housing were first introduced into the Building Code of Australia (BCA), Housing Provisions in 2003. The BCA is part of the National Construction Code series. The objective was to reduce energy use and hence greenhouse gas emissions. Since then, Australians have been able to enjoy electricity and gas savings by living in energy efficient homes with reduced consumption of operational lighting, heating and cooling energy.

The graphic depicts two typical Australian residential properties – a 2003 house (3 NatHERS stars) and a 2013 house (6 NatHERS stars). Both houses are located in Adelaide, climate zone 5. The two hypothetical houses can be compared and contrasted to highlight the development in energy efficiency requirements.

The following topics are highlighted: roof lights, insulation (roof and ceiling), insulation (external walls), heated water system, artificial lighting, and glazing and shading. The specifics of these topics is explained and detailed below. To represent the typical contrast of a residential home from 2003 with that of 2013, the graphic also illustrates adjustment in furnishing. The two hypothetical residential properties illustrated in the energy efficiency infographic – a 2003 house and a 2013 house depict the evolution of a typical Australian home. The changes reflect the implementation of stronger minimum energy efficiency requirement in the BCA increasing from a 3 to 6 star energy rating. Note: any values stated are indicative only. An increase in NatHERS stars typically means a decrease in household energy consumption. NatHERS is the Nationwide House Energy Rating Scheme.



How Have Housing Energy Efficiency Requirements Made A Difference?

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What's in a Star?[1]

How do we use energy?[2]

2003-2013, A Comparison

The two hypothetical residential properties illustrated above - a 2003 house and a 2013 house - depict the evolution of a typical Australian home. The changes reflect the implementation of stronger minimum energy efficiency requirements in the Building Code of Australia (BCA)[3], increasing from a 3 to 6 star energy rating. *Note: Values stated below are indicative only.*

Thermal Performance

Insulation

- Generally, the higher the R-value the better the thermal performance.

Save up to 45% on heating and cooling energy with a well insulated roof and ceiling, and an additional 20% with wall insulation.*

Glazing & Shading

Windows **Roof lights**

Typical Construction:

● 2013 Double glazed clear glass, aluminium framing
○ 2003 Single clear glass, aluminium framing

- Higher performance glazing required for larger glazed areas and in certain orientations.
- Selection of the appropriate glazing and permanent shading devices for your climate zone is a key element of passive design.

Shading can block up to 90% of heat gained from direct sunlight.*

Appropriate shading of glass and openings reduce unwanted heat gain in summer, improves comfort, and saves on building cooling costs.

Heated Water System

Electric energy → **Renewable or low GHG intensity energy**

2003 (no BCA requirements) → 2013

Depending on the climate you live in, solar hot water systems can provide between 50% to 90% of your hot water for free just by using the sun's energy.

Artificial Lighting

Traditional Incandescent → **CFL or LED**

2003 (no BCA requirements) → 2013 Energy efficient lighting solutions

- The use of efficient lighting solutions was required with the introduction of the lighting provisions in 2010.

Fluorescent light bulbs use about 25% of the energy of traditional light bulbs.

[1] Approximate values calculated from NatHERS star criteria
[2] Source: YourHome (4th edition, 2010), Baseline Energy Estimates
[3] The BCA is part of the National Construction Code Series
[4] Total R-Value includes added insulation and building construction (m².K/w)
* Source: YourHome (4th edition, 2010)

Figure 12

REFERENCES

1- How Buildings Work (The Natural Order Of Architecture)

By Edward Allen. Oxford University Press (2005)

2- ISOVER, Saint-Goban Group

Energy Efficiency in Buildings (2008)

3- Energy in Buildings (1988), edited by

Arthur H. Rosenfeld and David Hafemeister

4- ABCB

The Australian Building Codes Board. The National Construction Code

Housing Energy Efficiency (2013)