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José María Pino Suárez 400-2 esq a Lerdo de Tejada. Toluca, Estado de México. 7223898475
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TÍTULO: Requisitos para la restauración verde y renovación de edificios existentes.

AUTORES:

1. Farshad Asadbeigi.

2. Javad Majrouhi Sardroud.

3. Alireza Bijar.

RESUMEN: Como la destrucción y rehabilitación de edificios puede causar una alta contaminación del medio ambiente y un alto consumo de energía, la restauración ecológica y la modernización de edificios pueden considerarse como uno de los principales enfoques para lograr un volumen reducido de gases de efecto invernadero y consumo de energía. Además de revisar los estudios anteriores sobre la rehabilitación y restauración de edificios ecológicos, este estudio ha evaluado los pasos de los métodos utilizados para la rehabilitación y restauración de edificios ecológicos. En consecuencia, se han evaluado el costo-beneficio de los métodos y las limitaciones de los mismos.

PALABRAS CLAVES: edificios verdes, restauración de edificios, ciclo de vida del edificio, factibilidad de renovación de edificios.

TITLE: Requirements for green restoration and renovation of existing buildings.

AUTHORS:

1. Farshad Asadbeigi.

2. Javad Majrouhi Sardroud.

3. Alireza Bijar.

ABSTRACT: As the destruction and rehabilitation of buildings can cause high environmental pollution and high energy consumption, ecological restoration and the modernization of buildings can be considered as one of the main approaches to achieve a reduced volume of greenhouse gases and consumption of energy. In addition to reviewing previous studies on the rehabilitation and restoration of green buildings, this study has evaluated the steps of the methods used for the rehabilitation and restoration of green buildings. Consequently, the cost-benefit of the methods and their limitations have been evaluated.

KEY WORDS: green buildings, building restoration, building lifecycle, building renovation feasibility.

INTRODUCTION.

Building construction and relevant operations has possessed large amount of total energy consumption at the world. According to the statistics, buildings totally include about 30-40% of total consumption of energy generated by human and are responsible for about 40-50% of greenhouse gas emission (Asif et al, 2007).

The construction industry at Canada is responsible for consumption of about 50% of natural resources, 52% of fresh water resources and production of about 11tons of wastes. In Brazil, the value reaches to 70% of the mass of waste materials caused by construction activities (Pinto, 1999). In the EU, 38.7% of energy consumption (Spyropoulos & Balaras, 2011), in US, 42% (Administration, 2010) and in Brazil, 44% of total electricity is consumed by administrative and commercial buildings

(Administration, 2010). 33% of greenhouse gases emitted in atmosphere are produced by energy consumption in lifecycle of buildings (Munarim & Ghisi, 2016; Ghazanfarpour et al, 2013).

According to the mentioned, it is essential to pay attention to construction industry to achieve sustainable development. Sustainable development, in definition, is a kind of development with least and managed impact on the environment to provide high economic and social achievements based on the needs of next generations. To achieve sustainable development, multidisciplinary approach should be taken including many features such as energy saving, analysis of materials such as water and reuse and recycling of materials and less and controlled production of greenhouse gases and the most important gas is greenhouse gas (CO2) (Ramesh, 2010; Sher & Lee, 2004).

In construction industry, the most energy consumption is possessed to existing buildings; although the replacement rate of these buildings with new buildings is only about 1-3% per year (Ma, et al, 2012). As majority of buildings around the world have been built in period before standardization and optimization of energy consumption (e.g. about 395 of houses in England are built before World War II) (Munarim, & Ghisi, 2016) and many of them are cultural heritage and destroying and renovating them can cause high pollution and high energy consumption; restoration and renovation of existing buildings is a priority. It should be mentioned that for economic reasons, the governments have emphasis on optimal energy consumption and greenhouse gas emission more than everything in field of restoration and renovation (Munarim, & Ghisi, 2016; Warner & Kaur, 2017).

As it was mentioned, rapid increase in energy efficiency in existing buildings is essential for on-time decrease in global energy consumption and enhancement of sustainability of the environment. Over the past decade, many governments and international organizations have taken considerable efforts to improve the energy efficiency in existing buildings. For example, federal government of the USA has allocated considerable financial supports to support retrofitting of existing buildings (Ramesh, 2010).

At present, Home Energy Rating System (HERS) is the prerequisite of housing loan in US. Moreover, the US government has promised that the new commercial buildings will be more efficient up to 2020 in terms of energy consumption to 20% and energy consumption will be reduced up to 2030 in new houses in average about 30-50% (Menassa, 2011).

In EU, issuance of energy performance certificate (EPC) in early 1990s decade was considered as a necessity to decrease energy consumption and greenhouse gas emission. In 2007, the EU considered a policy called 20-20-20 horizon, based on which energy consumption reduction till 2020 was about 20% and use of renewable energies was going to be increased to 20% and also increase productivity in buildings to 20% was considered (Ma, et al, 2012).

Also, China took the policy of increase on energy productivity to 20% by means of implementation of environmental standards and energy productivity and making environmental isolation of building and energy productivity in buildings (Ma, et al, 2012). In 2010, the Britain State approved underlying law to enhance energy productivity of 7million houses in Britain till 2020 with the aim of decrease in carbon emission to 29%. International Energy Agency (IEA) established a collection of projects to promote energy productivity in existing buildings such as Holistic assessment toolkit on energy efficient retrofit measures for government buildings; prefabricated systems for low energy renovation of residential buildings; Reliability of energy efficient building retrofitting; Energy & greenhouse gas optimized building renovation (Ma, et al, 2012).

These efforts could provide guideline for policy and financial supports and technical support to implement energy efficiency measures in existing buildings. By that time, considerable researches were conducted in field of development and analysis of different opportunities of energy productivity to improve energy performance in existing buildings. The results show that energy consumption in existing buildings can be described considerably through optimized retrofitting or renovation as required measures to enhance an old building (Flourentzou & Roulet, 2002).

Retrofitting and renovation of existing buildings as one of the main approaches to achieve greenhouse gas reduction and energy consumption in buildings can include abundant challenges and opportunities.

The main challenge to the studies and decision making can be existence of multiple uncertainties such as climate change, change in services, change in human behavior, change in state policy and so on. Each mentioned factor can have direct impact on retrofitting techniques and success of a retrofitting project.

Various measures of retrofitting can sometimes have different impacts on communications of building subsystems based on choosing retrofitting technologies. Encountering such uncertainties and actions of system can be considerable technical challenge in every sustainable building retrofitting project. Other challenges may include financial limitations and long-term settlements and delay in operations (Tobias & Vavaroutsos, 2009, Australia, 2010).

The tendency of owners of building for retrofitting, if there is no financial support on behalf of the government, can be another challenge, especially in absence of encouragement policies. Retrofitting costs, which can be mostly key factor in building restoration, is responsibility of owner of the building; although major part of the benefit is assigned to renters. On the other hand, retrofitting of a building can provide big opportunities to improve energy efficiency, increased employee efficiency, decreased repair and maintenance costs and thermal comfort (thermal comfort us the mental status showing the satisfaction of person by thermal environment and is assessed by the person's mind) (Ramesh, 2010). Moreover, it may help improvement of state energy security, decreased exposure to energy cost fluctuations, providing job opportunities and increased more residential buildings (Ernst, 2010; Sweatman & Managan, 2010). Today, many retrofitting technologies are available at the market easily.

However, making decision on using which technology as retrofitting method for special project is a multipurpose optimization problem exposed to various conditions and limitations such as special features of construction, total available budget, project target, types if construction services and productivity.

Financial profit is not the one and only criterion to choose retrofitting technologies. Optimal solution is evaluation and measurement in wide range of factors relevant to energy and non-energy factors such as energy, economic, technical, environmental, legal and social factors. Hence, solving general problem of building retrofitting is depended on taking a systematic approach to select the best option based on the consequences and costs. In this study, key retrofitting activities such as energy audit of performance evaluation of building, economic analysis, risk measurement and confirmation of energy saving encompassing the building retrofitting have been explained.

DEVELOPMENT.

History.

Since long times ago, natural mechanisms have been used to improve the living conditions and thermal comfort and air conditioning in construction. This can be observable in use of windproof in Iranian homes and trapping the sun radiation in houses in cold regions. Since last decade of 19^{th} century, thermal insulation was analyzed in field of heat transfer and humidity insulations in field of building. In 1930s-decade, solar house, also called House of Tomorrow, was made by George Fred Keck, which was underlying achievement of solar energy (Ionescu et al, 2015). In 1960s, increasing use of computers and using computerized thermal analyses could enhance the knowledge and quality of thermal comfort in buildings.

The oil crisis begun from 1973 could improve the interests in energy productivity in buildings and using insulations and thermal recycling in air conditioning system and using self-efficient houses in terms of energy and green house was switched by that time.

Since 1980s, with advent of smart buildings, the integrated system of controlling equipment and different systems was created gradually.

In 1992, Energy Autonomous House was designed for the first time. In 1994, new standard called Minergie was emerged, which was a Swiss made quality label for low-consumption buildings in energy and the first Plus Energy House was created (Sunflower Building), the amount of energy generation of which was more than its energy consumption (Ionescu, et al, 2015). Since 2002, with creation of building integrated computer system, smart building was matured. Energy-efficient buildings have such technologies, which can minimize energy consumption rate such as use of Low E Layer windows, which never let heat come inside in summer and never let heat go outside in winter and can create a greenhouse environment.

In general, there are 4 key moments in making green buildings:

I: 1939: building Solar House 1

II: 1970: energy crisis and increased price of fossil fuels

III: 1990: making the first passive house with zero energy consumption in Germany.

IV: 1996: establishment of passive house institute

According to the approval of the EU in terms of energy consumption, buildings can be classified as follows (Ionescu, et al, 2015):

1. Standard Energy buildings with average energy consumption less than 65kwh/m2 per year.
2. Low energy building with average energy consumption less than 40-50kwh/m2 per year.
3. Ultra-Low Energy Building with average energy consumption less than 20-30kwh/m2 per year.

Low energy buildings are usually equipped by high level of insulation, windows with high efficiency and low level of air filteration. The most general definition of a low energy building is a building with energy performance higher than productivity of a standard building.

Ultra-low energy building takes benefit of renewable energy in addition to provide above mentioned conditions and these systems can decrease energy consumption of building to the level of ultra-low energy buildings or passive houses.

Interestingly, more than 90% of buildings of EU have energy consumption more than standard level (Ionescu et al, 2015).

New Zero Energy Building (NZEB) is a building with very high performance in field of energy consumption, which can supply the required energy from the renewable resources in building or near the building (Baracu, et al, 2013).

There are 4 definitions for Zero Energy Building (ZEB) (Hernandez & Kenny, 2010):

1. They consume energy per year as much as they generate.
2. They send energy per year to the network as much as they get.
3. In terms of cost, the generated energy in building that is supplied is equal to the energy got by the building in addition to the cost caused by pollution and building pollutants.
4. They can supply renewable energy as much as they get.

Review of literature on green restoration and renovation of buildings.

In this section, the relevant literature on green building restoration is presented:

1. Analysis of lifecycle.
2. Key steps in a sustainable building retrofitting plan.
3. Key factors affecting fundamental building retrofitting.
4. Strategies of sustainable building retrofitting.
5. Building energy audit.
6. Economic analysis of sustainable retrofitting.
7. Risks analysis in sustainable retrofitting.
8. Measurement and confirmation of energy saving.

9. Feasibility of building green renovation.
10. Green restoration and renovation of historical buildings.
11. General problems to building retrofitting.

Life cycle energy analysis method.

The method (LCEA) is an approach, which analyzes and measures whole energy entered to a building during lifecycle. The method includes following steps (Ramesh, 2010):

1. Embodied: this step includes construction, transportation of materials, establishment and installation of the facilities.
2. Operation: includes all activities taken during normal building lifecycle.
3. Demolition: includes transportation, destruction of building and carrying the waste materials to the recycling factory.

Embodied energy.

The energy is used in construction of building and includes supplying materials (such as the energy needed for excavation, extraction and making them in factory), transportation, construction and installation of equipment. The energy includes two parts of initial and recurring embodied energy, which can be estimated as follows:

$$EEi = \sum m_i * m_j + E_c \qquad \text{(I)}$$

EEi: Initial embodied energy

m_i: The materials used I building

m_j: The energy of construction or extraction of each unit of materials

E_c: The energy used in site for construction and using building

Hence, the energy is highly depended on used materials, energy initial resources and using the conversion processes in making construction materials and products.

Recurring embodied energy includes whole energy for maintenance, reconstruction and rehabilitation of building.

$$EEr = m_j * m_j * [(L_b / L_{mi}) - 1] \qquad \text{(II)}$$

EEr: Recurring embodied energy (secondary)

L_b: Building lifecycle

L_{mi}: Material lifecycle

Operation energy.

The energy is needed to preserve the thermal comfort and daily protection of building. This kind of energy is usually used for good ventilation, house hot water, lighting and function of household devices and is highly depended on expected comfort and welfare (financial and cultural conditions of users), climate and building function. The energy can be expressed as:

$$OE = E_{OA} * L_b \qquad \text{(III)}$$

OE : Operation energy in building lifecycle.

E_{OA}: Annual operation energy.

L_b: Building expected lifecycle.

Demolition energy.

The energy is needed to destroy the building and to carry the waste materials to the recycling factory.

$$DE = E_D + E_T \qquad \text{(IV)}$$

DE: Demolition energy

E_D: Energy needed for building destruction

E_T: Energy needed to carry waste materials to the recycling factory

Lifecycle energy.

The energy is an integration of energies mentioned above:

$$LCE = EE_i + EE_r + OE + DE \qquad \text{(V)}$$

It should be mentioned that saving caused by recycling waste materials and using them again in lifecycle is not considered.

This is the process, by which the materials and energy of a system (building) can be measured. The main challenge in this field is the restricted information on environmental effects of production of construction materials and the real process of construction and destruction.

According to the investigations, 85% of energy needed by buildings during the lifecycle is relevant to utilization energy, 15% is relevant to construction energy and restoration and maintenance and about 1% relevant to destruction. One of the opportunities to reduce construction energy is reuse of waste materials, which can return 55% of energy needed for making materials (Ramesh, 2010).

The main source of energy, especially on operation energy, is very underlying. This is because; the main source of electricity energy in some countries is fossil fuel, which can cause emission of greenhouse gases. If renewable fuels are used for electricity generation, environmental energy of operation energy can be reduced.

On type of buildings, although the building with steel skeleton needs less energy compared to concrete building, because of higher thermal conductivity of steel, lifecycle energy consumption of steel frames is a little more than concrete buildings (Ramesh, 2010). According to the mentioned, it could be found that as the assessment and analysis method of lifecycle is the basis of computer methods and ultimately, the analysis of retrofitting and risk measurement options and confirming the saving rate; analysis and evaluation of lifecycle is the most important method in determining greenness of building. The method is in summary based on figure 1.

Key steps in a sustainable building retrofitting plan.

Overall process of retrofitting a building can be divided to 5 main steps (table 2):

Figure 1: Estimating building lifecycle energy (T Ramesh, 2010).

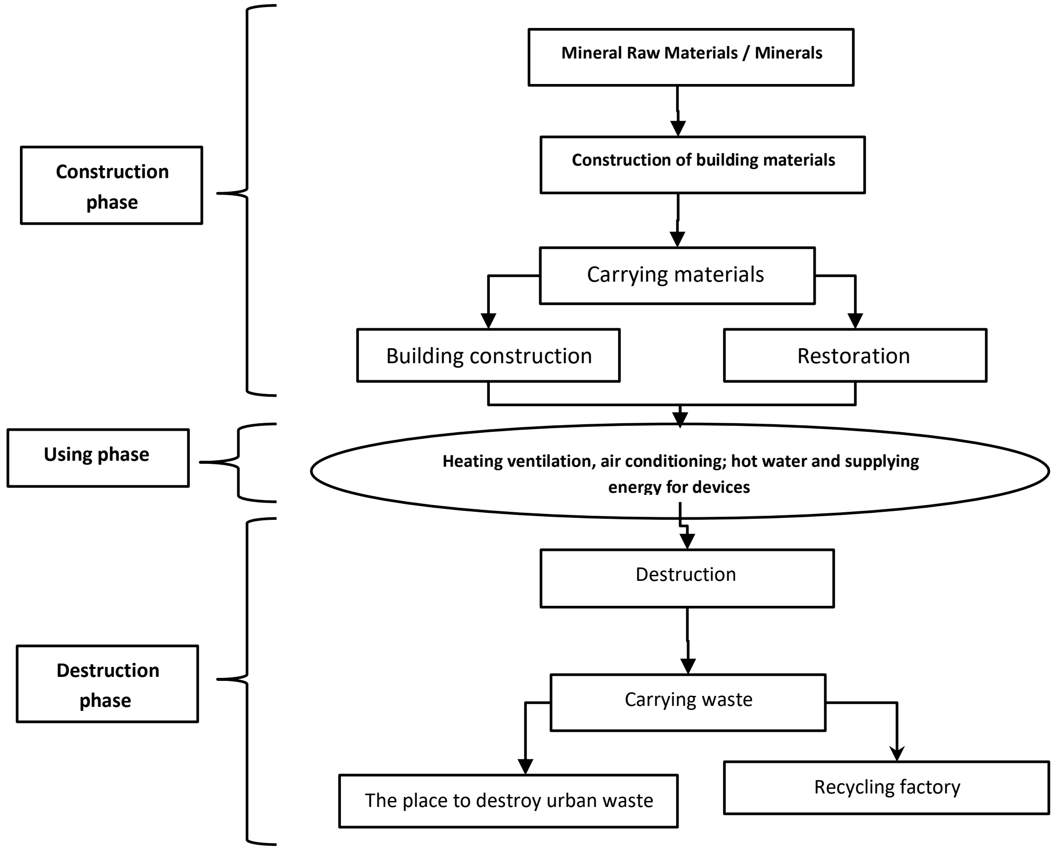


Table 2: key steps in a sustainable retrofitting plan (Ma, et al 2012).

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Launch of the project and pre-survey of retrofitting	Performance evaluation and energy audit	Identifying retrofitting options	Implementation and establishment of site	Realization and feasibility
Defining the framework of work	Energy audit	Energy saving estimation	Site implementation	Measurement and verification (V&M)
Setting project goals	Choosing key performance criteria	Economic analysis	Test and establishment tests	
Determining available resources	Building performance evaluation	Risk assessment		
Analysis before retrofitting		Prioritization of retrofitting options		

Phase 1: Launch of the project and pre-survey of retrofitting: in this phase, the owners of building or their representatives feel need to renovation and restoration and determine the framework, project goals, available resources and working plan based on type and amount of budget.

Pre-survey of retrofitting may be also needed for better understanding of operation problems and main concerns of the residents. The owners of building usually select an experienced company in field of ESCO energy services to be responsible for planning and implementing building retrofitting.

Phase 2: energy performance evaluation and audit: energy audit is for analysis of building energy data, understanding energy consumption in building, identification of energy wastage regions and providing recommendations for zero energy measures or energy conservation measures (ECM). Sometimes, for performance evaluation, it is needed to benchmark the building energy consumption based on criteria of performance indices or green ranking system. Troubleshooting can be used to identify the inefficient equipment, inadequate control design and any other problem in construction operation. energy audit details and performance evaluation and building detection are introduced in summary in the following respectively.

Phase 3: identifying retrofitting options: in this phase, different retrofitting options are evaluated and their hedges and advantages are evaluated by computer simulation, analysis and economic analysis and risk assessment and the best option is selected.

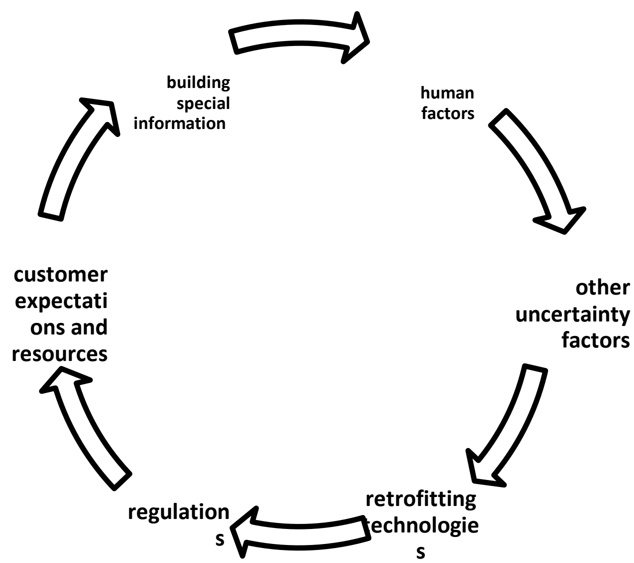
Phase 4: implementation and establishment n site: this phase includes implementation of the retrofitting measures selected in previous steps. Then, to make sure of optimal function of retrofitting measures, tests and establishment examinations are used. It should be mentioned that implementation of some retrofitting measures may cause considerable lag in construction operation and residence of the residents.

Phase 5: the final step of validation and energy saving: when retrofitting measures have been set and implemented in best way, measure and verification (M&V) standard methods can be used to analyze energy saving (Ma, et al, 2012). In this method, satisfaction of residents and owners of building by the overall result of retrofitting is needed.

Key elements affecting fundamental building retrofitting.

Success of a building retrofitting plan is depended on multiple factors. Figure 2 illustrates the key elements including considerable effects in fundamental retrofitting such as policies and regulations, customer resources and expectations, building retrofitting technology, special information, human factors and other uncertainty factors.

Figure 2: elements affecting sustainable building retrofitting (Ma, et al. 2012).



In rest of paper, a summary of general problems of green renovation are presented:

- Every building has its special features. Retrofitting measures taken in a building may not be useful to another project.

- Advantages of using several ECMs can't be equal to whole advantage of using each ECM. Offering an ECM is depended on thermodynamic performance and its physical functions among different recommendations of measures (Ma, et al, 2012).
- Choosing ECM is a multipurpose optimization issue. Multipurpose optimization provides an academic region, which is a wide range of methods with high potential to solve the complicated decision-making problems (Diakaki, et al, 2008). Choosing criteria and weighting is essential to codify the optimization problem for building retrofitting.
- Optimization problem can be explained using model-based methods or model-independent approach. In model-based approach, energy simulation models (toolkit) are used to estimate energy saving of different ECMs. Analysis of energy saving should be detected with inconsistency of modeling. Independent models for target system need no model. Advanced system is a model-independent system.
- It should be noted that optimization is a multipurpose issue. Hence, to solve that, same as other multipurpose problems, universal optimization techniques such as Neural Network Algorithm and Genetic Algorithm, Branch and Bound (B&B) and Simulated Annealing (SA) should be applied.

Sustainable building retrofitting strategies.

Overall retrofitting strategy includes 2 parts:

a) Strategic planning and model (choosing toolkit).

b) Controlling main activities of retrofitting in overall retrofitting process.

An underlying issue is that regular control on construction system operation and repetitive analysis of operation data during continuous period (e.g. after retrofitting) is needed to make sure than system acts based on efficient method.

Building energy audit.

Energy audit is investigation of using energy in a region or site. In this phase, energy consumption and depended costs are identified and analyzed and that what kinds of energy can be used and what measures can be taken to control consumption and cost (Diakaki, et al, 2008).

Energy audit plays key role in an energy retrofitting project to identify the regions with energy saving potential and required information in construction performance evaluation.

Building performance evaluation.

Existing buildings have tendency to achieve better performance, change in use, dysfunction or malfunction over the time (Ma, et al, 2012). The events can mostly cause decline and worsening in overall system performance over the time and can cause inefficiency of building and declined condition of thermal comfort.

Quantity advantages of building energy protection.

Reliable quantity estimation of energy advantages to prioritize retrofitting measures is essential in a system supporting sustainable retrofitting decision. Performance of different measures of retrofitting can be mainly evaluated through energy simulation and modeling.

Various software packages taking building simulation are available in this field such as Energy Plus, eQUEST, DOE-2, ESP-r, BLAST, HVAC- SIM+, TRNSYS and so on, which can be used for simulation of thermodynamic information and different retrofitting measures of energy (Ma et al, 2012).

Economic analysis of sustainable retrofitting.

Choosing retrofitting measures is a business between investment and advantages gained due to implementation of retrofitting measures. Economic analysis, which facilitates the comparison of retrofitting measures, can be a sign that which energy retrofitting alternatives are more efficient and cost-effective.

Various methods of economic analysis can be used to evaluate the economic efficiency of building retrofitting measures. Some of them such as net present value (NPV), internal rate of return (IRR), Overall Rate of Return (ORR), benefit-cost ratio (BCR), discounted payback period (DPP) and simple payback period (SPP) can be used to evaluate economic feasibility of a retrofitting project (Kreith & Goswami, 2007; Krarti, 2016).

There are various studies relevant to economic analysis of energy efficient measures. Remer and Nito have presented NPV as the most conventional method for optimal building energy evaluation among 25 techniques (Remer &Nieto,1995).

Risk assessment in sustainable retrofitting.

Risk assessment has been identified as determination of qualitative or quantitative value of risk relevant to a status and recognized threat. Risk assessment can provide information for decision makers on being exposed to risk of a certain decision (Ben & Steemers, 2014). As it was mentioned before, building retrofitting has various uncertainties such as uncertainty in estimating energy saving and energy consumption measurement, weather forecasting, energy consumption pattern change, decline in system performance and so on. The result of such uncertainties is that return on investment in building retrofitting is highly uncertain. Therefore, risk assessment is essential for decision makers with presentation of sufficient level of reliability to choose the best retrofitting solution. Although there are many methods of risk assessment and risk management, probability-based risk assessment method is most likely method to use. Probability-based risk assessment methods are expectation value analysis, criterion variance and coefficient of variances, risk rate decline, equivalent certainty method, Monte Carlo simulation, decision making analysis, option analysis and real time sensitivity.

There are various studies focusing on risk assessment and analysis of uncertainty of building retrofitting. For example, Menassa has provided a quantitative approach, which has provided determination of investment value in sustainable building retrofitting with regard to different uncertainties relevant to lifecycle cost and perception of benefit gained by such investment (Menassa, 2011).

Measurement and verification of energy saving.

Measurement and verification (M&V) of the process of using reliable measurement is determining real time saving created by satisfaction by an energy management plan. The main objective of M&V is real time determination of energy saving based on implementation of retrofitting measures. Energy saving can be shown with Eq through estimation of difference between measurement energy in the period before retrofitting and after that. After estimating for difference caused by zero energy retrofitting factors, in which E-saving is energy saving, can be estimated as follows:

Esaving = Epre-retrfo — Epost-retro ±Eadjust VI

Epre-retrfo: estimation of using energy for a defined period in period before retrofitting.

Epost-retro: estimation of using energy for a defined period in the period after retrofitting.

Eadjust: the difference between using energy before retrofitting and after that caused by the difference on measurement factor energy of zero energy retrofitting; such as climate, residence plans and so on. The main challenge in using a good M&V is need to identify and determine quantity of energy changes caused by changes in zero energy retrofitting measurement factors. In performance of international protocol of M&V, there are 4 M&V options used to measure and estimate energy saving:

a) Insulation retrofitting – key parameters measurement.

b) Insulation retrofitting – measurement of all parameters.

c) Perfect probability.

d) Calibrated simulation.

Feasibility of green building retrofitting.

It should be noted that interference, even if is taken to improve building performance, can have negative effects on the environment. Hence, the building and surrounding area should be analyzed alongside.

As majority of buildings of the world have been built in the pre-standardization age and energy optimization age; some of them have artistic and cultural aspect and destroying and reconstruction of them can cause high pollution and using so much energy and hence, they should be renovated.

For economic reasons in field of renovation and reconstruction of buildings, the focus of governments is on energy consumption and optimization and then, greenhouse gas emission, especially CO2.

Now, numerous computer simulation programs are available for optimization of energy consumption and renovation of buildings. In these plans, some information predicts utilization of existing buildings in the step of designing even before construction or renovation. The data include items such as energy consumption demand, internal heat, humidity, using natural light, surrounding area and so on. For 1 year, the software programs have been made generally based on evaluation of lifecycle (Ma, et al, 2012, Ramesh, 2010).

Using cleaner energies and green optimization of buildings, emission of CO2 gas and acid rain gases can be decreased.

In this case, 4 scenarios can be considered for rehabilitation and renovation of buildings (Munarim & Ghisi, 2016):

1. Ordinary repair and maintenance of building.
2. Ordinary repair and maintenance of building, along with building insulation.
3. Reconstruction of interior space, new interior design based on better energy efficiency and more fundamental measures to improve efficiency of consumption and energy wastage.
4. Whole building destruction and making new building based on environmental criteria.

To take any of above-mentioned methods, the environmental impacts such as decreased natural resources, global warming, decreased thickness of ozone layer, emission of toxic materials, pollution of aquatic animals, toxicity of soil, acidity of the environment and other complications should be considered.

In general, 4 types of damage are existed (Munarim & Ghisi, 2016):

1. Climatic change.
2. Human health.
3. Quality and impacts on the ecosystem.
4. Decreased natural resources.

It should be noted that one reason for restoration and renovation of buildings is protecting the cultural heritage and architecture. Migration and making people move from old and burn out buildings in cities can cause distribution of population; although restoration of old regions of the city can decrease traffic and decrease in greenhouse gas emission, decreased energy consumption relevant to destruction of buildings and carrying waste materials and decreased volume of the waste materials of buildings and ultimately, decreased demand for energy consumption and natural resources.

In field of choosing feasibility and type and method of building restoration, the lifecycle analysis method can be used. Interestingly, based on surveys and real time statistics, under mild climate, the lifetime of building is depended on social and economic values and criteria of that building and not the materials used to build that (Munarim & Ghisi, 2016).

Green restoration and renovation of historical buildings.

The early studies in this field were conducted in late 1970s and early 1980s, which was at the same time with beginning of oil crisis and increase in price of fossil fuels. Then in a 15-year period (1983-1998), because of improvement in world economy and decreased oil price, the stagnation of studies in this field was begun. Afterwards, with increase in oil price and advancement of modern technologies such as thermography, the thermal isolation ability of buildings was increased.

In terms of number, if studies and number articles in field of analysis of energy efficiency in historical buildings, the states including Italy, UK, Spain and China can be respectively counted. Italy is in top of this list and the reason is multiple historical buildings in this country and profitable status of tourism. In regard with field of study, 72% of the studies have been relevant to energy efficiency and thermal comfort and the Italy again has the main portion.

Among the studies, 23% have been relevant to residential building, 17% religious' buildings, 11% library and universities and remained 23% of studies can be counted in no special group.

In regard with historical period, the buildings of 19 and 20th centuries have been the main cases in the studies. In terms of use, respectively residential buildings, museums and religious buildings with possessing 24%, 17% and 14% of studies have possessed highest level of statistics (Martínez-Molina et al, 2016):

Residential buildings.

Many historical buildings consume less energy compared to contemporary buildings because of more interaction with the climatic environment, good elements and architecture consistent with the climate and environmental conditions without including mechanical facilities and thermal comfort and ventilation system. This shows that with lack of destruction of these buildings, passive technology of the buildings can be used.

Religious buildings.

In many cases restoration and renovation of religious buildings can decrease humidity and increase thermal comfort and also with installation of consistent thermal facilities and double-glazed windows, the artistic works and the paintings in these buildings can be protected. To simulate the ventilation and thermal comfort of buildings, fluid dynamics' software can be used. The most well-known software program is FLUENT, which has the ability to model the fluid and heat transfer in complicated geometries.

With the simulation taken in this field, it has been confirmed that ancient natural ventilation systems work well and can provide a good environment in terms of temperature, sustainability and comfort.

Using passive technologies, mostly used in historical buildings, can be also used in modern buildings. For example, using these technologies in renovation of a building in UK could decrease emission of greenhouse gases at 83% and cause energy saving at 55%.

Some example of the passive technology can be observed in traditional buildings at Bushehr, which can provide a cool environment in arid area and also can provide humidity by means of using light colors in building skin and using wooden ceiling.

General problems of building retrofitting.

The problem of building optimization and retrofitting is identifying and implementing the most cost-effective technologies of retrofitting, which are effective to achieve increased energy performance with preservation of satisfying and acceptable services of thermal comfort in interior space under a series of limitations (Baek & Park, 2012). The following issues are the problem with building retrofitting, which should be considered carefully in a building retrofitting project:

Lack of awareness of energy performance.

An issue in improvement of energy efficiency is that, it is hard to identify its impacts. Even if energy saving relevant to restoration is implemented in a building, its impacts can sometime be felt hardly and this can be intensified at the time that consumption pattern is changed because of change in energy price (e.g. increasing the temperature of thermal facilities). Even in case that repair and maintenance costs of home like light and heating costs are reduced because of renovation, the reduction of cost is lower than the investment costs and the ROI period is too long. Therefore, there is low active investment, which is active in field of improvement of energy performance. Another issue is lack of awareness, in which the energy performance of building can be regarded insignificant in terms of investment value. Energy performance in existing homes most of the time is neglected same as the façade at the selling time or renting. Even if the asset value of the home is increased with improvement of energy efficiency, proving the increase in value to probable buyer or renter is not simple. In other words, energy performance of a home is insignificant in market price of that home. Therefore, unawareness of energy performance can force them to attend and invest to improve home energy efficiency.

Financial reasons.

Financial problems most of the time can be appeared as a barrier to improve energy efficiency in building. High costs are needed to improve energy performance of existing houses as much as the modern buildings. The costs of investment and renovation of house, especially for low-income families, can be big pressure. At the UK, the renovation costs are high, although can show only 21% of total income. The portion of households is not same as different income class in this field. However, in low-income families, the cost of renovation is only equal to one third of the costs of highest income level, although it takes about 6.3% of total income (Baek & Park, 2012). This can make the pressure of renovation on low-income families be higher than heavy level. On the other hand, the homes of low-income families have mostly low performance. Hence, improvement in energy performance can most likely lead to considerable impacts. Such balance between homes with high potential for reduction of Co2 and income of residents can be considerable barrier to improvement of energy performance in existed residential buildings.

Insufficient information.

When a new building is built, the owner, builder, architect, real estate broker and other experts can observe the effect of energy performance efficiency regularly during the work; although the owner of existing home has low chance to visit the experts and can rarely obtain the relevant information.

According to a survey on the status of house receivables by the Ministry of Housing, Infrastructure, Transportation, and Tourism of Japan, the biggest hardness of restoration operation after lack of monetary is insufficient information (23.7%). In the studied restorations, a few numbers of consultation organizations are available for the renovation methods and the information of builders are also restricted. The insufficiency of information can be the main barrier to renovation of building energy consumption (Baek & Park, 2012).

Lack of supervisory systems.

The construction of new building should be under integrated and defined legal structure before switching. However, there is no special supervisory system to cover the renovation sector of existing residential buildings. Hence, high supervisory costs are needed. For these reasons, existing homes with weak energy are mostly left with no effort for renovation.

According to the mentioned, it could be found that what can be the reason for sustainable building restoration and renovation with low rate. Currently, the existing buildings are being renovated slowly. For example, the for example the portion of commercial buildings is about 2.2% per year (Olgyay & Seruto, 2010).

Titles of some studies in field of green restoration and renovation of existing buildings over the recent years.

Every year, various articles are being presented in field of green renovation of existing buildings and the date issues are decreased energy consumption, energy efficiency, environment protection, welfare of residents and so on. In table 4, the titles and summary of some relevant studies over the recent years are presented. With overview of variety of the table subjects, the need to further studies in this field can be understood.

Discussion.

Systematic approach for sustainable building retrofitting.

Figure 3 has illustrated systematic approach for identification, determination and implementation of the best retrofitting measures of existing buildings in 3 steps. This can be used for retrofitting any kind of building that needs partial changes or retrofitting:

Lifecycle analysis.

As it is observed, various climates are contained. In regard with building use, office buildings have high embodied energy because of using concrete and steel and being multi-story. In regard with operation energy, per m2 of office building, because of saving better thermal comfort conditions, light and high-energy facilities and devices; higher energy is needed. Hence, per m2 of office-business building, higher energy level is needed in lifecycle compared to residential building. Per m2 of residential building, usually 150-400kwh energy is consumed annually; although the value is about 250-550kwh in offices and business buildings.

The results obtained from the investigations show that in low energy building (LEB), because of special design of the buildings, they consume lower energy during their lifecycle compared to conventional urban buildings and this can be caused by active and passive technologies. However, the initial embodied energy of these buildings is a little higher than conventional buildings.

In regard with zero energy building (ZEB), although they are independent in terms of energy; they are not cost-effective because of high initial embodied energy and high costs of repair and maintenance. Along with advanced technologies, complicated and costly repair and maintenance costs and services, investment risks and abundant uncertainties, this issue has made construction of such buildings restricted to studies and laboratory cases or the cases supported by governmental budgets.

In these investigations, it could be observed that main part of lifecycle energy needed by buildings is operation energy. Hence, by means of technologies and active and passive methods, the energy can be declined. However, it should be noted that the way should be continued to a level that no reverse result is obtained and the embodied energy is not over increased. For example, using passive technologies, some of which are available in low cost and have cultural and historical origin consistent with the environment, can be good solution. Such technologies can be considered in the framework of ECM recommendations.

Another issue in these studies is that lifecycle energy in different countries is not same and non-cold regions and also developing countries, which supply electricity from fossil fuels, have higher energy consumption than others. For example, in Thailand, energy consumption in an office is about 950kwh per year, which is significantly higher than developed countries. It should be mentioned that because of type of technology, portion of fossil fuels in electricity generation in these countries is too high.

Feasibility.

In selection of feasibility and type and method of building retrofitting, value of using a building can be determined in terms of environmental, social and economic indices. For purpose of feasibility and determination of better building retrofitting, avoiding this action should be firstly predicted carefully using computer simulation and the toolkit of analysis of the lifecycle of environmental impacts. Then, it should be used to show the environmental advantages and economic advantages to protect the buildings and cultural values.

In feasibility, systematic approach methods including risk management and economic evaluation should be applied. In fact, based on relatively high risk of investment in this sector, type and amount of required financial resource is important.

Sometimes, demolition and reconstruction of buildings may be explainable in terms of economic and investment criteria; although they may be rejected based on cultural and social factors and urban design in terms of feasibility.

Historical buildings.

In the list of green building restoration, palaces and political centers are in last ranks and the reason can be hard access to these places. Hence, there are not numerous studies in field of buildings with political use.

Reconstruction and enhancement of energy efficiency in buildings with historical and cultural value can not only help reduction of carbon emission and waste of energy, but also can increase sustainable development and improvement of thermal comfort inside the building. Hence, the best way to preserve cultural heritage, along with sustainable development, can be adjustment of historical buildings with modern environmental standards and their protection and renovation. This issue is highlighted in countries and cities with older historical buildings or those, which have more tendencies for renovation than demolition and reconstruction because of cultural attachments, type and adjustment of urban design and the aforementioned issues.

In general, cultural and economic parameters play determinant role in taking measure for restoration and energy consumption in buildings. In developed countries, energy consumption rate is lower and trend for restoration of buildings is more than other countries; although the developing countries have more tendencies for reconstruction. This is because; various factors affecting reconstruction and retrofitting are subjective factors such as thermal comfort, sense of comfort, cultural attachments and so on, which need sociological studies, along with academic studies based on mathematics. Only sociological studies in this field include questionnaires filled out in special populations. In regard with the field of studies, majority of articles have emphasized energy saving, financial issues, CO_2 production rate and thermal comfort and such specific consideration shows importance of financial issues and policy of the governments on their commitment to security of energy, decreased consumption of fossil energies and global warming. Lack of studies in field of mental impacts of retrofitting and renovation can be hearing comfort, and emission of gases and toxic materials caused by building lifecycle; For example, investigations on toxic materials caused by demolition and gases causing acid rain. Overemphasis on the lifecycle method to study greenness of buildings based on energy consumption can be also investigated from this point of view.

CONCLUSIONES.

According to the mentioned, the results can be summarized as follows:

-- The previous literature has shown that performance of energy and surrounding area of building can be improved significantly through retrofitting. However, achievement of energy consumption point, regardless of technology and embodied energy, can be challenging.

-- Majority of previous studies have been conducted using numerical simulation. Saving real time energy based on retrofitting measures in real time buildings may be different from what was estimated. Further studies with practical case studies are needed to help increasing reliability in potential retrofitting advantages.

-- Retrofitting whole organization with energy comprehensive simulation, economic analysis and risk assessment can be effective method to identify the best retrofitting solution. Working, analysis and further studies are needed to facilitate the most cost-effective building retrofitting in this field.

-- Majority of studies are conducted in developed countries with cold and mild climate and this is not in consistence with the pattern of increased energy consumption, especially on fossil fuels in developing countries or emerging economic powers like India.

-- Choosing good criteria and allocation of weighting factors in formulation of the most cost-effective retrofitting strategies and multipurpose optimization issues are the most required issues. The main concern of owners of buildings in considering retrofitting should be carefully considered during development of optimization problem.

Human factors can have direct impact on energy consumption in buildings. Comprehensive studies are mostly relevant to human factors in building retrofitting.

As investment in building retrofitting can lead to high degree of uncertainties, further studies are needed for risk assessment of fundamental repairs. This case is significant based on renovated nature of low energy buildings and lack of information and practical data in this field and high cost of repair.

In feasibility studies and evaluation of renovation and retrofitting buildings, the cultural factors, subcultures, urban design and subjective factors should be also considered in addition to numerical problems.

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DATA OF THE AUTHORS.

1. Farshad Asadbeigi. Master student of Civil Engineering-Construction Management, Department of Civil Engineering, Central Tehran Branch, Islamic Azad university, Tehran Iran; Email: farshadasadbeigi1356@gmail.com

2. Javad Majrouhi Sardroud Assistant Professor, Department of Civil Engineering, Central Tehran Branch, Islamic Azad university, Tehran, Iran. Email: j.majrouhi@iauctb.ac.ir

3. Alireza Bijar. Master student of Civil Engineering-Construction Management, Department of Civil Engineering, Central Tehran Branch, Islamic Azad university, Tehran Iran; Email: alireza.bj@gmail.com

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