An Examination of the Energy-Efficient High-Rise Building Design

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Abstract. The need for sheltering that started with the existence caused to the concept of housing and has gone through various phases with sedentary life and urbanization. Due to urbanization, a process experienced in parallel with industrialization and economic development, the need for energy has increased. With the increasing need of energy, a great majority of natural resources are being used in the construction industry, particularly at high-rise buildings. It becomes increasingly impossible to meet energy needs of high-rise buildings with nonrenewable resources. Nevertheless, under today's conditions and with current technology, use of renewable energy sources is a quite expensive method. In order to meet the increasing demand in energy, it is required to use existing energy in an efficient and productive manner. For this purpose, this study suggests a conceptual framework including principles, strategies and methods related to energy efficient building design while examples of energy-efficient high-rise buildings applied worldwide are examined within the suggested framework.

Keywords: Energy · Energy-efficient building · High-rise building Design parameters

1 Introduction

About 11,000 years ago, our primitive ancestors, who lived in the region between the rivers Euphrates and Tigris in stone age when pottery was unknown (Neolithic age without pottery), had architectural skills and they had gathered in regular intervals (at Göbekli Tepe) for religious rituals. Gatherings due to these rituals had led to sedentary life [1] in time. The need for sheltering that started with the existence resulted with the concept of housing and has gone through various phases in parallel with sedentary life and urbanization. Urbanization is a process experienced in parallel with industrialization and economic development. Due to rapid population growth and industrialization, migration from rural areas to urban areas has increased and resulted in rapid urbanization accompanied by unhealthy life conditions in cities.

S. Fırat et al. (eds.), *Proceedings of 3rd International Sustainable Buildings Symposium (ISBS 2017)*, Lecture Notes in Civil Engineering 7,
https://doi.org/10.1007/978-3-319-64349-6_13

Rapid urbanization resulted with certain problems. Housing problem caused by the migration to cities following industrialization has led to unhealthy and irregular building and need for energy has increased. With the increasing energy demand, a great majority of natural resources are being used in the construction industry, particularly at high-rise buildings. It becomes increasingly impossible to meet energy needs of high-rise buildings with nonrenewable resources. Nevertheless, under today's conditions and with current technology, use of renewable energy sources is a very expensive method. In order to meet increasing energy demand, it is required to use existing energy in an efficient and productive way. For this purpose, this study suggests a conceptual framework including principles, strategies and methods related to energy efficient building design while examples of energy-efficient high-rise buildings applied worldwide are examined within the suggested framework.

2 An Examination of Energy-Efficient Building Design Parameters

Due to the increasing need of energy in cities, studies on energy-city relationship in urban planning processes have gained importance. Principles, strategies and methods for energy efficient urban planning of eligible and habitable residential and natural environment are proposed in the paper by Yücel Yıldırım et al. [2] are presented in Table 1.

Table 1. Principles, strategies and methods of energy-efficient urban planning

Principles (P)	Strategies (S)	Methods (M)
Energy Conservation (EC)	Reducing utilization of nonrenewable energy resources (EC1)	Reduction in energy consumption (EC1.1)
		Integration of energy technologies to city, elimination of the deficiency of renewable energy systems (EC1.2)
		Considering local climates at building design (EC1.3)
	Generation and utilization of renewable energy resources (EC2)	Enforcement of the regulations of implementation for renewable energy generation in settlements (EC2.1)
		Creation of aids and incentives for utilization of renewable energy sources (EC2.2)
		Arrangement of spatial areas containing renewable energy utilization (EC2.3)
		Development of social awareness and training on renewable energy (EC2.4)
	Determination of policies and basic principles for compliance and preventive actions for climate change (EC3)	Legislating and enforcement of the law on climate change (EC3.1)

(*continued*)

Table 1. (*continued*)

Principles (P)	Strategies (S)	Methods (M)
		Regulations for increase of energy efficiency and savings for controlling and reducing greenhouse gas emissions (EC3.2)
		Preparation of climate maps of settlements, and keeping them updated (EC3.3)
	Reduction of pollution (EC4)	Balanced distribution, preservation, and enhancement of green spaces within settlements (EC4.1)
		Connection of existing outdoor and green spaces to each other and to pasture area (EC4.2)
		Utilization of local vegetation suitable for climate (EC4.3)
		Development of urban forestry (EC4.4)
		Implementation of green wall and roof systems (EC4.5)
Land Conservation (LC)	Conservation of topographic structure of land (LC1)	Provision of harmony between land usage and topographic structure (LC1.1)
	Conservation of habitat (LC2)	Formation of inventory for natural resources, using values as basis of spatial planning (LC2.1)
		Preservation and growth of agricultural areas (LC2.2)
	Development of settlement plans by energy efficient development form and structure (LC3)	Selection of right location for upper-scale decisions based on climatic properties (LC3.1)
		Reducing heat island impact (LC3.2)
		Minimization of infrastructure and superstructure problems arising from land (LC3.3)
Water Conservation (WC)	Increasing utilization efficiency of water resources (WC1)	Utilization of systems allowing efficient usage of water
		Taking legal measures for efficient utilization and management of water resources and enforcement of the law on water management (WC1.1)
		Reduction in water consumption (WC1.2)
		Unpolluted utilization of water resources (WC1.3)

(*continued*)

Table 1. (*continued*)

Principles (P)	Strategies (S)	Methods (M)
Waste Reduction (WR)	Formation of waste and recycling systems (WR1)	Promotions to local administrations for waste systems and recycling (WR1.1)
		Increasing public sector supervision in waste management (WR1.2)
		Sorting of wastes on site, use of recycling technologies (WR1.3)
Ensuring Accessibility (EA)	Generation of environment-friendly urban transportation policies and plans (EA1)	Drawing plans of transportation and land usage suitable for public transportation (EA1.1)
		Developing energy-efficient transportation means and systems (EA1.2)
		Minimization of private vehicle ownership (EA1.3)

Today, a great majority of natural resources utilized in all areas of life, including transportation, industry and building, are being used in the construction industry, which deteriorates ecological balance and makes environment having harmful impact on human health. Solution of environment and energy problems relies on increasing use of renewable energy sources and efficient use of energy. Design parameters on efficient use of energy in construction industry may be listed as follows [3, 4]:

- Selection of location,
- Topography,
- Position of the building and its distance to other buildings,
- Direction of the building,
- Form of the building,
- Building facade's physical properties that affect heat transmission,
- Outdoor brightness level,
- Non-building obstacles that may affect climate and visual comfort,
- Physical properties of the building's indoor spaces,
- Dimensions and structure of building components such as windows and glasses,
- Properties of components constituting artificial lighting system,
- Solar control and natural ventilation systems.

In consideration of methodologies and data presented in articles by Gültekin and Yavaşbatmaz [5], Koç and Gültekin [6], Gültekin [7], Yılmaz and Hotunluoğlu [8], Barış [9], and Bashiri and Begeç [10], RoT Ministry of Energy and Natural Resources General Directorate of Renewable Energy year 2012 Activity Report [11] and Urbanisation Council Commission Report [12], book composed by Atabay et al. [13], MA thesis of Zinzade [14], "Regulation on Principles and Procedures Pertinent to Increasing Energy Efficiency in Transport" issued by the Ministry of Transportation [15], principles (P), strategies (S) and methods (M) on energy-efficient urban planning were assessed with design parameters related to energy-efficient building design. In conclusion to this paper, methods relevant to energy-efficient building design were presented from Tables 2, 3, 4, 5 and 6 and a conceptual framework was suggested.

Table 2. A conceptual framework on energy-efficient building design (energy conservation)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
EC	EC1	EC1.1	Selecting appropriate location for building
			Appropriate position of the building and appropriate distance to other buildings
			Orientating the structure in accordance with physical environment data
			Shaping form of structure in accordance with physical environment data
			Making use of the daylight at lighting
			Selecting energy-efficient construction materials
			On exterior surfaces, using construction materials of colors compatible with the climate
			Using high-performance joinery and glasses
			Reducing the building crust surface
			Introducing energy saving by efficient insulation systems
		EC1.2	Using solar batteries at power generation
			Making use of solar collectors at water heating
			Considering position relevant to the sun at energy-efficient building design
			Using wind turbines at power generation
			Making use of wind energy at ventilation and cooling
			Providing lighting with renewable energy sources
		EC1.3	Application of architecture compatible with the local climate
			Selecting local construction materials
	EC2	EC2.1	Enactment of regulations aiming at increasing energy efficiency at buildings
			Preparing a Enactment of Regulations aiming at increasing efficiency of energy resources and energy use at buildings
		EC2.2	Supporting energy-efficient projects to be implemented
			Providing incentives to reduce energy density
			Operation of a fixed-rate guarantee incentive mechanism on the condition of not being equal for each renewable energy source
			Supporting the right of unlicensed production for integration of small-scale enterprises to the national economy and to assure their efficient use
			Providing financial incentives such as VAT exemption, customs duty exemption
EC	EC2	EC2.3	Making use of renewable energy sources at building design
			Designing exemplary energy-efficient projects
			Implementation of pilot applications
		EC2.4	Efficient use of media

(*continued*)

Table 2. (*continued*)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
			Supplying training and certification services jointly with the energy management for energy surveys and efficiency enhancing projects
			Concerning energy efficiency, improvement of effective and productive cooperation with public bodies and agencies, universities, private enterprises and non-governmental organizations
			Preparing training and awareness videos
			Holding competitions
	EC3	EC3.1	Implementation of policies preventing climate change
			Preventing misuse of land
			Development and use of green technologies
			Following international meetings on climate change and implementation of decisions taken
		EC3.2	Development of renewable recovery techniques for elimination of greenhouse gas emissions
			Protection of natural resources with their physical, biological and ecological features
			Use of standardized construction materials that pose no problem of health and pollution
		EC3.3	Employing climate change maps as basis at building design
			Assessment of biological data
	EC4	EC4.1	Improving green area standards set forth in the zoning legislation
			Preserving current green areas during design process
			Introduction of a green mass standard that will eliminate greenhouse emission
			Constant improvement of the settlement's green value through standards, incentives and certification
		EC4.2	Arranging at least 40% of the land surface in current transformation zones as green areas or areas containing green elements
			Creating a network of green and open areas to improve urban flora and fauna, reduce greenhouse gas emission and to enable air circulation
		EC4.3	At settlements, using vegetation compatible with local climate conditions
			Using construction materials compatible with local climate conditions
			Preserving current vegetation as possible
		EC4.4	Preserving current forest areas
			Increasing the number of urban forests
		EC4.5	Selecting the plants in accordance with dominant wind direction
			Introducing vegetation compatible with climate conditions for each direction

Table 3. A conceptual framework on energy-efficient building design (land conservation)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
LC	LC1	LC1.1	Constructing the building in compliance with topography
			Protection of natural topography
			Introduction of a design that is compatible with natural features
			Selecting location in compliance with density of settlement
	LC2	LC2.1	Preserving existing natural resources
			Using natural resources inventory as a basis in design and its integration
			Protecting fertile land
		LC2.2	Preventing use of agricultural land for other purposes, preventing build-up
			Improvement of agricultural land lost due to misuse and their reclaiming for agriculture
	LC3	LC3.1	Forming construction areas according to climate data
			Efficient use of climate areas
		LC3.2	Preserving current tree cover
			Increasing areas to be forested
			Choosing right locations for the trees
			Selecting appropriate locations for plants in immediate vicinity of the buildings
			Implementation of green area works for improving climate of the settlement
			Application of green wall systems
			Application of green roof systems
		LC3.3	Identification of infrastructure and superstructure problems
			Ensuring spontaneous, mutual and reliable exchange of information with local agencies that implement infrastructure and superstructure works
			Creating sources for infrastructure and superstructure investments
			Identification of material, safety, positioning and excavation standards
			Coordinated implementation of planning and repair-maintenance works
			Carrying fertile land left inside the build-up area to green areas and making use of them

Table 4. A conceptual framework on energy-efficient building design (water conservation)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
WC	WC1	WC1.1	Use of instalments and equipment that consume water efficiently
			Installation of a waste water and grey water plant
			Using rainwater collection and storing systems
		WC1.2	Planning of water resources use
			Increasing efforts of awareness and consciousness in all segments of the society
			Compliance with standards on water retention in buildings

(*continued*)

Table 4. (*continued*)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
			Efficient and effective use of water
			Landscape arrangements that use water efficiently and require little maintenance
			Choosing in the landscape design plants that require little water and maintenance
			Increasing areas that have vegetation resistant to drought
			Treatment and reuse of waste water
			Reuse of rainwater after collecting at appropriate areas
			Treatment and reuse of grey water
		WC1.4	Renovation of sewage systems to prevent contamination of water resources
			Controlling polluting elements from sewage and storage areas by use of necessary technologies
			Reducing use of toxic pesticides

Table 5. A conceptual framework on energy-efficient building design (waste reduction)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
WR	WR1	WR1.1	Enhancing cooperation between local governments, public and private enterprises
			Implementation of training programs to raise public awareness and behavioral change on waste management
			Ensuring communication between public and public bodies authorized for collection, transport and disposal of wastes
			Implementation of the deposit system by local governments
		WR1.2	Developing the material management plan to prevent loss in source and production of wastes
			Identifying locations of waste and recovery plants in relevant plans
			Disposal of wastes without harming the habitat and topography
			Disposal of wastes without causing pollution in soil and water
			Raising awareness in issues of waste management and recycling
		WR1.3	Use of recyclable and reusable construction materials
			Use of construction materials that are capable of rapid self-renewal
			Sorting, storage and classification of reusable materials

Table 6. A conceptual framework on energy-efficient building design (ensuring accessibility)

Energy-efficient urban planning			Methods of energy-efficient building design
P	S	M	
EA	EA1	EA1.1	Preparing a transport plan that keeps the demand of transportation at a minimum level
			Development of pedestrian/bicycle transport systems and processing on physical plan
			Improvement of methods to enable use of public transport from the regional parking lots to urban centers
			Enhancing rail transport systems in urban transport
		EA1.2	More common use of clean fuels in transport
			More common use of vehicles with less fuel consumption
			Raising awareness of the consumer and making low-emission vehicles attractive
			More common use of smart traffic practices and smart transport systems that make use of information and communication technologies
			Raising efficiency standards in vehicles
		EA1.3	Planning relations between sheltering, work and instalment areas in a way that requires minimal energy
			Extending public transport network
			Creating pedestrian lanes
			Introduction of local parking lots

3 An Examination of Worldwide Energy-Efficient Building Design on High-Rise Buildings

Importance of efficient use of energy has been perceived in different manners in each country and in this context; different solutions and recommendations have been suggested. United States of America (USA) became one of leading countries to realize importance of energy efficiency and starting from 1970s, when an oil crisis was experienced, studies on energy efficiency were continued with an increasing momentum.

In consequence of the energy efficiency studies conducted in USA, achievements were obtained between the years 1973 and 2005, such as significant contribution to protection of environment, improving energy efficiency of household appliances, and avoiding construction of further power plants. Furthermore, USA did not find those achievements sufficient and a national action plan called "Vision 2025" was prepared in 2008 due to reasons such as energy efficiency is an untouched and low cost energy source which enhances energy supply security and reduces future risks of carbon policies that are already ruled by uncertainty [16].

On the other hand, European Union (EU) member states, starting from the beginning of 1970s, have implemented studies in order to reduce dependency on oil, enhance energy supply security, support competition by decreasing energy costs, reduce unemployment, protect the environment and minimize emission of greenhouse gases [16]. EU Commission, with its indirect taxation study in the year 2007, revised the Directive on Energy Taxation, attempted to introduce an encouraging energy taxation system, has examined the benefits of tax reductions and other incentives to increase the production of high energy efficient certified equipment and devices [17]. Furthermore, the EU, concerning energy savings, has enacted the Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings [18], Council Directive 2003/96/EC of 27 October 2003 Restructuring the Community Framework for the Taxation of Energy Products and Electricity [19], Commission Directive 2003/66/EC of 3 July 2003 Amending Directive 94/2/EC Implementing Council Directive 92/75/EEC with Regard to Energy Labelling of Household Electric Refrigerators, Freezers and Their Combinations [20], Communication from the Commission on the Implementation of the Energy Star Programme in the European Union in the Period 2006–2010 [21], Evaluation of the Energy Labelling and Eco-design Directives [22] and Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on Energy End-Use Efficiency and Energy Services and Repealing Council Directive 93/76/EEC [17, 23].

In Japan, where negative impact of the 1970s oil crisis was experienced, "Energy Conservation Laws" [24] was revised in 1999. In Japan, where energy efficiency studies are supported by the government through financial models that include tax incentives, long-term reimbursement credits, industrial corporations and the public support the studies on a voluntary basis and city governments are implementing from time to time various efficiency programs within their boundaries [25, 26].

In the process of design and application procedures of buildings, which have a major share in worldwide energy consumption, efficient use of energy shall be enabled when the legislative regulations and methods presented in the Table 2 evaluated together.

Due to decreasing energy resources and increasing environmental problems in the world, design and application of energy-efficient high-rise buildings are on the rise. Because initial investment costs of these buildings are high, office building applications are more commonly observed. In this paper, it has been examined whether the high-rise building examples in the literature are constructed according to the methods related to energy-efficient building design and whether the methods are fully implemented. Visionaire Building, Solaire Building and Helena Building in USA, Burj Mohammed Bin Rashid Tower in the United Arab Emirates, Telus Garden Building in Canada and Sky Terrace @Dawson Building in Singapore are some of the energy-efficient high-rise building projects. These examples, in consideration of methods of energy-efficient design listed in Tables 2, 3, 4, 5 and 6, are examined in the Table 7.

When it comes to energy-efficient building design approach, we failed to obtain sufficient information on international examples of high-rise buildings from literature. Therefore, examples of housing projects presented in the Table 7 were examined on limited information. It was found out that methods listed in the suggested conceptual framework are being partially implemented in the examples of high-rise building projects.

Table 7. High-rise building examples constructed in accordance with energy-efficient building design approach

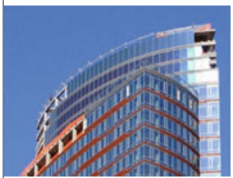
High-rise buildings		Energy-efficient building design approach
Visionaire Building [5, 27–29]	   *Country*: New York City, USA *Date of the Project*: 2006–2008 *Height*: 109.73 m *Number of Floors*: 35 *Intended Use*: Housing	• LEED Platinum certificate • Custom made BIPV panels (solar batteries) applied on western and eastern facades of the building generate electric power • Building has a rainwater storage system • Rainwater collected on the roof is used for irrigation of green areas • About 35% of the building's electric load is supplied from renewable energy sources • Materials used at construction of the building had been supplied from an area of a diameter of 800 km and from recyclable resources • Construction materials of self-renewing nature, such as bamboo were used indoor areas • Green roof application contributes in decreasing heat island effect • Durable and recyclable construction materials were used and efficient use of sources was ensured in the building • Materials used in the building were supplied locally and economically sustainable design was provided • Non-toxic construction materials were used during construction of the building • Insulating glass is used • Full length floor-to-ceiling glasses makes possible better use of natural light • Building has a waste water treatment system that enables reuse of waste water in the building • Air filtering system allows fresh air entry inside the building • In order to reduce significantly the power demand of building the heating and cooling systems are operated with natural gas

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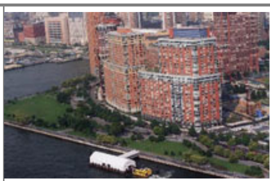
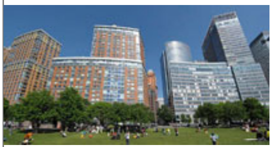
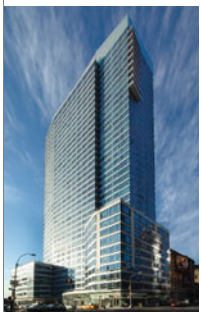
Table 7. (*continued*)

High-rise buildings		Energy-efficient building design approach
Solaire Building [5, 30–33]	  *Country*: New York City, USA *Date of the Project*: 2001–2003 *Height*: 85.29 m *Number of Floors*: 27 *Intended Use*: Housing	• LEED Golden certificate • Green roof application designed to collect almost 70% of the rainwater contributes in decreasing urban heat island effect • Rainwater collected on roofs is used at irrigation of green areas • Excess water not absorbed by vegetation is collected with grey water in a cistern and treated; it is used at irrigation of the green roof and parks in the vicinity • Waste water from the building is recycled • Solar batteries supply energy to meet the building's energy need • Supplying energy by solar batteries reduces energy consumption costs • Two thirds of materials used at construction of the building were supplied from intimate environs • 93% of waste materials produced at construction was recycled • Selecting recyclable construction materials increased source efficiency of the building • Tax deductions reduced construction costs and encouraged investor for construction of more energy-efficient buildings
Helena Building [5, 34–38]		• LEED Golden certificate • Green roof application contributes in decreasing urban heat island effect • Rainwater is collected and used at appropriate locations • Solar batteries generate energy • 20% of materials had been supplied from an area of a diameter of 800 km and use of local materials was supported • High-performance facade components reduce harmful effects of sun on indoors • Supplying construction materials from recyclable and local sources, energy and source efficiency was enhanced, costs

(*continued*)

Table 7. (*continued*)

High-rise buildings		Energy-efficient building design approach
	 *Country*: New York City, USA *Date of the Project*: 2002–2005 *Height*: 122.2 m *Number of Floors*: 37 *Intended Use*: Housing	were decreased and environmental pollution was reduced • Supplying the building's energy demand from renewable energy sources such as wind and sun minimizes energy consumption • High-performance double glass application reduced the harmful effect of ultraviolet rays on furniture • Glass reinforced concrete used on the exterior allows better use of natural light • Ventilation culverts on windows enable ventilation of rooms without opening windows • Wet surfaces, cupboards and doors were constructed of panels that are composed of wheat stalks that are easily renewable, recyclable and non-toxic, which contributed in reduction of wastes • Energy-saving power switches were used • Waste water obtained from the black water treatment plant was used in toilets, ventilation and air-conditioning systems (HVAC) and cooling towers of ¾ of buildings and at garden irrigation and efficient use of water was thus ensured • Devices with 'Energy Star' sign were used to reduce energy consumption
Burj Mohammed Bin Rashid Tower [39–41]	  *Country*: Abu Dhabi, United Arab Emirates *Date of the Project*: 2007–2014	• Energy efficiency was improved by means of triple-wall facade system • With the facade lining of high reflectivity that requires minimum-level maintenance, heat island effect was decreased, compatible conditions of comfort were supplied indoors • Energy efficiency was improved by solar collectors • Shading components were used on the facade to provide heat and visual comfort indoors • Towers were directed in positions that decrease sun effect • Tower roofs were designed to allow installation of further solar panels • Since power is supplied from a regional center, natural ventilation is supported by windows that can be opened

(*continued*)

Table 7. (*continued*)

High-rise buildings		Energy-efficient building design approach
	Height: 381.2 m *Number of Floors*: 88 *Intended Use*: Housing	• High-efficiency water fittings were used for water saving • Local plant species were grown to decrease garden irrigation and for water saving • Local materials were used to decrease costs of transporting imported materials at construction
Telus Garden Building [42–45]	  *Country*: Vancouver BC, Canada *Date of the Project*: 2012–2016 *Height*: 167 m, 88 m *Number of Floors*: 53 Condo, 24 Office *Intended Use*: Condo, Office	• Office building has LEED Platinum certificate. Condo has LEED Golden certificate • About 300 solar panels placed on the roof are generating 65000 kWh of power each year • Green roof application contributes in reducing heat island effect • Motion-sensitive, energy efficient lighting system reduces energy consumption • Building hosts a fully integrated and smart building system that controls all systems including energy-efficient lighting, heating, cooling and fire alarms. This system allows utilizing fresh air instead of recycled air • Rainwater is collected and used at appropriate locations • Building, which is included in the regional power system, contains a system that converts indoors heat for heating of air and water and approximately 1.000 tons kg of CO_2 gas emission is prevented per year • Since the building is located in proximity of the Sky Train, it hosts an electric vehicle charging station and bike facilities • Green mortgage bond was used in funding of the office buildings

(*continued*)

Table 7. (*continued*)

High-rise buildings		Energy-efficient building design approach
Sky Terrace @Dawson Building [46–48]	   *Country*: Soo Khian Chan, Singapore *Date of the Project*: 2008–2015 *Height*: 142 m *Number of Floors*: 43 (5 towers) *Intended Use*: Housing	• BCA Green Mark Platinum certificate • Rainwater is collected • Drip irrigation system is used for irrigation • Shallow depressions where rainwater is directly diverted without any processing and natural and foreign plants are grown host a 'rainwater garden', in other words, a bio-retention system [49]. Water collected in these areas is used for garden irrigation • Energy is generated by solar panels located on the roofs and generated energy is used for lighting of common areas and operation of lifts • High-performance double glass application enables decrease in heat loss • Water-efficient devices are being used • Motion-sensitive sensors are used to decrease power consumption at common areas and staircases to decrease energy consumption • Since they are equipped with variable voltage, frequency adjuster and sleep mode operation costs of the lifts have been decreased • Wastes are collected in the waste chute

It is observed that methods such as utilization of renewable energy sources, application of rainwater collection and treatment systems, reuse of treated waste water at appropriate areas, application of green roof systems to reduce the heat island effect, use of devices with high efficiency for water saving, use of local and recyclable construction materials, making use of natural lighting and ventilation to reduce energy consumption and application of high-performance facade and glass systems to decrease heat loss have come into prominence. We failed to get access to information such as positions, building directions, topographic compatibility and preservation of natural resources at buildings.

4 Conclusion and Suggestions

In today's world, where most of the world population lives in cities, it is a rather expensive method to provide all of increasing energy need from renewable energy sources with today's technology and conditions. It is therefore necessary to use existing energy efficiently and productively, which is a cheaper application to meet the increased energy need.

The conceptual framework suggested in this study may be adopted as a guideline in energy efficient building design, and consequently, may be used as a guide for different disciplines. In energy-efficient building design, although application of systems and studies that enhance energy performance increase initial investment costs, operation and maintenance costs required throughout the life of these buildings may be 5–10 times bigger than these application costs [50]. Accordingly, efficient and productive utilization of energy and renewable energy resources must be adopted as a government policy, and the public awareness must be increased. People shall be more selective as public awareness increases on efficient and productive utilization of energy, and investments of lesser energy consumption for less money shall be taken into consideration. In today's world, where economic growth and social welfare lead to more energy consumption, decrease in energy consumption, preservation of the environment, and reduction the burden of energy costs on the economy shall be provided with the enforcement of laws and regulations for efficient and productive utilization of energy.

Since energy is one of the elements that affect production costs at the highest level, generating the same quantity of output by using technologies that require less energy consumption for energy efficiency may result in decrease in costs. This will enhance competitive capacities of countries. Furthermore, by efficient use of energy, consumption will be lessened and accordingly, the countries' dependency on foreign energy sources will be reduced.

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