3. SUSTAINABILITY AND ENERGY ISSUE IN BUILT ENVIRONMENTS, ENERGY DEMAND AND CARBON EMISSIONS OF BUILDINGS

To understand associations between sustainability and energy issues in the built environments and to find effective strategies for energy saving in built environments, this chapter aims to examine the urban dilemma, energy demand and carbon emissions of buildings as well as the attributes of buildings.

3.1. Definiton and Measurement of Sustainability

The catchword or the keyword "sustainability", particularly used by politicians and professionals, has become an integral part of the life cycle since humanity has assumed its fate. Despite the long time since it was understood, it has not been defined in a manner it deserved. The definiton of sustainability is an issue that will determine the decision about the next millennium (Krishan, 2002).

Sustainability can be interpreted in many legitimate aspects such as environmental sustainability, economic sustainability or social sustainability. There isn't a general agreement on precise definitions within these different aspects. For instance, environmental sustainability may be interpreted in terms of preserving ecosystems, reducing CO_2 emissions or reducing the use of non-renewable natural resources. Engineers, architects or industrial designers still have the task of developing new technologies and consumer goods to address the technical problems such as shelter and food, health, comfort or economic benefits that arise in the quest for a solution to the growing world population. Sustainability is thought to be essentially practical rather than a theoretical science. Many different disciplines should be brought together in the context of sustainability. Therefore there is a need for collaborative strategies (Robinson, 2004, Holden, Elverum, Nesbit, Robison, Yen and Moore, 2008, Itard and van den Bogaard, 2010).

Within the framework of 3-P approach (Figure 3.1), sustainability has the role of protecting and maximizing the benefit of the 3Ps, which is also called the triple bottom line. 3P is used for "People, Planet, Profit" (Elkington, 1997).

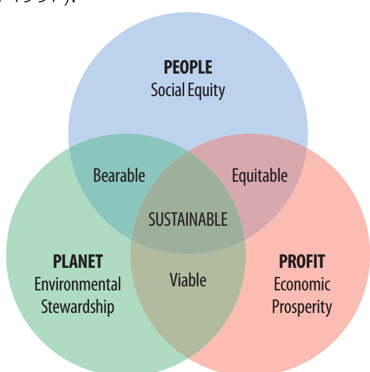


Figure 3.1. The triple bottom line or the three P's (New Leaf Sustainability Consulting, 2019)

It is impossible to address all relevant environmental, economic, and social perspectives. "Sustainable development is the development that meets the present needs without compromising the ability of future generations to meet their own needs" according to Brundtland Report (Brundtland, 1987). When it comes to defining ecological sustainability itself, Brundtland's definition is not very practical because it has no specificity (Itard and van den Bogaard, 2010).

The problem of defining sustainability is closely related to the problem of measuring it. The four ways to measure sustainability and its drawbacks and advantages are given below (Itard and van den Bogaard, 2010):

- Using quantities of materials and energy used,
- Using simple indicators based on the three step strategy such as materials with low environmental impact, materials with high environmental impact, recoverability, renewability, downcyclability, recyclability, and dismantleability of materials and components used (Hendriks, 2001, Duijvestein, 1997, Rovers, 2005, Brouwers and Entrop, 2005),
- Using the environmental footprint of materials and processes (Wackernagel and Rees, 1996),
- The use of environmental impacts in the context of life cycle assessment (LCA) methodology (ISO, 1996 & 2006).

According to recent research in the world, efforts to reduce energy consumption alone are unlikely to lead to more responsive environments or improve quality of life. Therefore, more comprehensive methods should be sought to evaluate and monitor the change and transformation in built environments to achieve sustainable environments. Whether focusing on energy consumption or on wider sustainability issues, most assessment methods are building-related or household-oriented. Therefore, although these methods systematically examine separate spatial and social entities, they neglect the spaces between the holistic dimension and the social dimension (Verovsek, Juvancic and Zupancic, 2018). In this context, the footprint is a measure for sustainability, and a simple measure of the sustainability of a population's consumption was introduced as the ecological footprint by Wackernagel and Rees (Wackernagel and Rees,1996).

3.1.1.Ecological footprint

The simplest way to define an ecological footprint would be to name the impact of human activities measured as a biologically productive land and water area required to produce consumed goods and to assimilate the generated waste. To put it simply, ecological footprint is the amount of environment necessary to produce services and goods necessary to support a particular lifestyle (Ecological Footprint, 2019). The ecological footprint converts all consumption into the land used in production, along with the theoretical land needed to sequester the greenhouse gases produced. Consumed goods and activities are taken into account when calculating the ecological footprint. In this way an idea can be reached about the sustainability of the society in different scales (local, national and international) (Sustainable Footprint, 2019). Human habitat, the physical manifestation of the socio-economic ecological context, is the largest consumer and energy producer in terms of ecological footprint. To obtain an optimum ecological footprint, different parameters such as those in Figure 3.2 can be optimized.

Parameters	Methods
Reduction in Energy Input	Through climate responsive design (The systemic strategy of climate responsive design is the first priority level and is critical)
	Appropriate technology (Participatory and intelligent use with active environmental control, and daylight optimization)
	Optimization of embodied energy through value engineering and lifecycle costing.
Lowering Environmental Impact	Maximize landscape integration, optimize land use, recycle rainwater
	Avoid toxic substances
	Minimize $C0_2$, CFC, and other environmentally decreasing emissions

Lowering Waste Production	Increase the recyclability of elements and materials in buildings, use of recycled materials	
	Recycle waste as alternative material/ source for water, energy, etc.	
Maximizing Use of Renewable Energy	Maximize solar usage with passive (building design), solar thermal tools, active PY integration.	
	Maximize alternative energy sources such as cogeneration, wind, minihydro, biomass etc.	

Figure 3.2. Parameters to optimise ecological footprint in buildings (Krishan, 2002)

One of the major advantages of ecological footprint is that it is a very powerful communication tool and a good means of rehearsal for the use of natural resources. Its major drawback is that it does not capture environmental impacts such as depletion of resources, toxicity or CO_2 emissions. However, the collection of data, which required measuring the environmental footprint, needs an inventory of the Energy-Resource Flow Ecological Footprint materials, energy and production processes used, as in a material flow analysis (Itard and van den Bogaard, 2010).

3.1.2. Energy-Resource Flow Ecological Footprint

To derive the energy and carbon footprint of micro combined heat and power (MCHP) systems, from the environmental standpoint, mainly fossil and/or non-renewable energy demand and related carbon emissions ought to be considered (Dorer and Weber, 2009).

The energy-resource flow model developed and illustrated in Figure 3.3 shows the input-output relationships. Air, water, land are the main environmental resource inputs while materials (embodied energy) and fossil fuels (primary energy) are the main natural resource inputs. Outputs - emissions are the main source that changes the environmental context. This internal input-output relationship determines the ecological footprint of community, city or region / country, which

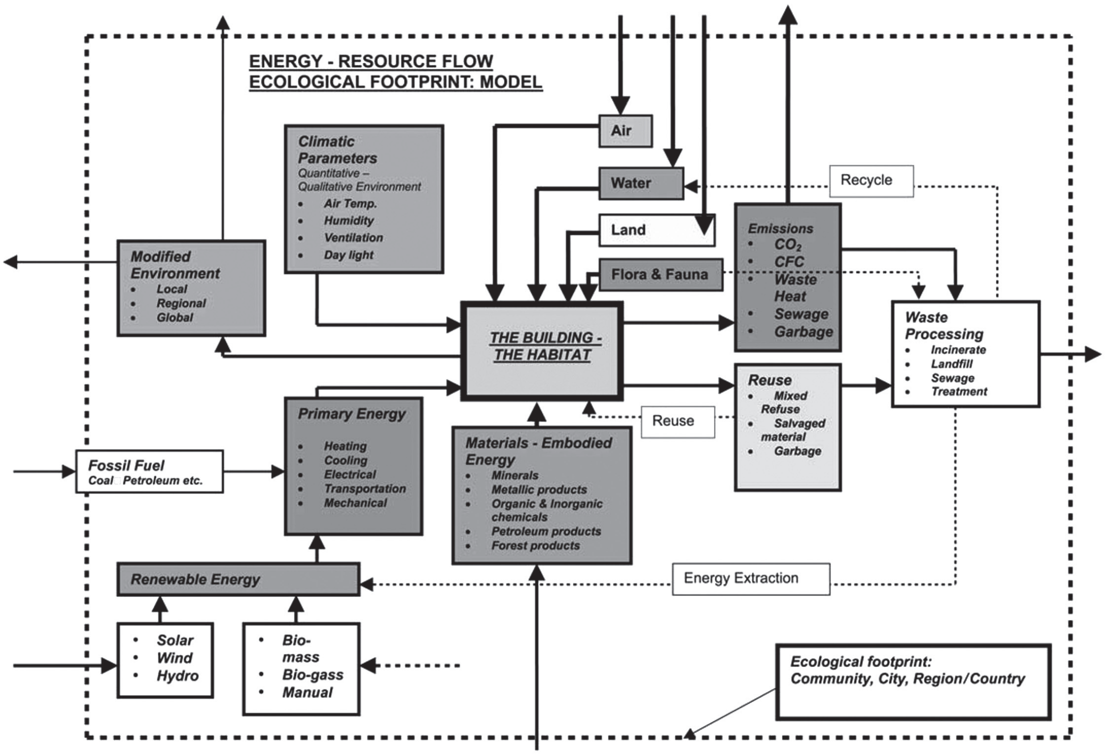


Figure 3.3. The energy-resource flow ecological footprint model (Krishan, 2002)

are the ultimate determinant of sustainability. Although there is a direct intervention for reducing environmental and natural resource inputs, waste treatment - energy extraction, combined with "renewable energy" systems, ensures the recycling of energy and resources. Nevertheless, the habitat / building is at the center of this entire flow model (Krishan, 2002).

3.2. Sustainability and Energy Issue in Built Environments

The built environment is not only the largest industrial sector in economic terms, but also the largest in terms of resource flow (Lazarus, 2005). According to the U.S. Green Buildings Council, buildings account for 65% of U.S. electricity consumption, 36% of total U.S. primary energy use, and 30% of total U.S. greenhouse gas (GHG) emissions (Greenbuild International Conference and Expo, 2018).

The European countries are in a similar situation to the U.S. Buildings in the European Union (EU) countries are responsible for 40% of EU energy consumption, and 36% of EU CO2 emissions (Benefits of Green Buildings, 2019). For this reason, the EU is pushing its 2020 targets for "more energy efficiency". The energy performance of buildings is key to the EU Climate & Energy targets, namely for 20% reduction of greenhouse gas emissions by 2020 and 20% energy savings by 2020. Improving the energy performance of buildings is a cost-effective way to combat climate change and improve energy security, but also creates job opportunities, especially in the construction sector (EuropeanUnion, 2016).

3.2.1. Urban Dilemma in the Context of Built Environments

As more people occupy cities to live, some challenges become easier to overcome, but some challenges such as sustainability becomes harder to achieve. The rise of the number of metropolises from 3 in 1901 to 23 in 1991 is a phenomenon that changes the urban context very quickly (Krishan, 2002). In terms of different sustainability perspectives, it is becoming more impossible to provide sustainable development, infrastructure, health, education and transportation services.

The proportion of urban population in the world is expected to increase from 55% (some 4.2 billion people) to 68% by 2050 in 2018, which means that the world urban population will almost double. By 2100, 85% of the population will live in cities, and the urban population will increase from 1 billion to 9 billion between 1950 and 2100. Some regions with urbanization rates in 2018 include: North America (82%), Latin America and the Caribbean (81%), Europe (74%) and Oceania (68%). While Asia has only 50% of urbanization, it is home to 54% of the world's population. With 43% urbanization at the world level, Africa is at the same level as Europe, which represents 13% of the world's urban population. The level of urbanization in Europe is expected to increase from 74% to 75% in 2020 and 83.7% in 2050 today. The urban population is growing much faster in developing regions than in developed ones. Africa is expected to be the fastest urbanization area. The urban population rate rises from 43.5% in 2020 to 59% in 2050. Most of the 43 megacities with an estimated population of more than 10 million by 2030 will be in the developing regions (Worldwide urban population growth, 2019). By 2025, China will have more than 220 cities with more than 1 million inhabitants and 8 megacities with more than 10 million inhabitants. China's 55% urbanization rate is expected to reach 60% compared to $ 6.8 trillion (Cheshmehzangi, 2016).

As the population grows, urbanization, of society which has an increasing impact on the environment, becomes inevitable, while the ecological footprint of cities is spreading (The University of Hong Kong, 2019). Globally, resident areas grow faster than the population. While the population growth in BRICS was 30% in the 1990-2014 period, the construction area grew by 67%. In the OECD, rates are halved: 18% for the population and 32% for residential growth. Unless there are better urban policies, over the next 20 years, the number of city dwellers may reach 5 billion in the developing world (60% of the world's population). Approximately 50% of the world's inhabitants live in settlements with less than 500,000 inhabitants. By 2050, the number of inhabitants will increase by 416 million in India, 255 million in China, and 189 million in Nigeria. One of the Goals of Sustainable Development 11 "Make cities and human settlements inclusive, safe, flexible and sustainable" is: 20 By 2030, ensure that everyone has access to adequate, safe and affordable housing and basic services, and upgrade to slums". The 10 objectives under this sustainable development goal (SDG) provide a framework for intensifying efforts to improve urban life for all (European Commission, 2019).

Reducing energy consumption and creating energy-efficient environments are the main objectives of many sustainability agendas followed by appropriate assessment methods in urban analytics. To date, the majority of assessment methods - whether it focuses on energy consumption or on wider sustainability issues - are building / household oriented, and they systematically examine separate spatial and social assets, ignoring the areas between them (linking infrastructures and services, mobility, public space and urban design solutions, etc.) and holistic and social aspects. (Verovsek, Juvancic and Zupancic, 2018).

3.2.2. Sustainability and Energy Issue in Urban Planning

The original concept of sustainable development has been defined as the form of today's development that will ensure the future continuous development of cities and urban communities. The theory of sustainable urban development is the result of environmental debate on environmental issues, and in particular the urban environment has been presented in the direction of "sustainable development theory" in order to support environmental resources.

Sustainable urban development is necessary to match environmental constraints and human activities associated with cities and design techniques within these constraints. In this theory, resources for current and future maintenance issues are increased through the conversion of waste into renewable resources and optimum use of land. A sustainable urban development theory raises issues such as preventing urban and regional environmental pollution, reducing the production capacity of the national, regional and local environment, promoting recycling, preventing harmful development, and eliminating the gap between the rich and the poor. Besides, it supports energy-efficient urban planning (Larijani, 2016). This theory is based on various scales using top-down and bottom-up methods. The relationship between these scales is presented in Figure 3.4.

Figure 3.4. The use of top-down and bottom-up method for sustainable urban development (Hamedani and Huber, 2012).

Sustainable growth for a sustainable world and sustainable countries requires an evolution through activities such as the movement of people and goods, and in the manner the urban areas use the resources. In addition to social and economic processes, physical infrastructure must evolve to accept the challenges of growth. However, sustainable urban development refers to a process in which sustainability can be achieved, including both environmental and social dimensions, emphasizing improvement, progress and positive change. Sustainable urban development emphasizes the need to reform market mechanisms to achieve environmental objectives and to balance economic and social issues. Several themes common to all definitions of sustainable urban development have emerged in time, which are presented in the following (European Commission, 2019):

- A change growth quality.
- Conservation and minimization of non-renewable resources.
- Integrating economic decisions with the environment.
- Strong consideration of the needs of future generations.

In the framework of the mentioned environmental, economic and social dimensions, Alqahtany et. al. (2014) proposed a model for sustainable urban planning development with the main dimensions, categories and criteria, which is presented in Figure 3.5.

The methodologies for impact assessment of the

Figure 3.5. A model for sustainable urban planning development with the main dimensions, categories and criteria (Alqahtany, Rezgui and Li, 2014)

built environment were first developed and implemented at the level of individual buildings and at the neighborhood level with well-known certification standards and tools today. These tools are often applied to planned structures and hypothetically take into account their entire life (from planning and construction to use, maintenance, renovation, and final demolition). With the expansion of urbanized areas, the focus of strategic planning and research has shifted to the scale of the neighborhood or local community. This creates a manageable yet diverse unit that can play a major role in achieving the sustainability and quality of life objectives at the urban scale (Verovsek, Juvancic, Zupancic, 2018).

In the last decade, there are several frameworks for neighborhood sustainability assessment, which are developed worldwide and are the most widely known systems such as HOE2R (HQE High Quality Environmental standard), CASBEE-UD (Comprehensive Assessment System for Building Environment Efficiency - Urban Development), BREEAM - Communities (Building Research Establishment's Environmental Assessment Method - Communities), LEED-ND (Leadership in Energy and Environment Design - Neighborhood Development) etc. Due to the increasing energy demand in cities, the energy issue is one of the most important dimension of each of these neighbourhood sustainability assessment tools.

Owing to the abovementioned increased energy needs in cities, studies on energy-city relationship in urban planning processes have gained importance. It is obvious that urban planning is not just about regulating and improving any physical space; urban development should be considered together with economic, communal, social, environmental and physical dimensions and it is necessary to evaluate their interactions with each other (Yazar, 2006).

In urban planning, spatial structure is generated by variables such as site selection, land use, urban size, urban macro form, density, communication and transportation facilities. Any change in any of these variables has a significant impact on energy supply requirements (Erbaş, 2008). Therefore, in order to ensure energy efficiency, variables should be taken into consideration in energy efficient urban planning.

"Energy Efficiency in Settlements" is the most important issue of the urban planning discipline (Sinmaz, 2015). In other words, energy efficiency, defined as the efficient use of energy, should start with urban planning. Energy that is saved as a result of efficient use is the lowest cost energy and it is a means of more-efficient energy use by adopting certain habits, applying improvement methodology or using new technologies, without sacrificing production and quality and the standard of social life (Chamber of Electrical Engineers, 2005). In order to ensure energy efficiency, urban plans that are sensitive to environmental problems, protect the ecological balance and fulfill the comfort and health requirements necessary for human life come to the forefront.

Energy conservation, land conservation, water conservation, waste reduction and ensuring accessibility are the principles to be considered in energy efficient urban planning. These principles will contribute to energy efficient urban planning in terms of environmental, economic, and social dimensions. In the energy efficient urban planning process, it is necessary to identify the qualified and livable natural environment in accordance with the strategies and methods for settlement plans and the principles of urban planning. Principles, strategies and methods of energy efficient urban planning proposed by Yıldırım et. al. are presented in Figure 3.6.

Principles	Strategies	Methods
Energy Conservation	Reducing use of nonrenewable energy resources	Site selection and execution for settlement areas according to the sun
		Reduction in energy consumption
		Integration of ernergy technologies to city, elimination of the deficiency of renewable energy systems (solar, wind, bioenergy, waste energy, water and geothermal)
		Promotion of architecture suitable to local climate and utilization of local building materials
	Generation and utilization of renewable energy resources	Issuance and enforcement of the regulations of imple1nentation for renewable energy generation in settlements
		Creation of aids and incentives for utilization of renewable energy sources
		Arrangement of spatial areas containing renewable energy utilization
		Development of social awareness and training on renewable energy
		Provision of city lighting by means of renewable energy systems
	Determination of policies and basic principles for compliance and preventive actions for climate change	Legislating and enforcement of the law on climate change
		Regulations for increase of energy efficiency and savings for controlling and mitigating greenhouse gas emissions
		Preparation of di mate maps of settlements and keeping them updated
	Reduction of pollution	Balanced distribution, preservation and enhancement of green spaces within settlements
		Connection of existing outdoor and green spaces to each other and to pasture area
		Utilization of local vegetation suitable for climate
		Development of urban forestry
		Implementation of green wall and green roofing systems
Land Conservation	Conservation of topographic structure of land	Provision of harmony between land usage and topographic structure
	Conservation of habitat	Formation of inventory for natural resources
		Formation of a basis in spatial planning by use of natural resource values as data
		Preservation and growth of agricultural areas
	Development of energy efficient development form and structure when preparing settlement plans	Selection of right location for upper-scale decisions based on climatic properties
		Mitigation of heat island impact
		Minimization of infrastructure and superstructure problems arising from land
Water Conservation	Increasing utilization efficiency of water resources	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
		Reduction in water consumption
		Having environmental planning utilizing water efficiently and requiring less maintenance
		Renewal of sewage systems to prevent contamination of water resources
	Reuse of waste water	Developing proper technologies for storing and recycling of water
		Treatment and reuse of waste water
		Collection of rain water and reusing in suitable areas

Waste Reduction	Formation of waste and recycling systems	Promotions to local administrations for waste systems and recycling
		Increasing public sector supervision in waste management
		Sorting of wastes on site, use of recycling technologies
	Designation of regular landfill areas and waste disposal facilities so as not to cause environmental population and waste of resources	Marking locations of such facilities on relevant plans
Ensuring Accessibilty	Generation of environment-fiiendly urban transportation policies and plans	Drawing plans of transportation and land usage suitable for public transportation
		Developing the pedestrian/bicycle transportation systems and marking them in the physical plan
		Developing energy-efficient transportation means and systems
		Minilnization of private vehicle ownership
	Preparation of environment-friendly and energy efficient urban plans	Establishing relationships between housing, working and required locations in such a way that they require minimum energy

Figure 3.6. An energy efficient urban planning approach (Yıldırım, Gültekin and Tanrıvermiş, 2016)

3.2.3. Sustainability and Energy Issue in Building Design

The building sector is one of the key sectors for achieving a sustainable society. In addition to the classical challenges faced by building planners during the design phase (architectural integration, cost, etc.), new constraints have recently emerged. In the European Union, around 36% of GHG emissions are generated by the built environment (European Commission, 2016). To improve the sustainability of the construction sector, many countries have implemented regulations not only on GHG emissions, but also on the amount of primary energy used in operation (European Commission, 2010, Vuarnoz et al., 2018).

Outlining the criticality of planning and design of the habitat/building, wherein, climate-responsive building design and ecological planning become the determinants of energy-resource flow and offer a powerful tool for optimisation (Krishan, 2002). This leads to defining a process of building design that is scientific and developed on an ecological basis. Process of building design is a complex exercise, involving interactive relationships between parameters of diverse nature and varying magnitude (Figure 3.7).

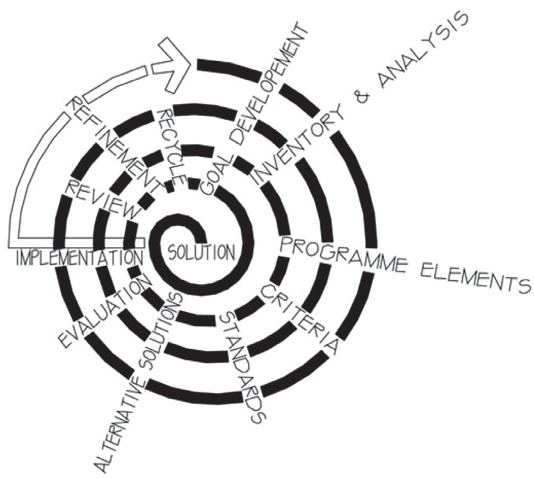


Figure 3.7. Process of building design (Krishan, 2002)

From time to time, various ideas dominated architectural thinking. However, the basic issue of energy - the ecological context - as an arrangement of sun, wind and light, was not a basic design paradigm. Therefore, the relationship between the established form and the ecology should be the driving force behind the process, based on a scientific methodology that leads to climatic responsive architecture (Krishan, 2002). In Figure 3.8 and Figure 3.9, demonstrate the climate responsive building design case studies, which would achieve energy efficiency, and energy saving systems.

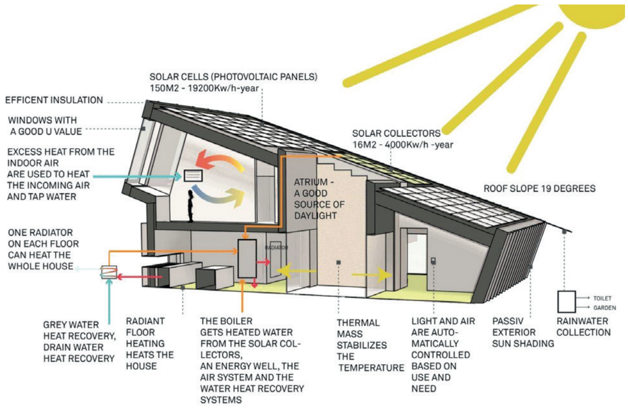


Figure 3.8. Energy saving systems in climate responsive building design (Green, 2019)

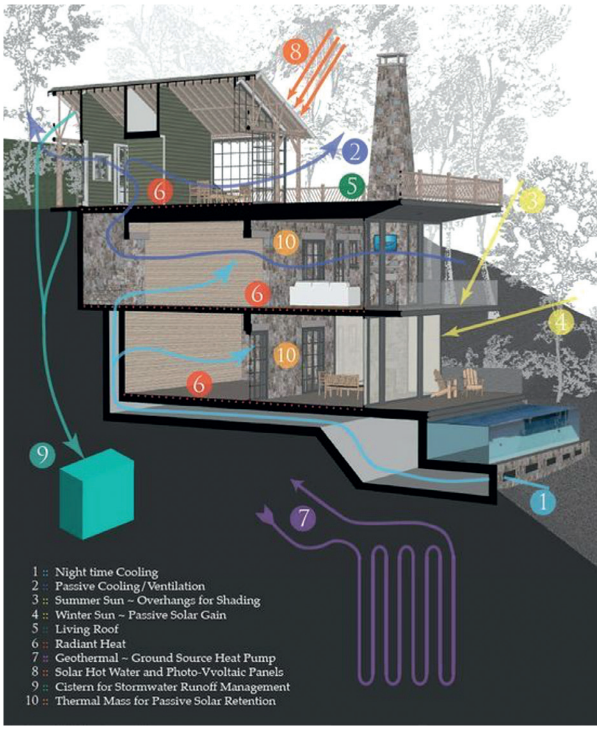


Figure 3.9. Climate responsive building design systems diagram (Good Architecture, 2019)

The cost of energy and natural resources used by buildings in construction, use and demolition processes is quite high (Collins, 2008). For a more livable and economic future; Sustainable building design procedures have been developed around the world that use land efficiently, use energy efficiently, experience projects to reduce water consumption, and take into account material efficiency and indoor air quality when waste efficiency and environmental issues are considered (Yıldırım, 2016).

Sustainable building design minimizes energy consumption, the use of resources and environmental impacts of buildings, providing minimum operating costs for buildings. In this context, buildings are evaluated in the framework of international building certification systems that contribute to minimizing the environmental impacts of buildings and guide designers and are certified according to sustainability classifications (Gültekin, 2018). The most widely accepted and widely used building certification systems in the world are Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED).

The aim of sustainable building design is to create a built environment that does not disrupt the ecological balance, minimizes the harmful impacts of buildings on the environment, uses resources economically, and provides the necessary conditions for human comfort and health (Gültekin and Yavaşbatmaz, 2013). It is seen that only the environmental aspects of sustainability are directly taken into account when talking about sustainable structure. However, in the design of sustainable buildings, the economic aspect that produces a positive long-term economic impact and the social aspect that improves the lives of people interacting with the buildings must be included in the design (Officine Green Building, 2017).

Gultekin et al. classified the aspects, strategies, criteria, and procedures of sustainable building design considering the conceptual frameworks of different scientific studies and the LEED (LEED. U.S. Green Building Council, 2017) and BREEAM (BREEAM. Category Issues and Aims, 2019) evaluation criteria in terms of environmental, economic and social aspects. This classification is presented in Figure 3.10, Figure 3.11 and Figure 3.12. According to this classification, strategies of environmentally sustainable building design aspect are classified as "site efficiency, water efficiency, energy efficiency and material efficiency"; strategies of economically sustainable building design aspect are classified as "resource efficiency and cost efficiency"; and strategies of socially sustainable building design are classified as "health and wellbeing and public awareness".

	CRITERIA	**PROCEDURES**
STRATEGY OF SITE EFFICIENCY	Protection of Natural Habitats	Preservation of existing natural resources
		Preservation of existing flora and fauna
		Disposal of wastes without harming the habitat
	Protection of Natural Topography	Construction of the building in compliance with topography
		Preservation of water table
		Disposal of wastes without harming the topography
	Protection of Fertile Lands	Prevention of misuse of agricultural lands
		Reduction of erosion and industrial pollutants
		Disuse of toxic pesticides
		Improvement of agricultural lands lost due to misuse
		Prevention of agricultural lands from being made available as settlement
		Carrying off fertile lands of the construction site to green areas
		Disposal of wastes without causing land pollution
	Improvement of Urban Areas	Selection of location according to urban density
		Increase in green areas
		Promotion of mixed-use urban development
		Effective use of construction sites
		Redevelopment of brownfields
		Reclamation of abandoned mine lands
		Rehabilitation of existing settlements and buildings
	Improvement of Transpottation Systems	Development of pedestrian/bicycle transportation systems
		Extension of public transport network
		Integration of building design with public transportation
		Development of public transportation from regional parking lots to city centers
		Improvement of rail transport systems in urban areas
		Provision of human-powered public transportation
		More common use of ciean fuels in transportation
		More common use of vehicles with less fuel consumption
		More common use of s1na11 traffic practices and systems
		Rise of efficiency standards in vehicles
		Creation of pedestrian ways, pockets, and lanes
		Creation of parking systems and local parking lots
	Mitigation of Heat Is land Effect	Preservation of existing tree cover
		Increase of forest areas
		Selection of right vegetation for right places around buildings
		Integration of green areas in building design
		Application of green wall systems
		Application of green roof systems

STRATEGY OF WATER EFFICIENCY	Reduction of Water Consumption	Use of waterless toilets and urinals
		Use of bio composting toilets
		Use of small volume cisterns
		Use of water-saving flushes
		Use of low-flow fixtures
		Use of timers and automatic control devices
		Use of indigenous landscaping
		Use of vegetation with less water need
		Use of low-maintenance vegetation
	Reuse of Waste Water	Treatment and reuse of greywater
		Treatment and reuse of rainwater
	Unpolluted Use of Water Resources	Renovation of sewage systems to prevent contamination of water resources
		Control of polluting elements in sewage and storage areas
		Disposal of wastes without causing pollution in water resources
		Reduction of toxic pesticides
		Management of water resources systems
STRATEGY OF ENERGY EFFICIENCY	Use of Passive Heating, Ventilating, and Air Conditioning	Use of trombe walls for natural heating and air conditioning
		Use of metal walls for natural heating and air conditioning
		Use of double-skin façades for natural heating and air conditioning
		Use of greenhouses for natural heating and air conditioning
		Use of venturi chimneys for natural ventilating
		Use of wind scoops for natural ventilating
		Use of atriums for natural heating and air conditioning
		Use of building shading devices for natural air conditioning
		Use of labyrinth systems for natural heating, ventilating and air conditioning
		Use of wind energy by cross ventilation method for natural ventilating
		Use of effective insulation system
		Selection of appropriate distance to other buildings compatible with local climatic conditions
		Selection of appropriate position for building compatible with local climatic conditions
		Selection of appropriate building form compatible with local climatic conditions
		Use of appropriate colors on fa9ades compatible with local climatic conditions
		Determination of building envelope surface compatible with local climatic conditions
		Selection of appropriate location for building
		Selection of right vegetation for right direction around buildings
		Preservation of existing green areas

	Use of Active Heating, Ventilating, and Air Conditioning	Use of photovoltaic panels for power generation
		Use of solar collectors for water heating
		Use of wind turbines for power generation
		Use of water source heat pumps for power generation and water heating
		Use of geothermal heat pumps for power generation and water heating
		Use of energy efficient appliances and equipment with timing devices
	Utilization of Daylighting	Use of light shelves
		Use of solar tubes
		Use of heliostats
		Use of anidolic ceilings
STRATEGY OF MATERIAL EFFICIENCY	Reduction of Environmental Impacts	Use of local building materials
		Use of natural building materials
		Use of high-performance building materials
		Use of long-lasting building materials
		Use of durable building materials
		Use of nontoxic and noncarcinogenic building materials
		Use of antibacterial building materials
		Use of low embodied energy building materials
		Use of low Volatile Organic Compound (VOC) building materials
		Use of building materials made from renewable sources
		Use of building materials with less maintenance need
		Use of building materials extracted without ecological damage
		Use of certified wood materials
		Use of environmental and health product declarations
	Reduction of Wastes	Use of reusable building materials
		Use of recyclable building materials
		Use of reclaimed building materials
		Use of recycled building materials
		Use of non-conventional products as building materials
		Rehabilitation and reuse of existing structures
		Rehabilitation and reuse of existing infrastructures
		Sorting, storage and disposal of wastes by waste management
	Proper Sizing of Building and Systems	Design of sufficient sized interior spaces
		Reduction of building envelope surface
		Use of simple geometrical forms for building design
		Utilization of flexible and modular building design
		Utilization of standard building material sizes

Figure 3.10. Environmental aspect of sustainable building design (Gültekin, 2018)

	CRITERIA	PROCEDURES
STRATEGY OF RESOURCE EFFICIENCY	Conservation of Raw Materials	Use of reusable building materials
		Use of recyclable building materials
		Use of reclaimed building materials
		Use of recycled building materials
		Use of long-lasting building materials
		Rehabilitation and reuse of existing structures and infrastructures
		Development of new eco-innovative building materials
		Optimization of supply chain
		Optimization of material production techniques
	Conservation of Nonrenewable Resources	Increase of use of renewable energy resources
		Reduction of energy consumption in all life cycle stages of buildings
		Use of energy saving electrical installation
		Use of energy saving heating, ventilating and air conditioning installation
STRATEGY OF COST EFFICIENCY	Reduction of Initial Cost	Use of local building materials to reduce transportation cost
		Use of recycled building materials
		Use of reclaimed building materials
		Reduction of transportation to and from the site
		Utilization of flexible and modular building design
		Use of standardized building components
		Use of common and available building components
		Safe and correct storage of building materials
		Reduction of time for assembly of building materials on site
		Selection of appropriate construction technologies for various building types
		Selection of appropriate suppliers for building materials
		Selection of right labor force for right positions
	Reduction of Operating Cost	Selection of long-lasting building materials and components
		Reduction of maintenance and repair cost
		Reduction of regular cleaning cost
		Selection of right location for heating, ventilating and air conditioning systems
		Use of easy-to-use building automation and control systems
	Reduction of Recovery Cost	Consideration of recycling potential of building materials in design phase
		Consideration of reclaiming potential of building materials in design phase
		Reuse of building materials or components
		Consideration of ease of demolition of building in the design phase
		Reuse of an existing building
	Satisfaction of the Construction Sector Actors	Improvement of productivity
		Increase of profitability
		Development of lower cost projects by increasing cost estimation
		Shortening the completion time of the project

Figure 3.11. Economic aspect of sustainable building design (Gültekin, 2018)

	CRITERIA	PROCEDURES
STRATEGY OF HEALT ANDWELLBEING	Creation of Livable Environments	Prevention of noise pollution
		Prevention of visual pollution
		Prevention of air pollution
		Prevention of water pollution
		Prevention of soil pollution
		Provision of fire protection
		Provision of resistance to natural hazards
		Consideration of the accessibility of disabled users
		Conservation of local heritage and culture
	Creation of Appropriate Indoor Comfort Conditions	Provision of sufficient indoor air quality
		Provision of appropriate indoor humidity ratio
		Provision of indoor visual comfort conditions
		Creation of visual connection with the outer environment
		Provision of indoor thermal comfort conditions
		Provision of indoor acoustical comfort conditions
		Provision of operable windows
		Provision of clean fresh air
		Use of low Volatile Organic Compound (VOC) building materials
		Prevention of electromagnetic pollution
		Use of nontoxic and noncarcinogenic building materials
		Use of antibacterial building materials
STRATEGY OF PUBLIC AWARENESS	Educating the Public	Organization of congresses and conventions on sustainable building design
		Implementation of training programs about sustainable building design
		Preparation of educational videos about sustainable building design
		Organization of competitions on sustainable buildings
		Efficient use of media about sustainable building design
		Educating the public in pilot sustainable buildings
	Development of Incentives and Policies	Provision of financial incentives such as tax and customs duty exemption
		Improvement of cooperation between public and private organizations
		Implementation of policies for efficient use of renewable energy technologies
		Implementation of the decisions made in the international meetings on environment

Figure 3.12. Social aspect of sustainable building design (Gültekin, 2018)

3.3. Energy Demand and Carbon Emissions of the Buildings

Construction is one of the main activities in which people influence resources and the environment. Construction accounts for approximately 40% of the total natural resources used by people and 40% of the total energy, and construction waste also accounts for 40% of the total waste generated by human activities. Therefore, sustainable structures (material production, planning, design, construction, operation, maintenance and disposal) designed to conserve resources and reduce environmental impacts throughout their lives have become a major concern. (Gong, Nie, Wang, Cui, Gao and Zuo, 2012).

The domestic built environment is responsible for a significant and ever-increasing portion (15-20%) of total energy-induced greenhouse gas emissions in the Western Europe. (Biesiot, W. and Noorman K.J., 1999). As a matter of fact, it was observed that emissions from buildings in the UK accounted for 19% of the UK Greenhouse Gas in 2016, increasing for the second year, and progress in reducing emissions from homes between 2008 and 2012 has come to a halt. Consequently, in an effort to avoid harsh climate change, defined as "do not allow global average warming of more than 2 °C above pre-climatic conditions" (Peter et al., 2013), recent developments in EU environmental policies aim to significantly increase energy efficiency in the local built environment. In the "Energy Roadmap 2050", the European Commission aims to reduce household-oriented and office-related emissions by approximately 90% by 2050 (as opposed to 1990 levels). According to the International Energy Agency, the largest energy use in buildings is for heating and cooling (37% of total energy use) and improvements "are not on track to meet global climate commitments". Evidently, there is a need for renewed strategies designed to reorganize progress in decarbonization of the local built environment (Hafner, Elmes, Read, 2019)

Recently, the Paris Accord has created a global framework to reduce global emissions to a level that limits heating to 1.5 °C, which means a reduction of more than 80% carbon in many high-income countries from the 1990s to 2050. For the built environment, this presents a challenging challenge. Building operation accounts for about one-third of global final energy consumption, and half of this due to space heating, cooling and hot water (IEA, 2013).

Many governments have identified buildings as a key sector that can develop under rapidly changing conditions, as well as energy security and socioeconomic development priorities, to contribute to the decline in energy demand and to help achieve GHG reduction policy objectives. Despite the 10% drop in natural gas prices, investments in buildings in OECD countries increased by 9% between 2014 and 2015, in addition to the introduction of energy efficiency policies that continued to increase in advanced building codes and standards (OECD/IEA, 2016). In the EU-27 countries, all new buildings should have 'nearly zero energy' at the beginning of 2021, with the contribution of existing buildings considered to be crucial to achieving the EU target of 80–95% emission reduction by 2050 (European Commission, 2011). The most ambitious targets for reducing energy demand in the U.S. have been set at the state level; California, for example, aims to reduce energy consumption in existing homes by 40% by 2020 (California Air Resources Board, 2008; Hamilton et al., 2017).

3.3.1. Energy Demand of Buildings

The energy demand in a building is due to various needs such as household lighting, heating and cooling, appliances,ventilation and domestic water. The quantity of final energy is considered in order to take in account the overall system efficiency of the different building's technical system. The final energy consumption of a building depends on its physical properties, usage and location. Consumption patterns change over the life of a building due to deterioration, renovation, refurbishment, climate and change of use, etc. (Vuarnoz et al., 2018).

To meet the energy demand of buildings, advanced renewable energy systems can provide long-term benefits to society, in other words,sustainability.

Advanced renewable energy systems contain energy carriers, onsite renewable systems, and energy storage technologies (Turner, J., 2001)

Energy carriers: In addition to on-site renewable systems, different energy carriers such as gas, oil, heat, electricity, biomass, district heating or cooling are available for the building's energy consumption. Apart from electricity, they can often be characterized by time-independent conversion factors (CFs). Grids are usual in buildings as energy supply. So far, it is not possible to monitor the carbon footprint of electricity from the grid in real time. LCA databases usually contain the average annual conversion factors of the electrical mixture (Frischknecht et al., 2005; KBOB et al., 2014). Recently, several studies have been published that calculate the CO2 equivalent (CO2-eq) content of electricity in an hourly step, based on historical data from France (Roux et al., 2016), Belgium (Messagie et al., 2014), Sweden (Kristinsdóttir, Stoll, Nilsson, & Brandt, 2013) and Switzerland (Vuarnoz & Jusselme, 2018).

Onsite renewable system: Mainly limited by the location and environment of a building, onsite renewable systems include wind, hydropower, solar energy, solar photovoltaic (PV), biofuels, etc. The renewable source of a heat pump is not necessarily considered when the modeling and performance assessment framework is used for a certification procedure (SIA Bulletin 2040, 2017). The conversion factors of the energy supplied by a system are calculated as the proportion of the embodied concern value (e.g. GHG emissions when determining CFGHG) to the amount of energy produced over its entire lifetime (Vuarnoz et al., 2018).

Storage technologies: Storage in a building energy system is not mandatory, but it can increase the benefits of renewable energies by providing better returns from resource investments. The practical application of energy storage in buildings is currently constrained with electricity and heat (Del Pero et al., 2018). The potential benefits of using energy storage are primarily economic or energy related, but storage enhances the environmental impact of that energy. This is because additional elements, each with its own embodied energy and losses, are added to the building energy system. Storage can be both carbon and cost-based. That is, low carbon energy can be obtained from the renewable system or grid when the relevant carbon content is low. The potential for substituting stored low-carbon high-carbon electricity from the grid may now be attractive, but will become less interesting in a largely renewable future. On the other hand, a renewable energy-based grid will require much more storage space than the existing one and will increase storage attractiveness (Vuarnoz et al., 2018).

3.3.2. Carbon Emissions of Buildings

The global climate system is particularly affected by GHG emissions from human development, such as urbanization activities (Prato, 2008). It is widely accepted that urban areas play a significant role in changing the global carbon cycle (Potere and Schneider, 2007). Accurate analysis of the urban carbon cycle and its interaction with regional and global ecosystems is crucial for predicting climate change and atmospheric CO_2 concentrations. However, recent studies have focused on the carbon fluxes of different land types such as forest, grassland and cropland, neglecting urban areas (Torssell et al., 2007, Chakraborty et al., 2006). As one of the main elements of built environments, buildings in urban areas consume natural resources including energy, minerals and water, and release many kinds of pollutants or wastes back to the global and regional ecosystems. These inputs and outputs result in air pollution and huge amount of CO_2 emissions. Therefore, reducing GHG emissions is one of the greatest challenges of this century (Ritchie and Roser, 2017). Carbon dioxide (CO_2) makes up the vast majority of GHG emissions (United States Environmental Protection Agency, 2017). Global warming caused by GHG, especially CO_2 emissions, continuously pose a threat to the existence of human and ecological environment and caused a series of global concerns in the last century, such as rising sea levels, crop failures, desertification, and pest proliferation (Yujie Lu, Peng Cui, Dezhi Li, 2016).

In this context, many countries have set long-term CO_2 emission reduction goals (IPCC, 2007) for various sectors.

The building sector is projected to contribute more than 31% of CO_2 emissions to total global emissions by 2020 and 52% by 2050 (I.P.C.C. 2011). In EU member nations, the building sector contributes to almost 50% of the carbon emissions emitted in the atmosphere throughout their lifecycle (A. Dimoudi, 2008). In Australia, around one quarter (23%) of total GHG emissions are the result of energy demand from the building sector. (W.K. Biswas, 2014). In the U.S., construction activities account for 40% of the carbon emissions of non-transport mobile resources (P. Truitt, 2009) and emissions from construction equipment and plants account for more than 50% of most types of emissions (A.A. Guggemos, A. Horvath, 2006). In the United Kingdom, construction-related activities account for about 47% of total CO_2 emissions (BIS, 2010), and they emitted 42.6 Mega tonnes of CO2e (MtCO2e) in 2011, among which approximately 10 MtCO2e is associated with construction operational activities and 22 MtCO2e is attributed to material production (J. Giesekam, J. Barrett, P. Taylor, A. Owen, 2014). In Korea, carbon emissions in the building sector comprise 23% of the country's total emissions (R.K. TRoK, 2011). Parallel to the mentioned ratios, countries have made some commitments to cut domestic CO2 emissions. One of these commitments is the Kyoto Protocol, which sets compulsory goals for 37 industrialized countries and European communities to reduce GHG emissions by 5% until the 1990s.

If the ways the embodied carbon is processed doesn't change in the building sector, the emissions from newly built buildings between 2015-2050 is predicted to account for 90%. The proportions of building sector related CO_2 emissions are presented in Figure 3.13.

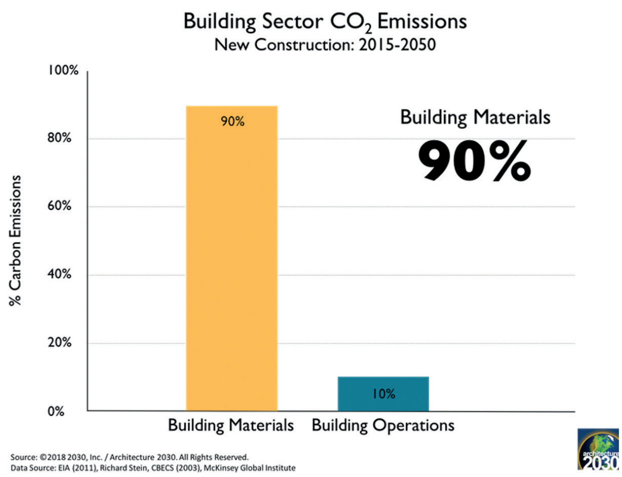


Figure 3.13. Building sector related CO_2 emissions (Melton, 2018)

The launching of the Kyoto Protocol has led to a number of studies aimed at evaluating CO_2 emissions from buildings (Chau and Leung, 2015). Building sector has the greatest potential of CO_2 emission reduction at a relative low expense compared to other sectors, reaching 5.3–6.7 Gt CO_2 per year (IPCC, 2007). This makes the studies on reduction of CO_2 emission from buildings be a hotspot for policy makers, scientists, and publics. In this context, reducing CO_2 emissions of a building throughout its life cycle has become a major concern in recent years (Gong and Nie, 2012). Although many studies have explored the various phases of the building's life cycle, most studies have paid special attention to energy savings. Only few studies examined the CO_2 emissions of buildings throughout their entire life cycle. The life cycle of a building can be divided into five stages chronologically. For determining CO_2 emissions of a building or a building material, the whole life cycle of this building or material has to be considered in terms of various features:

Extraction of raw materials and production of building materials: There is an intensive input of material and energy in this phase. Therefore, CO_2 emissions mainly arise from energy consumption emissions and industrial process emissions. These emissions result from primary energy and electricity consumption over the life cycle of all materials, including the raw materials extraction, transportation and production (You and Hu, 2011).

Building construction or renovation: In this phase, great amounts of building materials and energy are consumed in a short time to have a building constructed or renovated. Some construction wastes are generated and transported to landfills. These processes result in large amounts of CO_2 emissions (You, F. Hu, D., 2011).

Building operation: The intensity of materials inputs and outputs are relatively low in this phase so that the CO_2 emissions mainly come from energy consumption (You, F. Hu, D., 2011).

Building demolition: When buildings are out of use, manual or mechanical equipment is used for building demolition. While wastes from demolition are recycled, most of the construction waste is transported to the landfill. Therefore, CO_2 emissions are mainly due to energy consumption in this phase (You and Hu, 2011).

Wastes treatment and disposal: Most building waste is collected from landfills. Some are biodegradable, producing CO_2 from fugitive emissions. Others are non-degradable, occupying the land for at least 10 years and causing land footprint emissions. Given the recycling of waste, most building waste is not used in a building system, which means that the reduction of CO_2 emissions by recycling is relatively limited. CO_2 emissions at this stage are determined by energy consumption, leakage emissions of building wastes, land footprint emissions and carbon recycling through waste recycling (You and Hu, 2011).

3.3.3. Reduction of Energy Demand and Carbon Emissions in Buildings

Today, buildings account for a large proportion of total energy consumption in the world. Based on the energy consumption statistics of an International Energy Agency report, buildings account for approximately 30-35% of the world's total energy consumption (during construction and operation) and 40% of total CO_2 emissions (International Energy Agency, 2018). The main energy and sustainability goal is the energy efficiency to reduce the energy consumption and GHG emissions in buildings. In line with this goal, significant initiatives have been started to improve the energy performance of existing and new buildings. In the U.S., The US Department of Energy (DOE) Building Technologies Office has set goals to reduce the energy use intensity (EUI) of buildings almost 30% by 2030 and by 50% in the long term (Hong et al., 2018). Besides, in Europe, EU European Parliament and Council published Energy Performance of Buildings Directive (EPBD) in 2002 (European Commission, 2010, 2002). It was aimed to build a common methodology and standards for the evaluation of the building energy performance in this directive. In 2010, the directive was revised to start the applications for "zero-energy building" concept (EU, 2010).

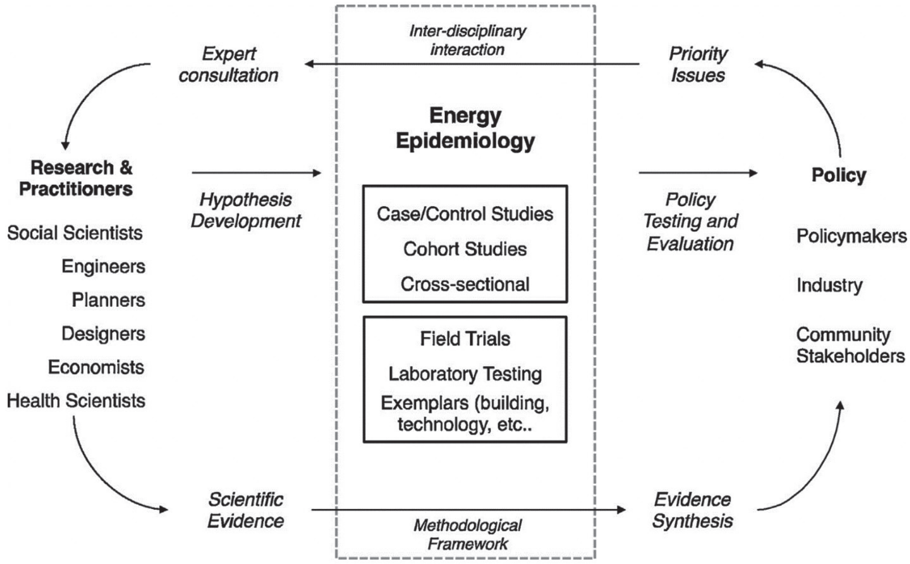
In the context of the mentioned initiatives and the others, mitigating climate change by transforming to a low carbon built environment pose pressing challenges for policymakers. In this case, it is more important to address decreasing the energy demand, which addresses all of the impacts, rather than focusing on one specific environmental impact. Reducing energy demand in buildings is considered an important component of GHG reduction strategies. As governments turn to large-scale sectoral interventions, more tangible research and evidence are needed to support the development, implementation and ongoing assessment of energy demand policy. The transition to a low carbon built environment will require both a more efficient delivery of energy services, a step change in the energy performance of buildings and an aggressive decarbonisation of the energy used. However, in national and regional environments, precondition data for building stocks needed to support this significant change in the energy performance of buildings is often not available, inaccessible or incomplete (e.g. energy meter data, physical building information, occupant details, etc.) (Hamilton, Summerfield, Oreszczyn, Ruyssevelt, 2017).

Policies focusing on energy demand in buildings are being developed in a complex, multi-purpose and interactive environment that is related with climate change, prices and affordability, energy supply, market regulations and health and welfare issues. However, to date, energy policy has not been sufficiently recognized or has failed to respond to this complexity. This meant that policies could not or did not adequately address many of these complex, socio-technical challenges in a timely manner. The return of the UK's building structure goals may be an example of this problem to support the now defunct zero carbon structure target (Marchand et al., 2015). This failure is seen in the mismatch of nationally defined contributions to the Paris Climate Agreement and in the mismatch of actions required to prevent 2°C global warming (UNEP, 2016). Energy and building policy focuses on the population scale, but current research is largely carried out at the level of individual units (eg buildings, people, households) and from a small-scale, single-discipline perspective. Beyond policies, building sector and technology manufacturers create products that focus on populations (e.g. national building stock, building typologies, cities). While these industries rely on population data to understand their markets, technology is conducting field trials to determine product potential. The limited availability of the detailed empirical data on energy demand of buildings makes it difficult to comprehend the potential of the market and the impact of commonly used technologies. This means that deep insights into the problems around energy demand in buildings, their existence and continuity within the population are severely limited; this also undermines effective policy, product development and spread. As national sustainable development and decarbonization plans evolve, government, research and commercial organizations will need better experimental data to support intervention programs, support modeling exercises and evaluate past practices and predict future predictions (Hamilton, Summerfield, Oreszczyn and Ruyssevelt, 2017).

The results of the low-carbon conversion of building stock, the scale of the decline in the proposed energy demand, the extent of the change in different building sub-sectors, and the urgency needed to achieve robust results have gained increasing acceptance (Summerfield and Lowe, 2012; Lowe and Oreszczyn, 2008). However, the current empirical evidence base in understanding the energy demand of buildings remains disproportionate with the need to support the robust implementation and evaluation of these policy measures or propose other initiatives (Geller et al., 2016; Hamilton, Summerfield, Oreszczyn and Ruyssevelt, 2017).

The energy and building research community faces an extraordinary challenge that requires a simultaneous transformation in the culture and implementation of energy and building research (Summerfield and Lowe, 2012). It involves going beyond research questions that address only the technical aspects of energy demand, and moving it to multidisciplinary studies aimed at solving the dynamic and interrelated effects of occupational behavior and the technical, social, lifestyle, economic and environmental factors that affect energy demand (Attari et al., 2010, Dietz, 2010, Wilhite et al., 2000, Sorrell, 2007). Instead, the dominant approach to most energy demand research is characterized by small-scale studies and fragmented discipline-specific methods that have difficulty in identifying events and undesirable consequences of interventions in a complex small-tier system (Pérez-Lombard, 2008). This led to a lack of clarity in terms of the basic theoretical constraints on the validity and applicability of estimates from building energy models (Galvin and Sunikka-Blank, 2016). As a result, the interpretation of research findings suffers in terms of its scope and generalisability in providing clear guidance for policy makers and industry (Summerfield and Lowe, 2012). Regardless of being national, sub-sector, or population-oriented, predictive models require robust data to define the 'basis' of energy and service demand; otherwise, they are at risk of applying future technologies to poorly defined socio-technical contexts (Hamilton, Summerfield, Oreszczyn, Ruyssevelt, 2017).

Considering the goal of reducing emissions, measures that promote the use of renewable energy can be as effective as energy efficiency measures, therefore, it is important to determine the optimal balance between the minimization of energy demand and the use of renewable energy (Almeida, Ferreira, 2018).



Şekil 3.14. Pratik olarak enerji epidemiyolojisi ve politika geliştirme ve değerlendirmesi ile olan etkileşimi (Hamilton, Summerfield, Oreszczyn, Ruyssevelt, 2017).

Historically, relatively few empirical large-scale evidence was available to guide both detailed and strategic policy development. Realistic transition pathways could be developed to substantial and long-term reductions in energy use and carbon emissions associated with buildings by (Hamilton, Summerfield, Oreszczyn, Ruyssevelt, 2017).

- Evaluating the scope of using actual building energy use data to inform policy making and to support industry in the development of low carbon and low energy solutions;
- Establishing best practice methods to collect and analyze data related to actual building energy use, including building and occupant data;
- Comparison of national approaches to addressing the energy performance gap to develop building stock datasets, develop building stock models, and identify lessons that can be learned and shared.

Building energy epidemiology is the study of energy demand to improve understanding of the variation and the reasons for the variation between the energy consuming population. Physical and engineering systems take into account the complex interactions between socio-economic and environmental conditions and individual interactions and practices of occupants.

Energy epidemiology offers a comprehensive approach to all relevant disciplines. Findings from large-scale studies provide a context for traditional small-scale studies and inform energy policy for input of predictive models (Figure 3.14). This approach can be used to investigate and identify energy demand mechanisms and determinants of conditions leading to different levels of demand. Energy demand in buildings, such as obesity, can be defined across a spectrum that includes a set of interactive factors that produce a defined and measured result.

Buildings are experiencing time-dependent changes in energy demand and this demand is met by energy supply, which can also show time-dependent life cycle burdens. As a result, performance assessments of the operational phase of buildings, which have so far been generally based on average annual conversion factors, do not allow the development of dynamic strategies for primary energy optimization or reduction of GHG emissions (Vuarnoz et al., 2018).

REFERENCES

Almeida M., Ferreira M. (2018) Ten questions concerning cost-effective energy and carbon emissions optimization in building renovation. Building and Environment, 143, 15–23.

Alqahtany, A., Rezgui, Y., Li, H. (2014). A Consensus-Based Framework for the Sustainable Urban Planning Development: "As an Approach for Saudi Arabian Cities. International Journal of Environmental Science and Development, 5, 124-131.

Attari, S.Z., DeKay, M.L., Davidson, C.I., Bruine de Bruin, W. (2010). Public perceptions of energy consumption and savings, Proc. Natl. Acad. Sci. U. S. A., 107, 16054–16059.

Benefits of Green Buildings. (2019). Retrieved from https://gbc.me/why-green-building/green-buildings/

Biesiot, W. and Noorman K.J., 1999. Energy requirements of household consumption: a case study of The Netherlands. Ecol Econ, 28, 367–83.

BIS. 2010. Estimating the Amount of CO2 Emissions that the Construction Industry Can Influence e Supporting Material for the Low Carbon Construction IGT Report, Department for Business Innovation & Skills, London, UK.

Biswas, W.K. (2014). Carbon footprint and embodied energy consumption assessment of building construction works in Western Australia, Int. J. Sustain. Built Environ, 3, 179-186.

BREEAM Category Issues and Aims. (2019). Retrieved from http://www.breeam.com/

Brouwers, J., Entrop, A.G. (2005). New triplet visions on sustainable building, Proceedings World Sustainable Building Conference, SB05, 4430-4435.

Brundtland, G. A. (1987). Our Common Future, report of the World Commission on Environment and Development, 1987. Published as Annex to General Assembly document A/42/427, Development and International Co-operation: Environment, 2.

Chau, C.K., Leung, T.M., Ng, W.Y. (2015). A review on Life Cycle Assessment, Life Cycle Energy Assessment and Life Cycle Carbon Emissions Assessment on buildings, Journal of Applied Energy, 143, 395–413.

Chakraborty, A., Bhattacharya, D.K., Li, B.L. (2006). Spatiotemporal dynamics of methane emission from rice fields at global scale. Ecological Complexity, 3, 231–240.

Chamber of Electrical Engineers (Elektrik Mühendisleri Odası). (2005). Retrieved from http://www.emo.org.tr/ekler/4cd7a8f7f9f8512_ek.pdf

Cheshmehzangi, A. (2016). China's New-Type Urbanisation Plan (NUP) and the Foreseeing Challenges for Decarbonisation of Cities: A Review. Energy Procedia 104. DOI: 10.1016/j.egypro.2016.12.026. 146-152.

Collins, A., Watts, S., McAlister, M. (2008). The economics of sustainable tall buildings. Proceedings of the CTBUH 8th World Congress, 175-185.

Del Pero, C., Aste, N., Paksoy, H., Haghighat, F., Grillo, S., & Leonforte, F. (2018). Energy storage key performance indicators for building application. Sustainable Cities and Society, 40, 54-65.

Dietz, T. (2010). Narrowing the US energy efficiency gap, Proc. Natl. Acad. Sci, 107, 16007–16008.

Dimoudi, A., Tompa, C. (2008). Energy and environmental indicators related to construction of office buildings, Resources, Conservation and Recycling, 53, 86–95.

Dorer V. and Weber A. (2009). Energy and carbon emission footprint of microCHP systems in residential buildings of different energy demand levels. Journal of Building Performance Simulation, 2, 31-46.

Duijvestein, C.J.A. (1997). Ecologisch Bouwen.

Elkington, J. (1997). Cannibals with forks: the triple bottom line of 21st century business, Oxford: Capstone.

Erbaş, E. (2008). Local Energy Planning in New Development Areas. UCTEA Chamber of City Planners Journal of Planning. 30European Commission Directorate General for Energy.

European Commission. (2019). Knowledge for policy. Retrieved from https://ec.europa.eu/knowledge4policy/foresight/topic/continuing-urbanisation/worldwide-urban-population-growth_en

European Union (EU). (2002). "Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings", Official Journal of the European Communities, 46, 65-71.

European Union (EU). (2010). "Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast)", Official Journal of the European Union, 53, 13-35.

European Union (EU). (2016). "Energy Performance of Buildings Directive (EPBD)" Retrieved from https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-performance-of-buildings/overview

Filho, W. L. (2000). Dealing with misconceptions on the concept of sustainability. International Journal of Sustainability in Higher Education, 1(1): 9-19.

Frischknecht, R., Jungbluth, N., Althaus, H. J., Doka, G., Dones, R., Heck, T., et al. (2005). The ecoinvent database: Overview and methodological framework. The International Journal of Life Cycle Assessment, 10(1), 3–9.

Galvin, R., Sunikka-Blank, M. (2016). Quantification of (p)rebound effects in retrofit policies –why does it matter? Energy, 95, 415–424.

Geller, H., Harrington, P., Rosenfeld, A.H., Tanishima, S., Unander, F. (2006). Polices for increasing energy efficiency: thirty years of experience in OECD countries, Energy Policy, 34, 556–573.

Gong, X., Nie, Z., Wang, Z., Cui, Gao, F., Zuo, T. 2012 "Life Cycle Energy Consumption and Carbon Dioxide Emission of Residential Building Designs in Beijing A Comparative Study", Journal of Industrial Ecology.

Green, D. (2015). Retrieved from https://www.businessinsider.com/norwegian-eco-friendly-house-2015-1?r=UK#though-the-home-is-designed-as-single-family-the-one-built-here-is-only-a-demonstration-heres-the-entire-rundown-of-the-houses-energy-saving-features-9

Greenbuild International Conference and Expo. (2018). Retrieved from https://new.usgbc.org/

Guggemos, A. A., Horvath, A. (2006) Decision-support tool for assessing the environmental effects of constructing commercial buildings, J. Archit. Eng.,12, 187-195.

Gültekin A B, Yavaşbatmaz S. (2013) Sustainable design of tall buildings. Journal of the Croatian Association of Civil Engineers – Gradevinar, 65(5):449-461.

Gültekin, A. B., Yıldırım, H. Y. ve Tanrıvermiş, H. (2018) "A Holistic Conceptual Scheme for Sustainable Building Design in the context of Environmental, Economic and Social Dimensions", Sustainable Buildings: Interaction Between a Holistic Conceptual Act and Materials Properties, InTechOpen, Chapter 2, pp. 19-47.

Hamedani, A. Z., Huber, F. (2012). A comparative study of "DGNB" , "LEED" and "BREEAM" certificate system in urban sustainability. 7th International Conference on Urban Regeneration and Sustainability.

Hamilton I., Summerfield A., Oreszczyn T., Ruyssevelt P. (2017). Using epidemiological methods in energy and buildings research to achieve carbon emission targets. Energy and Buildings, 154, 188–197.

Hafner, R.J., Elmes D., Read D. (2019). Promoting behavioural change to reduce thermal energy demand in households: A review. Renewable and Sustainable Energy Reviews, 102, 205–214.

Lazarus, A., Odell, W., Mendler, S.F. (2005). The HOK Guidebook to Sustainable Design. John Wiley and Sons Ltd, ISBN10 0471696137, New York, United States, 480

Hendriks, C.H.F. (2001). Sustainable Construction, Delft, the Netherlands (Aeneas)

Holden, M., Elverum, D., Nesbit, S., Robison, J., Yen, D. and Moore, J. (2008). Learning teaching in the sustainability classroom, Ecological Economics, 64, 521-533.

Hong, T., Langevin, J., Sun, K. (2018), "Building simulation: Ten challenges", Building Simulation, 11, 871–898.

Itard, L., and van den Bogaard, M. (2010). Teaching environmental sustainability to higher education students: Some Reflections. Open House International, 35(2).

IEA, (2013). Technology Roadmap: Energy Efficient Building Envelopes.

International Energy Agency (IEA). (2019), "Key world energy statistics 2018", Retrieved from https://webstore.iea.org/download/direct/2291?fileName=Key_World_2018.pdf.

IPCC, (2007). Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
I.P.C.C. Mitigation. (2011). Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), 521, Cambridge University Press, 2.

ISO, 1996, Environmental management – Life cycle assessment principles and framework, International Organization for Standardization, no 14040, 1997, Geneva.

ISO, 2006, Environmental management – Life cycle assessment requirements and guidelines, International Organization for Standardization, no 14044, 2006, Geneva.

J. Giesekam, J. Barrett, P. Taylor, A. Owen. (2014). The greenhouse gas emissions and mitigation options for materials used in UK construction, Energy Build, 78, 202-214.

KBOB, eco-bau, & IPB (2014). Recommandation KBOB 2009/1:2014: Données des écobilans dans la construction, état d'avril 2014. COordination des services fédéraux de la construction et de l'immobilier p.a. Office fédéral des constructions et de la logistique.

Krishan, A. (2002). A new language of architecture: in quest for a sustainable future. Environmental Management and Health, 13, 405-419.

Kristinsdóttir, A. R., Stoll, P., Nilsson, A., & Brandt, N. (2013). Description of climate impact calculation methods of the CO2e signal for the Active house project. KTH report, 1–26.

Larijani, A. H. (2016). International Academic Journal of Science and Engineering. 3, 9-14.

Lombardi, P., Trossero, E. (2013). Beyond energy efficiency in evaluating sustainable development in planning and the built environment. International Journal of Sustainable Building Technology and Urban Development. 4(4), 274-282.

Lowe, R.J., Oreszczyn, T. (2008). Regulatory standards and barriers to improved performance for housing, Energy Policy, 36, 4475–4481.

Lu, Y., Cui, P., Li, D. (2018). Carbon emissions and policies in China's building and construction industry: Evidence from 1994 to 2012, Building and Environment, 95, 94-103.

Marchand, R.D., Koh, S.C.L., Morris, J.C. (2015). Delivering energy efficiency and carbon reduction schemes in England: lessons from Green Deal Pioneer Places, Energy Policy, 84.

Melton, P. (2018). Feature Article. Retrieved from https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it

Messagie, M., Mertens, J., Oliveira, L., Rangaraju, S., Sanfelix, J., Coosemans, T., et al. (2014). The hourly life cycle carbon footprint of electricity generation in Belgium, bringing a temporal resolution in life cycle assessment. Applied Energy, 134, 469–476.

New Leaf Sustainability Consulting. (2019). Erişim adresi http://newleaf-llc.com/

Officine Green Building. Integrative Projects for Sustainable Architecture. (2017). Retrieved from http://www.officinegb.com/wp-content/uploads/2016/07/Flyer_OGB_s.pdf

OOIDA Foundation Resources. (2008). California Air Resource Board (CARB) Regulations. Retrieved from https://www.ooida.com/OOIDA%20Foundation/Resources/carb.asp

Pérez-Lombard, L., Ortiz, J., Pout, C. (2008). A review on buildings energy consumption information, Energy Build, 40,394–398.

Prato, T., (2008). Conceptual framework for assessment and management of ecosystem impacts of climate change. Ecological Complexity, 5, 329–338.

Potere, D., Schneider, A. (2007). A critical look at representations of urban areas in global maps. GeoJournal , 69, 55–80.

Truitt, P. (2009). Potential for Reducing Greenhouse Gas Emissions in the Construction Sector, US Environmental Protection Agency, 12.

Peters GP, Andrew RM, Boden T, Canadell JG, Ciais P, Le Quéré C, Marland G, Raupach MR, Wilson C (2013). The challenge to keep global warming below 2 °C. Nat Clim Change, 3, 4–6

Ritchie, H. and Roser, M. (2017). CO_2 and Greenhouse Gas Emissions. Retrieved from https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

R.K. TRoK. (2011). Third National Communication of the Republic of Korea under the United Nations Framework Convention on Climate Change, The Republic of Korea, Korea.

Robinson, J. (2004). Squaring the circle? Some thoughts on the idea of sustainable development, Cole.

Rockström, J., Gaffney, O., Rogelj, J., Meinshausen, M., Nakicenovic, N., Schellnhuber, H. J. (2017). A roadmap for rapid decarbonization. Science, 355, 1269–1271.

Roux, C., Schalbart, P., & Peuportier, B. (2016). Accounting for temporal variation of electricity production and consumption in the LCA of an energy-efficient house. Journal of Cleaner Production, 113.

Rovers, R. (2005). Reader Sustainable Building Module, Wageningen University.

SIA Bulletin 2040. (2017). Efficiency path for energy, 1–27.

Sınmaz, S. (2015). Integration of the Energy Efficiency Theme into the Urban Planning System of Turkey: An Approach for the City of Lapseki. UCTEA Chamber of City Planners Journal of Planning

Sorrell, S. (2007). The Rebound Effect: an Assessment of the Evidence for Economy-wide Energy Savings from Improved Energy Efficiency, UK Energy Research Centre.

Summerfield, A.J. and Lowe, R.J. (2012). Challenges and future directions for energy and buildings research. Build. Res. Inf., 40, 391–400.

Sustainable Footprint. (2019). Retrieved from http://sustainablefootprint.org/about-this-project/sustainable-footprint/

The University of Hong Kong Centre for Studies in Urban Sustainability. (2019). Retrieved from http://www.dupad.hku.hk/susurban/What%20is%20Sustainable%20Urban%20Development.htm

Torssell, B., Eckersten, H., Kornher, A., Bostro¨m, U. (2007). Modelling carbon dynamics in mixed grass-red clover swards. Agricultural Systems, 94, 273–280.

Turner, J. (2001). Carbon Management: Implications for R&D in the Chemical Sciences and Technology: A Workshop Report to the Chemical Sciences Roundtable, Chapter 7: Renewable Energy: Generation, Storage, and Utilization, National Research Council (US) Chemical Sciences Roundtable, 111-126.

U.S. Green Building Council. 2017. LEED. Retrieved from https://new.usgbc.org/leed

United Nations Environment Programme (UNEP). (2016). The Emissions Gap Report 2016. Retrieved from https://wedocs.unep.org/bitstream/handle/20.500.11822/10016/emission_gap_report_2016.pdf

United States Environmental Protection Agency. (2017). Sources of Greenhouse Gas Emissions. Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

United States Environmental Protection Agency. (2019). Sources of Greenhouse Gas Emissions Retrieved from https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

Verovsek, S., Juvancic, M., Zupancic, T. (2018). Widening the Scope and Scale of Sustainability Assessments in Built Environments: From Passive House to Active Neighbourhood. Academic Journal of Interdisciplinary Studies, 7, 129-135.

Vuarnoza, D., Cozzaa, S., Jusselmea, T., Magninb, G., Schaferb, T., Coutyb, P. , Niederhauserb, E-L. (2018). Integrating hourly life-cycle energy and carbon emissions of energy supply in buildings, Sustainable Cities and Society, 43, 305–316

Vuarnoz, D. and Jusselme, T. (2018). Temporal variations in the primary energy use and greenhouse gas emissions of electricity provided by the Swiss grid. Energy, 161, 573–582.

Wackernagel M., Rees W. (1996). Our ecological footprint: reducing human impact on the earth, New Society Publishers,Canada.

Wilhite, H., Shove, E., Lutzenhiser, L., Kempton, W. (2000). The legacy of twenty years of energy demand management: we know more about individual behaviour but next to nothing about demand, Society, Behaviour, and Climate Change Mitigation, 109–126.

World Wide Fund For Nature. (2019). Knowledge Hub. Retrieved from https://wwf.panda.org/knowledge_hub/teacher_resources/webfieldtrips/ecological_balance/eco_footprint/

Yazar, K. H. (2006). "A Proposal of an Urban Planning Method for the Medium Sized Cities within the Framework of Sustainable Urban Development." Ankara University Graduate School of Social Sciences Department of Political Science and Public Administration PhD Thesis. 20

Yıldırım, H. Y., Gültekin, A. B., Tanrıvermiş, H. (2016) "Evaluation of Energy Efficient Urban Planning Approach", Smart Metropoles - Integrated Solutions for Sustainable and Smart Buildings & Cities - SBE16İSTANBUL, İMSAD, 224-235.

You, F., Hu, D., Zhang, H., Guo, Z., Zhao, Y., Wang, B., Yuan, Y. (2011). Carbon emissions in the life cycle of urban building system in China—A case study of residential buildings, Ecological Complexity 8, 201–212.

Yujie Lu, Peng Cui, Dezhi Li. (2016). Carbon emissions and policies in China's building and construction industry: Evidence from 1994 to 2012, Building and Environment, 95, 94-10