Market Value of Green and Sustainable Buildings

Subjects: Green & Sustainable Science & Technology

Contributor: Ioannis Vardopoulos , Ioannis Vannas , George Xydis , Constantinos Vassiliades

Growing concerns over environmental issues and sustainable living have resulted in increased interest in renewable energy and energy efficiency. The real estate market is no exception, with homeowners increasingly considering the market value of green and sustainable buildings, which can offer both energy efficiency and potential health benefits.

green buildings | sustainable buildings | energy efficiency | residential sustainability

1. Introduction

Climate change is at the forefront of discussions, with the built environment being one of the main contributors, as it is responsible for almost 25% of global carbon dioxide emissions [1][2]. However, in urban areas, this number rises to 70% [3][4]. On the other hand, in terms of energy demand, the building sector in Europe accounts for over 40% of the total primary energy demand in the world [5][6][7]. Thus, the building sector is considered one of the major parameters for the prospective reduction of greenhouse gas emissions [1][8][9], bringing the energy renovation of buildings to the debate [6][10].

The interest in green buildings appears to be rapidly increasing during the past few decades, shifting away from the emphasis on conventional structures, aiming for sustainable development revolving around the reasonable use of energy and natural resources [3][11] and forcing the real estate housing market to face a paradigm shift [12][13]. Therefore, the real estate and the land development industry show an increasing recognition and interest in green and sustainable buildings [14][15]. This is supported by the World Green Building Council and its European network, which are actively funding efforts to inform investors of the benefits of purchasing green buildings [16], aiming to overcome the barrier of the high construction costs that underlie the diffusion of green buildings, despite that the high costs are offset by the green buildings' long-term economic benefits [12].

2. Market Value of Green and Sustainable Buildings

A building can be generally identified as "sustainable" or "green" when it is designed, constructed, and operated in an environmentally friendly and resource-efficient manner, according to a philosophy that puts its main emphasis on the efficient use of energy, water, and material resources [17], aiming at a reduced environmental footprint. This is achieved through energy-efficient design (lighting and HVAC systems), water conservation measures, the use of renewable energy sources, the incorporation of sustainable building materials, sustainable construction methods,

proper space arrangement, operation, maintenance, and subtraction (referring to the process of removing unnecessary features or elements from a building design in order to reduce the overall environmental impact and resource consumption) [18]. Additionally, a building is defined as “green” when it is designed, constructed, and functions in a way that reduces the general impact of the built environment, as well as when it minimizes the impact on people’s health [19]. The positive influence of these buildings is widely supported by the published scholarly literature [20][21] in terms of air pollution reduction, which is directly related to human physical and psychological wellbeing, *inter alia*, cardiovascular diseases, asthma, respiratory allergies, depression, and stress [22][23][24][25].

All the above characteristics, and the needed high specification standards, differentiate green buildings from other buildings. This was investigated by Robinson and Sanderford (2016) [26], who applied a propensity scoring methodology in order to calculate the status of the buildings, aiming to determine whether green buildings are equivalent to other premium buildings offered in the real estate market. The results indicate that some building characteristics can be considered good predictors of whether a building will be certified as green. Additionally, their high market values were discussed, illustrating that those luxury and premium buildings which are not green can also gain high market value, even though they do not offer the benefits that green buildings do, thus, showing that people are willing to pay extra to prosper from luxurious properties that are not energy efficient.

The different approach to green building design has also been highlighted by researchers, with Chegut et al. (2014) [27] noticing that they tend to be higher and bigger compared to other buildings of their type; they tend to be built far from motorways and train stations. Kok and Jennen (2012) [28] highlighted their higher quality. Iwaro and Mwasha (2013) [29] asserted that there is a link between building sustainability and the building envelope because the building envelope creates indoor environments that are suitable for human activities and shields the building from unfavorable external and internal influences such as pollution, climate change, temperature, humidity, heating, ventilation, air conditioning (HVAC) load, and lighting load. According to this work, the building envelope, which is directly affected by several external and internal influences, materiality, and processes, and its design are among the most crucial elements that will define a building’s greenness and sustainability. However, it is important to note that many other factors beyond the building envelope also contribute to a building’s greenness, such as the use of sustainable materials or construction techniques, and conservation strategies, among others [30].

Even though green and sustainable buildings appear to have a number of benefits, according to researchers, green building technologies have, in some ways, disturbed the real estate industry during the past years [31]. On the other hand, other researchers addressed [32] the interest of some real estate investors who invest in green buildings due to their higher returns. The increasing interest in green buildings led to responsible property investing (RPI), with which investors can demonstrate their commitment to sustainable and green development [33]. RPI is a component of responsible investment established by the UN Environment Programme Finance Initiative [34], which has as a main purpose of minimizing the impact of investment on society and the environment whilst guaranteeing financial profitability [35].

The above notes are supported by the fact that any building that has a LEED certification in the housing market can be sold at a 30% higher price, according to the research by Saeed and Mullahwaish (2020) [36], who also

proved how a property's green certification can improve its appeal in the real estate market and even raise its level of desirability, raising its market value. This is also supported by the fact that green residential buildings attract advanced market value in the housing market, according to the United States Green Building Council; the same report by this group connects green buildings to higher rents for real estate investors [37]. Thus, the shift is now changing, despite the fact that there are also preferences and concerns to consider. Firstly, several studies highlight a positive public perception of renewable energy sources for buildings. For instance, Karasmanaki et al. (2021) [38] found that people in European Union countries tend to support renewable energy driven by environmental values and concerns. Abdelkader et al. (2020) [39] highlighted that the perception of green buildings has a significant impact on individuals' intentions and behavior toward sustainable energy practices. Additionally, Qazi et al. (2019) [40] emphasized that public awareness plays a crucial role in facilitating the development of renewable energy technologies. Zhang et al. (2019) [41] reviewed renewable energy assessment methods in green building and green neighbourhood rating systems and provided valuable insights for investors, users, and policymakers interested in promoting green buildings and neighbourhoods. Additionally, the majority of real estate investors are open to spending more on developing more environmentally friendly and energy-efficient real estate properties, despite the fact that the real estate industry is slow to change its business-as-usual approach and there is a need for more incentives and greater awareness to encourage mass deployment of sustainable real estate [42].

Nagrale and Sabihuddin (2020) [43] argue that green buildings can have a positive impact on real estate investments due to the variety of benefits they offer. These benefits include reduced water pollution and greenhouse gas emissions, as well as the ability for owners and tenants to reduce their energy demand, resulting in lower costs. Leskinen et al. (2020) [33] added the economic parameter, saying that sustainable buildings are often valued higher in the market, leading to higher returns on investment and rental incomes. Real estate investors can also benefit from energy and water savings, reduced operation and maintenance costs, improved indoor environmental quality, and the greater indoor comfort and productivity that green buildings offer [44]. According to the research by Oladokun et al. (2010) [45], these benefits are divided into three main pillars, the environmental benefits (e.g., the protection of ecosystems and biodiversity, the improvement of air and water quality, and the reduction in solid waste), the economic benefits (e.g., the reduction of operating costs and future liability, the enhancement of asset value and profits, the increase in retail sales, and the optimization of lifecycle economic performance), and the occupational benefits (e.g., the enhancement of occupant comfort and health, reductions in healthcare costs, and the improvement of employee satisfaction and morale and their increased productivity).

Current research [27][46][47][48][49][50] and data from the private sector [51] have shown that green buildings can be considered as "premium" in the global market since sustainability practices are followed during the design and construction phases, with an additional 8% to 18% increase in sales prices and 3% to 13% increase in rental prices. It is also noted that the higher a building's green rating, the greater the monetary benefits for the real estate developer. The final selling price of green properties seems to be influenced by both rent and yield. In terms of the incentives that influence how income affects the price of a property, it has been observed that tenants tend to pay more for apartments that align with their "environmental" ethos, which emphasizes measures to improve the environment, mainly through minimizing the impact of humans on the earth.

The real estate market has been increasingly connected to the concept of sustainable buildings, and the term “green value” has emerged to refer to the sustainable value of a building, specifically its environmentally friendly features and energy efficiency. According to Hartenberger et al. (2017) [16], the quality of a building, starting from the design phase, followed by construction and operation, plays a significant role in the development of appropriate investment feedback, which is required to continue investing in buildings of the same category or greater quality [52]. Furthermore, owning a green building or property has been found to have benefits such as higher resale value, higher rental rates, increased occupancy rates, reduced operating rates, increased net operating income, and reduced capitalization rates [53]. To that effect, one important factor that affects the energy efficiency of buildings is the Energy Performance Certificate (EPC). Since 2010, European legislation has required all sellers to assess the energy performance of their properties in order to sell them, resulting in the development of the EPC, otherwise known as the ‘Energy Passport’. The EPC collects data on a building’s energy demands. It also provides information to future buyers at the time of sale in an accessible manner, allowing for easy comparison of the energy performance of different properties. It is essential to note that an energy-consuming dwelling will be worth less than a perfectly insulated one falling into the “low consumption” category with equal surfaces and characteristics. Thus, the EPC is an integral part of the data that buyers compare among properties. An unfavorable diagnosis will most likely be detrimental, leading to a downward revision of the price or renovation work to hope for a sale. As well as can be expected, the relationship between EPCs and the real estate market is a topic that has been explored in several papers [54][55][56][57]. However, the findings are still inconclusive. For example, Fregonara et al. (2014) [58] investigated the impact of the EPC level on listing prices and found that the EPC level has an impact on listing prices, while Olaussen et al. (2017) [59] found no evidence of a price premium associated with energy labels.

Although it is clear that energy efficiency has potential benefits for both the environment and the financial bottom line of real estate investors, there are also limitations to its implementation and impact on the real estate market. Christersson et al. (2015) [60] suggested that despite the financial advantages of energy efficiency investments at the building portfolio level, investors face challenges in realizing these advantages due to a lack of qualified service providers and a poor understanding of the overall value. Marmolejo-Duarte et al. (2019) [61] highlighted that while energy efficiency may not have a significant impact on the marketing of homes in Spain, companion policies such as subsidies and fiscal exceptions may be needed to increase the prominence of energy efficiency in the residential market. Duarte and Chen (2019) [62] found that although there is a positive correlation between residential prices and energy ranks, higher selling prices may not always compensate for the higher building costs associated with energy-efficient technologies. Encinas et al. (2018) [63] suggested that while some potential homebuyers are willing to pay for energy efficiency, willingness to pay is influenced by education level and a lack of understanding of the cost savings associated with energy-efficient modifications. Overall, the literature demonstrates that while there is potential for energy efficiency to have a positive impact on the real estate market, there are also significant limitations that must be addressed.

The literature also shows that the ownership status of green buildings (owner-occupied or tenant-occupied) provides different benefits for the users [64][65]. Owner-occupied green buildings have potential benefits for the owner, such as lower operating and maintenance expenses, higher efficiency, and higher reputation. On the other

hand, tenant-occupied green buildings can benefit from rent premiums, higher revenues, lower vacancy rates, higher efficiency, lower operating expenses, and, again, higher reputation [53][66].

References

1. Levine, M.; Urge-Vorsatz, D.; Blok, K.; Geng, L. Residential and Commercial Buildings. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK, 2007; pp. 53–58.
2. Santamouris, M.; Osmond, P. Increasing Green Infrastructure in Cities: Impact on Ambient Temperature, Air Quality and Heat-Related Mortality and Morbidity. Buildings 2020, 10, 233.
3. Savvides, A.; Vassiliades, C.; Michael, A.; Kalogirou, S. Siting and building-massing considerations for the urban integration of active solar energy systems. Renew. Energy 2019, 135, 963–974.
4. Vega-Azamar, R.E.; Glaus, M.; Hausler, R.; Oropeza-García, N.A.; Romero-López, R. An emergy analysis for urban environmental sustainability assessment, the Island of Montreal, Canada, Landsc. Urban Plan. 2013, 118, 18–28.
5. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC. Available online: http://data.europa.eu/eli/dir/2009/28/oj (accessed on 9 April 2023).
6. Vassiliades, C.; Savvides, A.; Buonomano, A. Building integration of active solar energy systems for façades renovation in the urban fabric: Effects on the thermal comfort in outdoor public spaces in Naples and Thessaloniki. Renew. Energy 2022, 190, 30–47.
7. Zancanella, P.; Bertoldi, P.; Boza-Kiss, B. Energy Efficiency, the Value of Buildings and the Payment Default Risk; EUR 29471 EN; Office of the European Union: Luxembourg, 2018.
8. Enkvist, P.; Nauclér, T.; Rosander, J. A Cost Curve for Greenhouse Gas Reduction; McKinsey: Atlanta, GA, USA, 2007; pp. 35–47.
9. Vassiliades, C.; Agathokleous, R.; Barone, G.; Forzano, C.; Giuzio, G.F.; Palombo, A.; Buonomano, A.; Kalogirou, S. Building integration of active solar energy systems: A review of geometrical and architectural characteristics. Renew. Sustain. Energy Rev. 2022, 164, 112482.
10. Sun, Y.; Li, H.; Andlib, Z.; Genie, M.G. How do renewable energy and urbanization cause carbon emissions? Evidence from advanced panel estimation techniques. Renew. Energy 2022, 185, 996–1005.

11. Windapo, A. Examination of Green Building Drivers in the South African Construction Industry: Economics versus Ecology. Sustainability 2014, 6, 6088–6106.
12. Heinzle, S.L.; Boey Ying Yip, A.; Low Yu Xing, M. The Influence of Green Building Certification Schemes on Real Estate Investor Behaviour: Evidence from Singapore. Urban Stud. 2013, 50, 1970–1987.
13. Massimo, D.E.; De Paola, P.; Musolino, M.; Malerba, A.; Del Giudice, F.P. Green and Gold Buildings? Detecting Real Estate Market Premium for Green Buildings through Evolutionary Polynomial Regression. Buildings 2022, 12, 621.
14. Aroul, R.R.; Hansz, J.A. The Value of “Green”: Evidence from the First Mandatory Residential Green Building Program. J. Real Estate Res. 2020, 34, 27–50.
15. Hsieh, H.-C.; Claresta, V.; Bui, T. Green Building, Cost of Equity Capital and Corporate Governance: Evidence from US Real Estate Investment Trusts. Sustainability 2020, 12, 3680.
16. Hartenberger, U.; Lorenz, D.; Sayce, S.; Toth, Z. Crerating an Energy Efficient Mortgage for Europe: Mortgage Lending Valuation and the Impact of Energy Efficiency: An Overview of Current Practice; RICS: London, UK, 2017.
17. EPA. Green Buildings at EPA; United States Environmement Protection Agency: Washington, DC, USA, 2023.
18. Singh, C.S. Green Construction: Analysis on Green and Sustainable Building Techniques. Civ. Eng. Res. J. 2018, 4, 107–112.
19. Kibert, J.C. Green Buildings: An overview of progress. J. Land Use Environ. Law 2004, 19, 491–502.
20. Yudelson, J. The Green Building Revolution; Island Press: Washington, DC, USA, 2008.
21. Khoshnava, S.M.; Rostami, R.; Zin, R.M.; Štreimikienė, D.; Mardani, A.; Ismail, M. The Role of Green Building Materials in Reducing Environmental and Human Health Impacts. Int. J. Environ. Res. Public Health 2020, 17, 2589.
22. Singh, A.; Syal, M.; Grady, S.C.; Korkmaz, S. Effects of Green Buildings on Employee Health and Productivity. Am. J. Public Health 2010, 100, 1665–1668.
23. Burnett, R.T.; Pope, C.A.; Ezzati, M.; Olives, C.; Lim, S.S.; Mehta, S.; Shin, H.H.; Singh, G.; Hubbell, B.; Brauer, M.; et al. An Integrated Risk Function for Estimating the Global Burden of Disease Attributable to Ambient Fine Particulate Matter Exposure. Environ. Health Perspect 2014, 122, 397–403.
24. Dockery, D.W.; Pope, C.A.; Xu, X.; Spengler, J.D.; Ware, J.H.; Fay, M.E.; Ferris, B.G.; Speizer, F.E. An association between air pollution and mortality in six U.S. cities. N. Engl. J. Med. 1993, 329, 1753–1759.

25. Habre, R.; Moshier, E.; Castro, W.; Nath, A.; Grunin, A.; Rohr, A.; Godbold, J.; Schachter, N.; Kattan, M.; Coull, B.; et al. The effects of PM2.5 and its components from indoor and outdoor sources on cough and wheeze symptoms in asthmatic children. J. Expo. Sci. Environ. Epidemiol. 2014, 24, 380–387.
26. Robinson, S.J.; Sanderford, A.R. Green Buildings: Similar to Other Premium Buildings? J. Real Estate Financ. Econ. 2016, 52, 99–116.
27. Chegut, A.; Eichholtz, P.; Kok, N. Supply, Demand and the Value of Green Buildings. Urban Stud. 2014, 51, 22–43.
28. Kok, N.; Jennen, M. The impact of energy labels and accessibility on office rents. Energy Policy 2012, 46, 489–497.
29. Iwaro, J.; Mwasha, A. The impact of sustainable building envelope design on building sustainability using Integrated Performance Model. Int. J. Sustain. Built Environ. 2013, 2, 153–171.
30. Kieu, L.T.; Schäfer, S. A Review of Values of Green Building at Building and City Scales. Green Build. Constr. Econ. 2020, 1, 37–50.
31. Zhang, Y.; Dong, R. Impacts of Street-Visible Greenery on Housing Prices: Evidence from a Hedonic Price Model and a Massive Street View Image Dataset in Beijing. ISPRS Int. J. Geo-Inf. 2018, 7, 104.
32. Khan, J.S.; Zakaria, R.; Shamsudin, S.M.; Abidin, N.I.A.; Sahamir, S.R.; Abbas, D.N.; Aminudin, E. Evolution to Emergence of Green Buildings: A Review. Adm. Sci. 2019, 9, 6.
33. Leskinen, N.; Vimpari, J.; Junnila, S. A Review of the Impact of Green Building Certification on the Cash Flows and Values of Commercial Properties. Sustainability 2020, 12, 2729.
34. The UN-Convened Network of Banks, Insurers and Investors Accelerating Sustainable Development, UN Environ. Program. Financ. Initiat. 2023. Available online: https://www.unepfi.org/ (accessed on 9 April 2023).
35. Pivo, G.; McNamara, P. Responsible Property Investing. Int. Real Estate Rev. 2005, 8, 128–143.
36. Saeed, A.A.; Mullahwaish, L.T. Effect of Green Areas Density on Real Estate Price in Ramadi City. Int. J. Des. Nat. Ecodyn. 2020, 15, 253–259.
37. Diller, M. The 2020 Green SmartMarket Report Overview. 2020. Available online: https://www.usgbc.org/education/sessions/2020-green-smartmarket-report-overview-12846735 (accessed on 9 April 2023).
38. Karasmanaki, E.; Tsantopoulos, G. Public Attitudes toward the Major Renewable Energy Types in the Last 5 Years: A Scoping Review of the Literature; Kyriakopoulos, G.L., Ed.; Academic Press: Cambridge, MA, USA; Elsevier: Amsterdam, The Netherlands, 2021; pp. 117–139.

39. Abdelkader, O.A. Impact of perception on “willingness and behavior” of individuals toward switching to sustainable energy practices in buildings. Energy Rep. 2020, 6, 2119–2125.
40. Qazi, A.; Hussain, F.; Rahim, N.A.; Hardaker, G.; Alghazzawi, D.; Shaban, K.; Haruna, K. Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions. IEEE Access 2019, 7, 63837–63851.
41. Zhang, C.; Cui, C.; Zhang, Y.; Yuan, J.; Luo, Y.; Gang, W. A review of renewable energy assessment methods in green building and green neighborhood rating systems. Energy Build. 2019, 195, 68–81.
42. Sichali, M.; Banda, L.J. Awareness, Attitudes and Perception of Green Building Practices and Principles in the Zambian Construction Industry. Int. J. Constr. Eng. Manag. 2017, 6, 215–220.
43. Nagrale, S.S.; Sabihuddin, S. Cost Comparison between Normal Building and Green Building Considering Its Construction and Maintenance Phase. Int. J. Sci. Res. Eng. Dev. 2020, 3, 77–80.
44. Kats, G.H. Green Building Costs and Financial Benefits; Barr Foundation: Boston, MA, USA, 2003.
45. Oladokun, T.T.; Gbadegesin, J.T.; Ogunba, O.A. Perceptual Analysis of the Benefits and Implementation Difficulties of Green Building in Lagos Metropolis, Nigeria. In Proceedings of the International Research Conference on Sustainability in Built Environment, Organised by Commonwealth Association of Surveyors and Land Economist, Columbia, Sri Lanka, 18–19 June 2010; pp. 166–178.
46. Eichholtz, P.; Kok, N.; Quigley, J.M. Doing Well by Doing Good? Green Office Buildings. Am. Econ. Rev. 2010, 100, 2492–2509.
47. Das, P.; Wiley, J.A. Determinants of premia for energy-efficient design in the office market. J. Prop. Res. 2014, 31, 64–86.
48. Fuerst, F.; McAllister, P. Eco-labeling in commercial office markets: Do LEED and Energy Star offices obtain multiple premiums? Ecol. Econ. 2011, 70, 1220–1230.
49. Newell, G.; MacFarlane, J.; Walker, R. Assessing energy rating premiums in the performance of green office buildings in Australia. J. Prop. Investig. Financ. 2014, 32, 352–370.
50. Ott, C.; Hahn, J. Green pay off in commercial real estate in Germany: Assessing the role of Super Trophy status. J. Prop. Investig. Financ. 2018, 36, 104–124.
51. Brookes, N. Active Capital: Trends in Global Real Estate Investment; London, UK. 2021. Available online: https://content.knightfrank.com/research/1801/documents/en/active-capital-the-report-2021-8447.pdf (accessed on 9 April 2023).
52. Kaklauskas, A.; Zavadskas, E.K.; Lepkova, N.; Raslanas, S.; Dauksys, K.; Vetloviene, I.; Ubarte, I. Sustainable Construction Investment, Real Estate Development, and COVID-19: A Review of

Literature in the Field. Sustainability 2021, 13, 7420.

53. Ciora, C.; Maier, G.; Anghel, I. Is The Higher Value of Green Buildings Reflected in Current Valuation Practices? J. Account. Manag. Inf. Syst. 2016, 15, 58–71.
54. Wilhelmsson, M. Energy Performance Certificates and Its Capitalization in Housing Values in Sweden. Sustainability 2019, 11, 6101.
55. Cespedes-Lopez, M.-F.; Mora-Garcia, R.-T.; Perez-Sanchez, V.R.; Perez-Sanchez, J.-C. Meta-Analysis of Price Premiums in Housing with Energy Performance Certificates (EPC). Sustainability 2019, 11, 6303.
56. De Ruggiero, M.; Forestiero, G.; Manganelli, B.; Salvo, F. Buildings Energy Performance in a Market Comparison Approach. Buildings 2017, 7, 16.
57. Marmolejo-Duarte, C.; Berrio, S.S.; Del Moral-Ávila, C.; Méndez, L.D. The Relevance of EPC Labels in the Spanish Residential Market: The Perspective of Real Estate Agents. Buildings 2020, 10, 27.
58. Fregonara, E.; Rolando, D.; Semerano, P.; Vella, M. The impact of Energy Performance Certificate level on house listing prices. First evidence from Italian real estate. Aestimum 2014, 65, 146–163.
59. Olaussen, J.O.; Oust, A.; Solstad, J.T. Energy performance certificates—Informing the informed or the indifferent? Energy Policy 2017, 111, 246–254.
60. Christersson, M.; Vimpari, J.; Junnila, S. Assessment of financial potential of real estate energy efficiency investments—A discounted cash flow approach. Sustain. Cities Soc. 2015, 18, 66–73.
61. Marmolejo-Duarte, C.; Spairani, S.; del Moral, C.; Delgado, L.; Egusquiza, A.; Ai, C. How Relevant is Energy Efficiency in The Marketing of Homes? Evidence from Real Estate Agents in Spain. IOP Conf. Ser. Mater. Sci. Eng. 2019, 603, 032053.
62. Marmolejo-Duarte, C.; Chen, A. The evolution of energy efficiency impact on housing prices. An analysis for Metropolitan Barcelona. Rev. La Constr. 2019, 18, 156–166.
63. Encinas, F.; Marmolejo-Duarte, C.; de la Flor, F.S.; Aguirre, C. Does energy efficiency matter to real estate-consumers? Survey evidence on willingness to pay from a cost-optimal analysis in the context of a developing country. Energy Sustain. Dev. 2018, 45, 110–123.
64. Shi, Y.; Liu, X. Research on the Literature of Green Building Based on the Web of Science: A Scientometric Analysis in Cite Space (2002–2018). Sustainability 2019, 11, 3716.
65. Zhang, Y.; Wang, H.; Gao, W.; Wang, F.; Zhou, N.; Kammen, D.M.; Ying, X. A Survey of the Status and Challenges of Green Building Development in Various Countries. Sustainability 2019, 11, 5385.

66. Teotónio, I.; Oliveira Cruz, C.; Matos Silva, C.; Morais, J. Investing in Sustainable Built Environments: The Willingness to Pay for Green Roofs and Green Walls. Sustainability 2020, 12, 3210.

Retrieved from https://encyclopedia.pub/entry/history/show/105122