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Taking the SDGs into Account: A BIM-Based Strategy for Integrating Smart Materials in Building Components

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ABSTRACT

The United Nations has set Sustainable Development Goals (SDGs) for 2030, with SDG 7 aiming for affordable, reliable, and modern energy, SDG 9 for Industry, Innovation, and Infrastructure, and SDG 13 for climate action. Buildings play a crucial role in achieving these goals, and the integration of smart materials into building components can enhance energy efficiency and sustainability. Building Information Modeling (BIM) is a powerful tool that can facilitate this integration. This study explores the use of BIM in integrating smart materials into building components, analyzing case studies and examples to illustrate its effectiveness. The findings highlight the pivotal role of BIM in advancing sustainability efforts within the construction industry, particularly concerning SDG 7, SDG 9, and SDG 13. The integration of smart materials in building components, guided by BIM, offers a promising pathway towards affordable, reliable, and sustainable energy solutions, adapting technology to achieve sustainability and address climate change. This research contributes to the discourse on achieving the SDGs and underscores the importance of interdisciplinary collaboration in addressing global energy challenges.

Keywords: Sustainable Development Goals (SDGs), Building Information Modeling (BIM), Smart Materials (SMs), Building Components, Design strategy.

1.INTRODUCTION

The Sustainable Development Goals (SDGs), also known as the Global Goals, are a set of seventeen interconnected objectives intended to serve as a "shared blueprint for peace and prosperity for people and the planet, now and in the future [1]–[3]." By putting sustainability at the forefront of their agenda, the SDGs emphasize the interwoven environmental, social, and economic dimensions of sustainable development. The SDGs were established by the United Nations General Assembly (UNGA) in 2015 as part of the Post-2015 Development Agenda. This agenda aimed to create a new global development framework to replace the Millennium Development Goals [4], [5]. These objectives were explicitly described and endorsed in a UNGA resolution known as the 2030 Agenda, sometimes known colloquially as Agenda 2030 [6], [7]. A UNGA decision identifying precise targets for each goal and providing indicators to assess progress made the SDGs more actionable in 2017 [3], [8]. Most targets must be met by 2030, but some have no deadline [9].

In fact, the construction sector has a significant environmental impact, particularly building materials, so there is a growing interest in environmental design and construction, as well as the selection of environmentally friendly building materials, because building materials have a significant impact on energy consumption. Thus, building material selection is crucial at the initial design process, and random selection of construction materials frequently entails subjectivity, uncertainty, and ambiguity. This method wastes time and resources while resulting in inefficient building environmental performance. As a result, this research proposes the use of building information modeling (BIM) technology as a tool to aid in the selection process of building materials in the construction industry from the early phases of the project, specifically smart materials (SMs) for their effectiveness in the energy conservation field and their ability to adapt to climate changes. The selection process is based on predefined criteria, which makes it faster and more accurate.

Since the study focuses on the field of the construction industry, building materials, and adapting technology for materials selection, especially smart building materials, the study therefore focused on the seventh, ninth, and thirteenth goals as shown in Figure 1 the research aims.

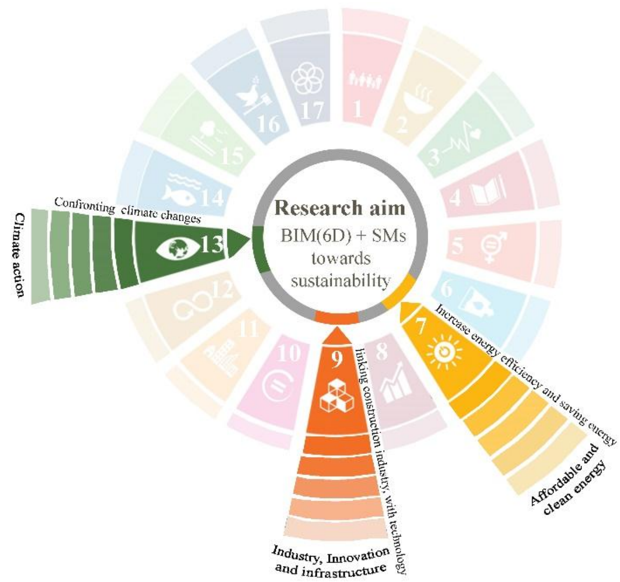

Figure 1: Research aims towards SDGs
Source: the authors after [72]

1.1. The seventh sustainable development goal (SDG 7)

“Affordable and clean energy” this is the slogan of the SDG 7. It’s aim to: "Ensure access to affordable, reliable, sustainable and modern energy for all." The aim comprises five targets that must be met by 2030 [9]–[12] as shown in Figure 2.

From an architectural point of view, the SDG 7 aims to increase energy efficiency and develop energy services in developing countries specifically. Furthermore, the building industry must put a focus on

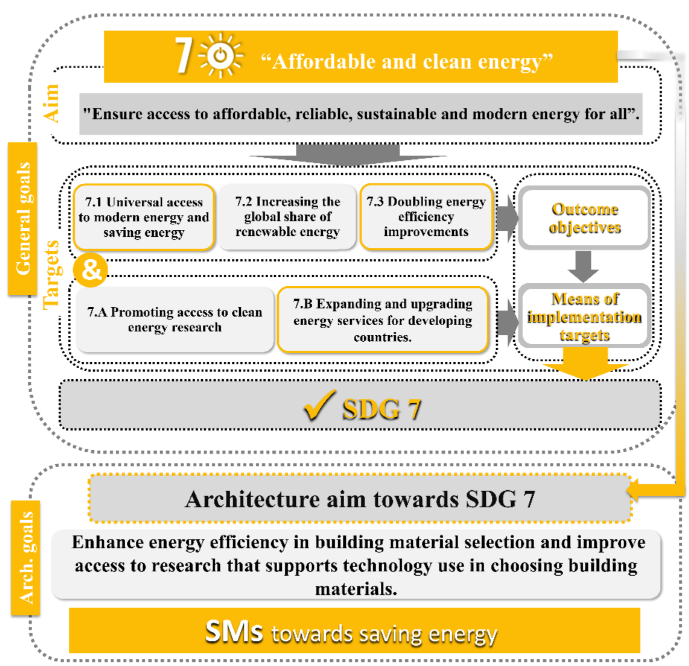

Figure 2: General & Arch. Goals of SDG 7
Source: the authors after [72]

total energy consumption from the beginning of choosing building materials and to enhance access to research that supports the use of technology in choosing building materials raising energy efficiency and saving energy, and this is what the research seeks to achieve.

Climate change necessitates adaptation of structures and towns to extreme weather conditions, necessitating the development of innovative design solutions, emphasizing the role of architecture, planning, and design.

1.2. **The ninth sustainable development goal (SDG 9)**

“Industry, Innovation and infrastructure” this is the slogan of the SDG 9. It’s aim to: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation." The aim comprises eight targets that must be met by 2030 [10] as shown in Figure 3.

From an architectural point of view, the SDG 9 aims to develop the construction industry, as well as research and prototyping to test the potential of new tools, processes and solutions. The innovations generated in industry must be continually measured against the site-specific climate impact on sustainability [12]–[14]. Therefore, the aim of the study was to adapt BIM tool to achieve sustainability in the construction industry by selecting optimal building materials.

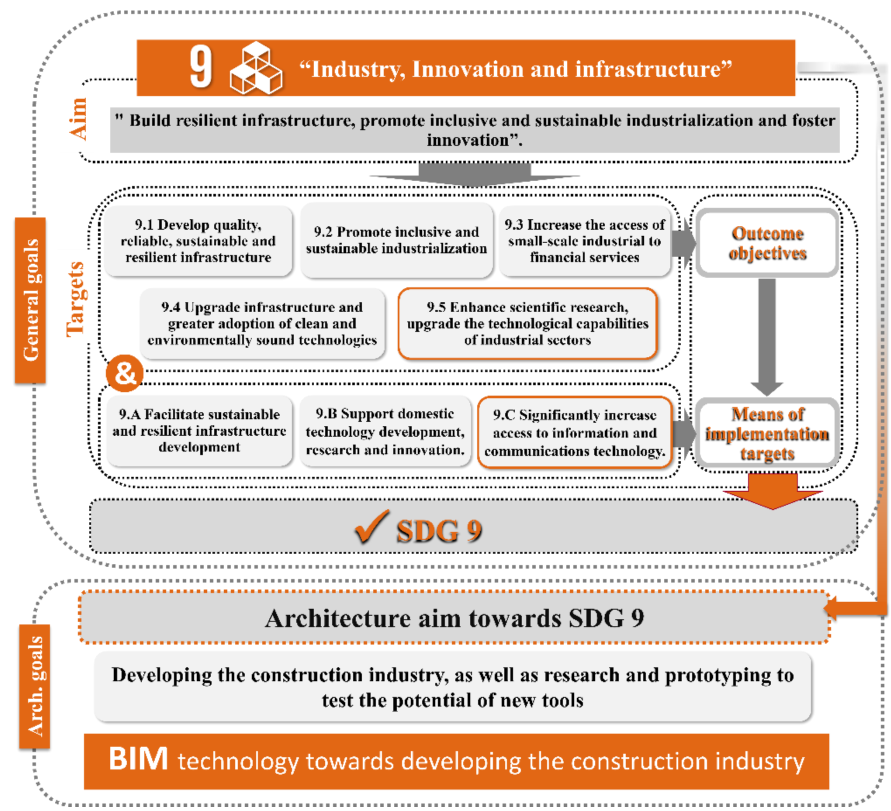

Figure 3: General & Arch. Goals of SDG 9
Source: the authors after [72] [72]**.**

1.3. **The thirteenth sustainable development goal (SDG 13)**

“Climate action” this is the slogan of the SDG 13. It’s aim to: "Take urgent action to combat climate change and its impacts." The aim comprises five targets that must be met by 2030 [11] as shown in Figure 4.

So, the SDG 13 aims to designing new buildings which can enhance climatic comfort while consuming the least amount of energy for heating, cooling, and lighting. This necessitates taking into account the local environment and designing with natural light, natural ventilation, and the thermal qualities of building structures in mind. [15]–[17].

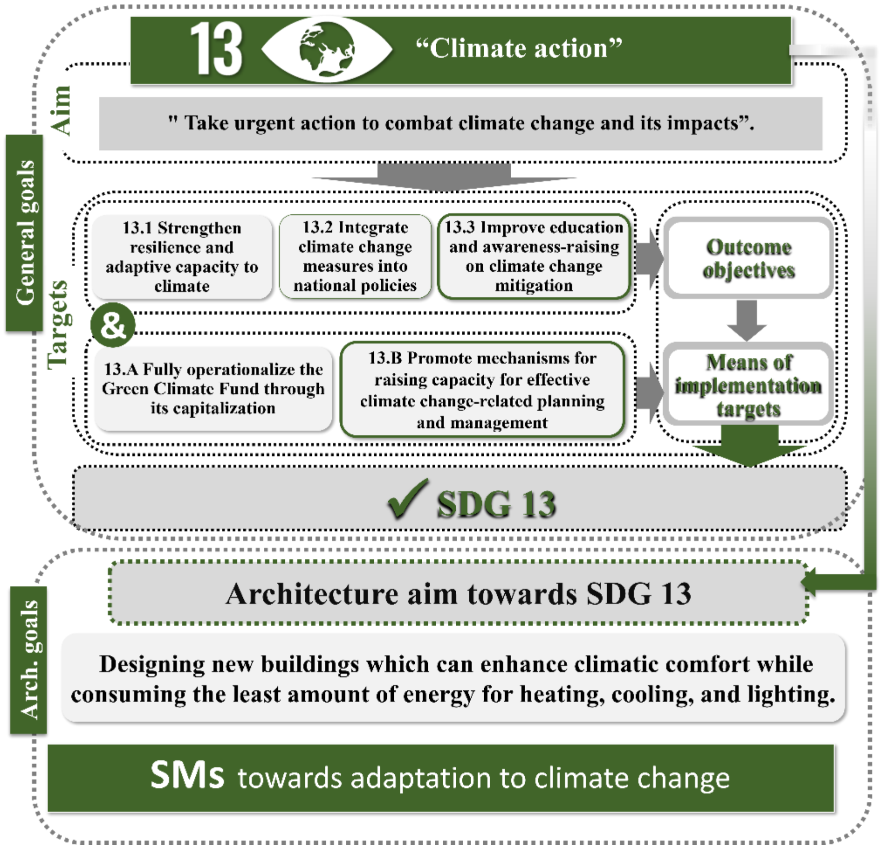

Figure 4: General & Arch. Goals of SDG 13
Source: the authors after [72].

It is clear from the previous review of SDG 7, SDG 9, and SDG 13, the aims of these goals that related to architecture are to increase energy efficiency, develop the building industry, and introduce technology as a tool to achieve sustainability in the field of construction and development of buildings to adapt to climate changes.

Therefore, the study suggests using BIM technology as a tool for selecting smart building materials to increase energy efficiency and conserve energy due to the adaptation of these materials to climate factors. surroundings and response to climate change as shown in Figure 5.

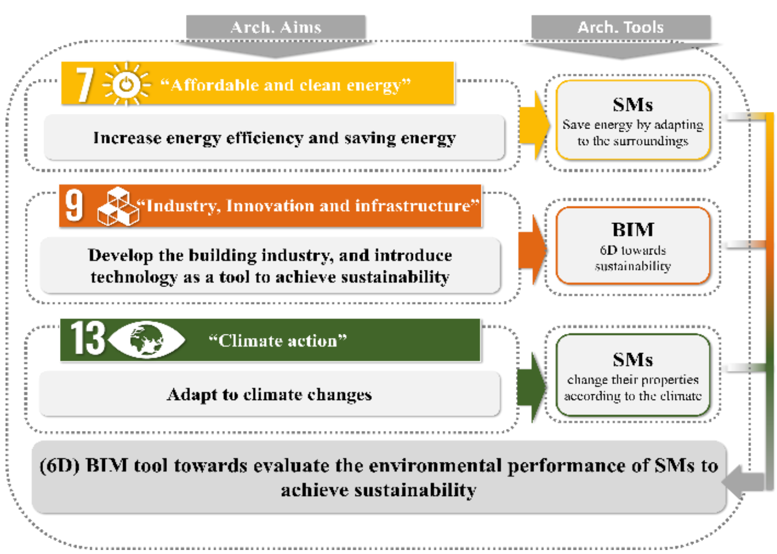

Figure 5: Arch. Aims and Tools towards SDGs
Source: the authors after[72] [72] [72].

2.THE HISTORY OF BIM AND THE 6TH DIMENSION ABOUT SUSTAINABILITY FACTOR

BIM ideas began to appear in the late seventies of the last century and was called the Building Production Model (BPM), many think that Autodesk was the first to invent building information modelling technology, but it was a misinformation as the beginning was for Graphi Soft with its software (Archi CAD) where the company established what it called virtual construction in1987, and the word "Building information Model" was not used until 1992, and its actual spread started about ten years later with the purchase of Autodesk (Revit) [18]. Building information modeling has evolved over the years as shown in Figure 6. BIM continued to evolve and new dimensions began to be added to it, and development is still continuing, so modeling was used in historical documentation (HBIM), green buildings (Green BIM), Building Energy modeling (BEM) and others.

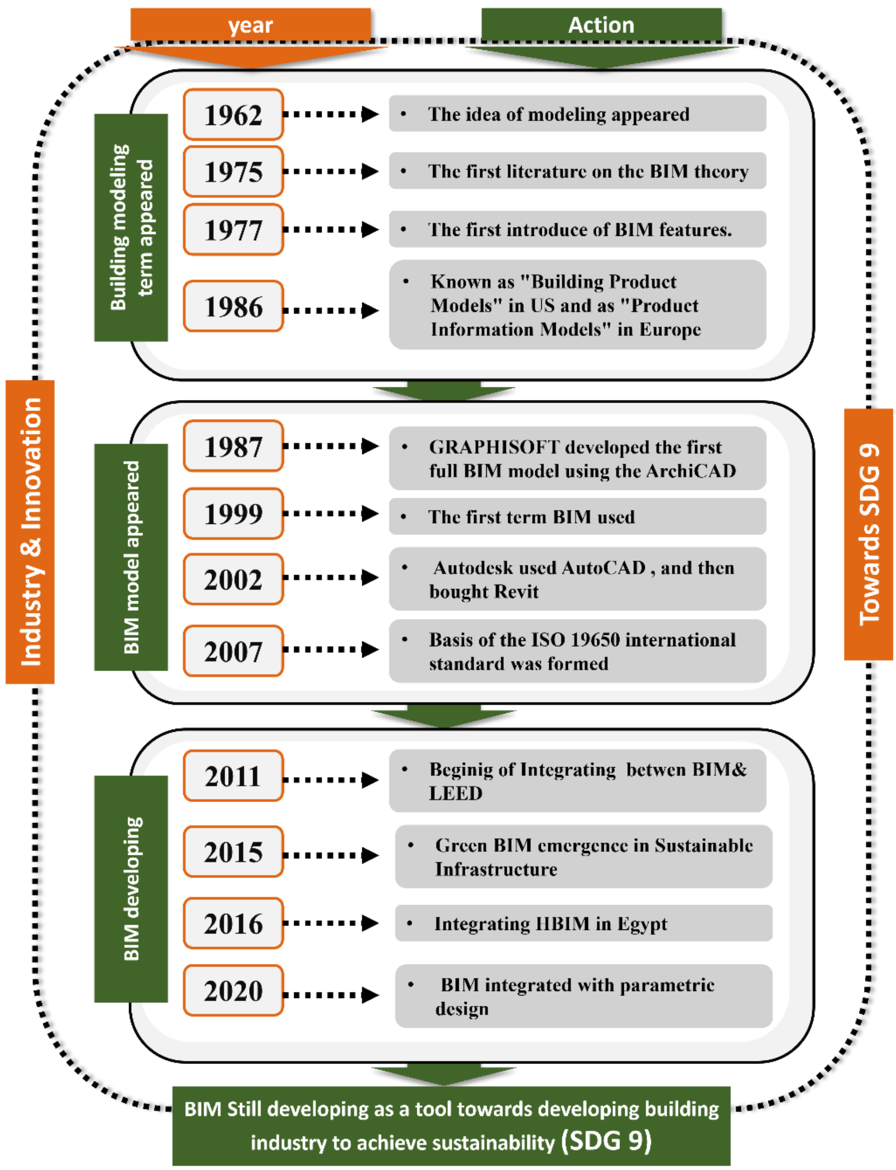

Figure 6: BIM history over years
Source: the authors after [73]–[79]

BIM plays a crucial role in achieving sustainable building design and construction. Numerous research studies have been conducted to illustrate how the early adoption of BIM in sustainable design can enhance project delivery efficiency and effectiveness [19]. These studies have discovered that BIM has the potential to expedite the sustainability evaluation process by reducing the time required for reviewing various design options [20]. Additionally, BIM systems have integrated various processes, including thermal, daylighting, and energy simulations, for analyzing building sustainability. Computational techniques enable the extraction of BIM data for diverse sustainability assessments [21]. The BIM follows specific dimensions, 6D contribute to the attainment of sustainability objectives as shown in Figure 7.

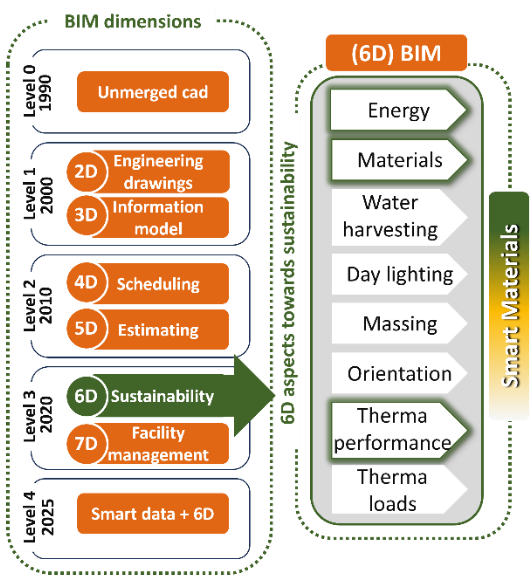

Figure 7: BIM dimensions & 6D aspects
Source: the authors after [81], [83]–[85]

The process involves building simulations for energy efficiency and environmental data to model the project's energy requirements. It involves calculating thermal loads, sustainable design, and comparing alternative design possibilities. Simulations are repeated in the design stages to assess the validity of the analysis's conclusions and aid in decision-making, ensuring a clear understanding of the project's energy requirements [22], [23]. So, that support for BIM technology to achieve sustainability in the building industry, particularly the 6D in BIM, is obvious.

3.ENHANCING SUSTAINABILITY BY USING BIM TOOL TO SELECT BUILDING MATERIALS

Many research studies have incorporated Building Information Modeling (BIM) with various platforms like life cycle sustainability assessment, life cycle cost analysis, sustainability evaluation, and energy management to automate the selection process of traditional building materials [24]–[30]. BIM has been utilized to streamline the material selection process in response to the increasing research focus on this area. By leveraging BIM, a system has been developed to facilitate the comparison of building material performance based on multiple parameters. These parameters vary in importance depending on the specific project requirements, ultimately aiding in the identification of the most suitable sustainable building materials. Table 1 shows summary of studies for using the BIM tool to select traditional building materials.

Table 1. Summary of Studies for using the BIM tool to select traditional building materials in light of the SDGs.

Ref.	BIM dimension	Effect on sustainability	Towards SDG s
[31]	5D - 6D	Data were employed to compute construction cost and thermal transfer value.	SDG 7
[30]	6D	The suggested alternate materials saved 73% of the embodied energy.	SDG 7
[32]	6D	Calculating LEED points towards achieving sustainability.	SDG 7 – SDG 13
[33]	7D	Strategies and systems for energy and life cycle assessment have been developed.	SDG 9
[34]	6D	Conduct an environmental impact assessment of materials before construction.	SDG 9
[35]	6D	Using BIM, the material for exterior walls is decided. The material information and specifications from the BIM model are used to rate the alternatives.	SDG 7
[36]	5D - 6D	More energy-efficient designs and less rework, which would cut down on time and cost overruns.	SDG 7
[37]	6D	Select the most valuable exterior walls materials	SDG 9

		during the design stage.	
[38]	4D	BIM aided in the rapid and precise reduction of steel reinforcing area.	SDG 9
[39]	6D	Diminish the environment's passive contribution.	SDG 7
[40]	6D	Achieve building interior thermal comfort, lower cooling load rate, and hence total building energy consumption.	SDG 13
[41]	4D	Material quantities are extracted instantly from a model, Cost calculation is done in initial design phase.	SDG 9
[42]	4D	Choosing the most effective materials in achieving the required operational cost in the building's life cycle.	SDG 9
[43]	6D	Minimize building energy requirements while simultaneously improving indoor environmental quality.	SDG 7

BIM is an intelligent, innovative, interactive, and responsive technology that allows engineers to take model data and use it efficiently to provide relevant information to workflows and other associated processes, redefining the way the construction industry creates [19], [44]–[46]. We can also see that all dimensions of BIM work together to achieve sustainability in a sequential way. Each dimension serves as an introduction to the next dimension, but the sixth dimension plays the most important role because it helps in making decisions based on the results of the analyses [47]–[51]. Also, the future of BIM lies in the combination of the sixth dimension and smart information. With the increasing interest in the building and construction sector to make it more sustainable, interest is directed towards building materials. The optimal choice is made in the early stages of project design because of its significant impact on the environment and achieving sustainability. The use of BIM has been noted in selecting building materials with stable properties. The challenge in this study was: Can BIM understand the behavior of small objects, automatically adjust their properties according to some external variables, and perform energy analyses to choose the most efficient ones?

4.TYPES AND SYSTEMS OF SMS INTEGRATED IN BUILDINGS

The way SMs respond to external stimuli determines their classification and are generally categorized into two types: Type 1 is Energy exchange materials and Type 2 is Property-exchange materials as shown in Figure 8. SMs type 1 consists of "Energy generating materials", and "Energy reflective materials" that transform energy from one form to another, both directly and inversely [52]–[55]. SMs type 2 respond to a direct external stimulus by changing one or more of their properties [56], which are immediate and reversible adjustments that do not require an external control system [57], [58]. They include: "Color-changing materials", "Thixotropic materials", and "State-changing material".

Although Smart material has the potential to do one task by jointly constructing a material synthesis technique. In addition to the capacity to feel the shift that is occurring that causes the process, they may perform several functions. Smart material systems are categorized on the basis of how the system responds [52], [59].

- **Passive smart materials systems**

  When the system detects a certain shift in stimulus and reacts directly with some form of work or activity, the material system is called a passive system. The energy needed by the device to activate this activation is taken from the resources of the world. This form functions as a loop that's closed [53], [60].

- **Active smart materials systems**

  The material work is routed by a device and regulated. This device includes a sensor capable of detecting the change in stimulus, then sends a signal to the controller to react and activate the material system accordingly. Adjustable output of devices. They have the ability to change their geometric or material features under the impact of electric, thermal, or magnetic fields, indicating that they have an innate potential to transduce energy [61], [62].

- **Hybrid Smart Materials Systems**

  A hybrid system can incorporate the features of both an efficient and inefficient system that can function as a passive system, but output, such as the active shading system, can be monitored and controlled by an active system. It provides, on hot summer days when integrated with sunlight, shading on glass, but in winter its functions are regulated by an active system to prevent shading and allow the heat necessary to enter [58], [60].

Smart materials play a major role in the construction sector because they can understand the surrounding climatic conditions and adapt to them to achieve the best performance of internal spaces and comfort for users. Smart materials have proven their ability to conserve energy and achieve sustainability in buildings, and this is what the whole world is seeking to achieve in the coming days. The problem lies in their diversity and the presence of many different types, which makes choosing among them difficult and inaccurate in the initial stages of the project. Therefore, the search for a tool that also adopts the idea of sustainability, can understand the behavior of these materials possible and the availability of comprehensive information.

, and can perform an accurate simulation of their performance in an integrated and accurate environment that helps in making the decision to choose between these materials is extremely important so that we can ensure the accuracy and efficiency of choosing a specific type before starting implementation work [63], [64].

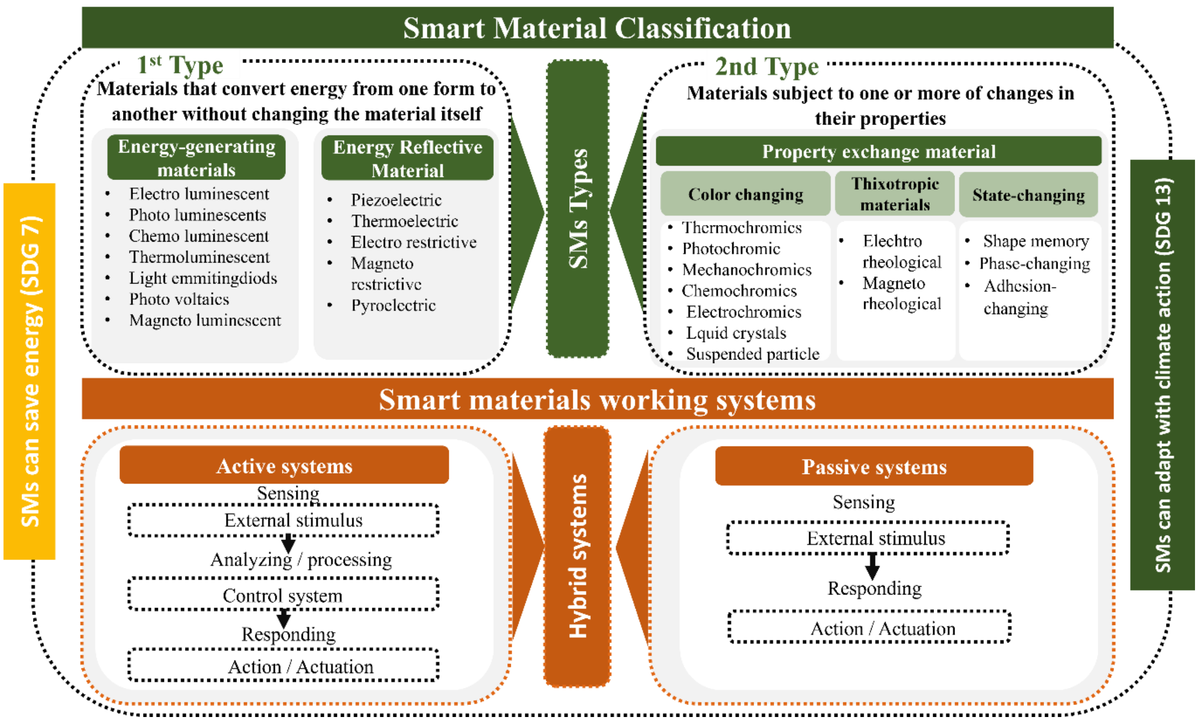

Figure 8: Classification of smart materials and their working systems.
Source: the authors after [57], [62], [66], [86], [87].

5.INTERRELATIONSHIP BETWEEN BIM AND SMS INTEGRATED IN BUILDING COMPONENTS

Due to the lack of projects that rely on BIM technology as a tool for selecting smart building materials, case studies based on BIM technology were examined in general in construction and its impact on project efficiency was studied, as well as case studies that relied on SM to improve the efficiency and quality of the building and some projects that were integrated between BIM and SMs.

A methodology was developed to select the study cases which rely on the diversity of projects between a local, global, and regional, variety of climate regions as

Then BIM dimensions that the building depended on, the number and type of building components that SM integrated with, achieving SDG 7, SDG 9, and SDG 13. Figure 9 illustrates the methodology of choosing case studies and aspects of analyzing them.

Table 2:4 illustrates examined projects. Due to the lack of information on national projects, 8 national projects, 10 regional projects and 32 international projects were examined. They were classified according to the location, the building type, implementation date, the use of BIM, and the type of building materials used.

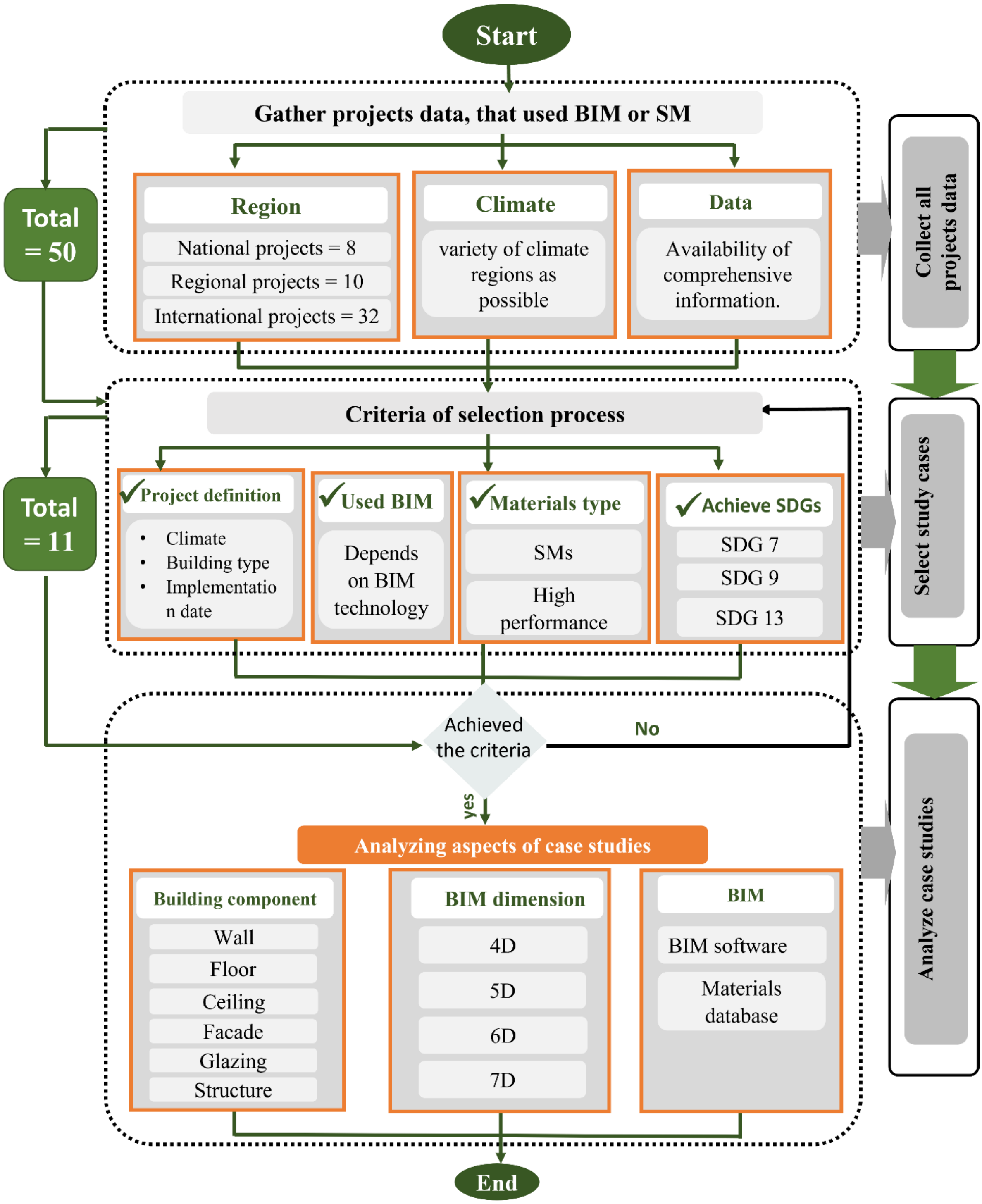

Figure 9: Flowchart of choosing case studies methodology studies and aspects of analyzing them.
Source: the authors.

Table 2. Examined national case studies. Source: the authors.

Climate	Project name	Building type	Implementation date	Used BIM	Material choice			SDGs
					SM	High performance material	Traditional material	
Hot desert	The New Egyptian Museum	Museum	2023	✓	✗	✓	✓	SDG 7-9
	Mall of Egypt	Commercial	2017	✓	✗	✓	✓	SDG 7-9
	Alamein city	Multi-purpose	2018	✓	✗	✓	✓	SDG 9
	Central bank of Egypt	Bank	2018	✓	✗	✓	✓	SDG 9
	JW marriot hotel	Hotel	2003	✗	✓	✗	✓	SDG 9
	The iconic tower in the New Administrative Capital	Multi-purpose	2019	✓	✓	✓	✓	SDG 7-9
	Vocational training center in Shubra El-Kheima	Eeducational	-	✗	✓	✗	✓	SDG 7
	New united national bank Headquarters	Bank	-	✗	✓	✗	✓	SDG 7

Table 3. Examined regional case studies. Source: the authors.

Climate	Project name	Building type	Implementation date	Used BIM	Material choice			SDGs
					SM	High performance material	Traditional material	
Semi-arid to arid desert	Alpin Limited – Masdar City Office	Multi-purpose	2009	✓	✓	✗	✓	SDG 7-9-13
Hot and dry desert	King Abdullah university of Science and Technology (KAUST)	University	2009	✓	✗	✓	✓	SDG 7- 9
	Abdul Aziz Khaled Center for Culture	Culture center	2019	✓	✗	✓	✓	SDG 7- 9
	Louvre Abu Dhabi	Museum	2017	✓	✓	✗	✓	SDG 7-9-13
	Serviced Apartments Complex	Residential	2015	✓	✗	✓	✓	SDG 7- 9
	Doha Alfardan Office Tower	Office	2012	✓	✗	✓	✓	SDG 7- 9
	National bank of Kuwait	Bank	2017	✓	✗	✓	✓	SDG 7- 9
	Amman Airport	Airport	2005	✓	✗	✓	✓	SDG 7- 9
	Qatar national convention Centre	Exhibition center	2011	✓	✗	✓	✗	SDG 7- 9
	DEWA headquarters | Dubai, UAE	Authority	-	✓	✓	✗	✓	SDG 7-9-13

Table 4. Examined international case studies. Source: the authors.

Climate	Project name	Building type	Implementation date	Used BIM	Material choice			SDGs
					SM	High performance material	Traditional material	
Mediterranean	courtyard by Marriott	Hotel	2009	✓	✓	✗	✓	SDG 7
	New public power corporation headquarters	Banking	2020	✓	✗	✓	✓	SDG 7-9
	Aviva stadium	Stadium	2010	✓	✗	✓	✓	SDG 9
	Tanjong Pagar Guoco Tower	Multi-purpose	2016	✓	✓	✗	✓	SDG 9
	Randselva Bridge, Norway	Bridge	Under construction	✓	✗	✓	✓	SDG 7-9
	Statoil Regional and International Offices, Norway	Offices	2012	✓	✗	✗	✓	SDG 9
Hot humid and cold	Maryland general hospital	hospital	2010	✓	✗	✓	✓	SDG 7-9
Hot tropical	WHIZDOM 101	Multi-purpose	2018	✓	✓	✗	✓	SDG 7
Ocean	Arab Institute in Paris	Culture center	1987	✗	✓	✗	✓	SDG 7
	Alto Tower	Office	2020	✓	✗	✓	✓	SDG 9
	Crossrail	subway	2009	✓	✗	✗	✓	SDG 9
	Lè Architecture	Offices	2017	✓	✗	✓	✓	SDG 9
	The Eden Project, England	Culture Center	2011	✓	✓	✗	✓	SDG 7
-	Luminary office building	Office	1800	✗	✓	✗	✓	SDG 7
Wet continental	Pavilion for the cooper-Hewitt national design museum	Museum	2003	✗	✓	✗	✓	SDG 7-13
	Silver Oak Winery	Factory	1973	✓	✓	✗	✓	SDG 9
	WeWork	workspace	2011	✓	✗	✗	✓	SDG 9
	National Library of Sejong City	Library	2013	✓	✗	✓	✓	SDG 7-9
subtropical	One island east skyscraper	Commercial offices building	2000	✓	✓	✗	✓	SDG 7-9-13
Tropical humid	Shanghai Tower	Multi-purpose	2015	✓	✓	✗	✓	SDG 7
	Shanghai Disneyland	Entertainment	2011	✓	✗	✗	✓	SDG 9
	Nanjing International Youth Cultural Centre	Cultural Centre	2018	✓	✗	✓	✓	SDG 7-9
	Haier Global Creative Research Centre	Research Centre	2016	✓	✗	✓	✓	SDG 7-9
	Enseada House	Residential	2015	✓	✗	✗	✓	SDG 9
	Central Taiwan Innovation Campus MOEA	Research Institute	2014	✓	✓	✗	✓	SDG 7-9-13
Desert and semi-desert	Oakland International Airport	Airport	-	✓	✗	✗	✓	SDG 9
	Good Samaritan hospital	Hospital	2011	✓	✗	✗	✓	SDG 9
Mild and moist	Savings Bank Building	Bank	-.	✗	✓	✗	✓	SDG 7-13
	Hamond school, Britain	school	-	✓	✓	✗	✓	SDG 7-9
	Floating Pavilion Culture Center, Roterdam	Culture Center	2021	✓	✓	✗	✓	SDG 7-9
humid subtropical	Office building in Philadelphia	Offices	-	✗	✓	✗	✓	SDG 7-13

6. SELECTED SMS-BUILDING CASE STUDIES ANALYSIS

From Table 2:4 and based on the analysis methodology in Figure 9, the case studies were selected based on climate diversity as possible, the use of BIM technology in choosing building materials, whether smart materials or high-performance materials. 6 projects BIM technology and high-performance building materials were used, and 5 projects BIM was used with smart building materials, Figure 10 shows the distribution of selected case studies, but most of the projects did not provide sufficient information on the extent of using BIM in choosing building materials. Table 5 shows the components of the building with which materials have been integrated and BIM dimensions used, and their impact on SDGs (all climatic data from. [65]).

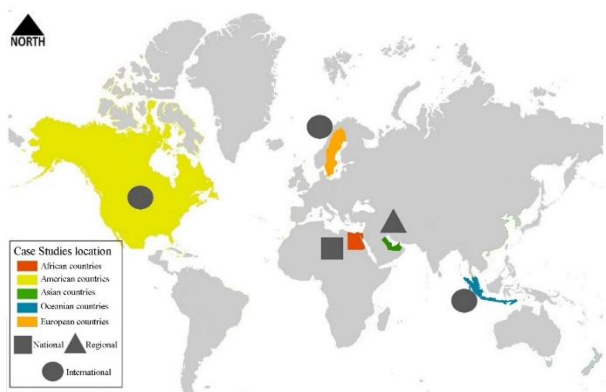

Figure 10: Distribution of selected case studies. Source: the authors.

7.DISCUSSION

Due to the through reviewing previous literature, there is a growing interest in achieving energy savings, developing the construction industry, and designing new buildings which can enhance climatic comfort while consuming the least amount of energy towards SDGs: SDG 7, SDG 9. SDG 13. That's through the use of SMs as one of the effective solutions in this field. On the other hand, there is also interest in applying BIM technology as an effective tool in reaching the optimal choice of traditional building materials in the initial design stages as one of the solutions for energy savings [31], [34], [38], [42], [66], [67]. Through the analysis of previous case studies, it was emphasized the effectiveness of BIM technology and smart materials in achieving building sustainability, energy conservation, developing and raising the efficiency of the construction industry, as well as confronting climate change, through tangible results on the ground, but BIM technology was not used clearly in selecting and evaluating the environmental performance of smart materials, even in projects that combined the two technologies [68]–[71]. It was noted from the analysis of the case studies that most of them were concentrated in the United States. Materials were integrated with facades and glazing to a greater extent. Most projects worked to achieve the 6D towards achieving SDGs and relied on Revit as a BIM software and linking material databases to it via Excel. However, the reciprocal relationship between the use of BIM in selecting smart materials integrated into building components is still ambiguous and uncertain and requires further experimentation and study, since there are not enough studies. Therefore, this study proposes searching for a new mechanism to integrate smart materials simulation into BIM tools towards a new vision to enhance its use to measure and analysis of the environmental performance of smart materials. Figure 11 shows the design strategy which the study proposes as a starting point for future studies by determining the type of SMs that will be chosen from, then identifying the building component that will be integrated to them, then identifying BIM software that can deal with these SMs and understanding their behavior. After that, entering the data for the materials into the BIM model through Excel sheet. After BIM learns about the properties of the SMs, it simulates the energy performance of each material. To present indicators which help in selection process.

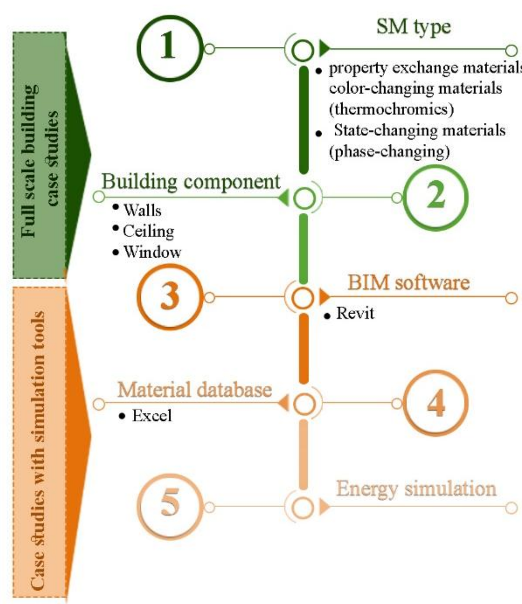

Figure 11: Design strategy. Source: the authors.

8.CONCLUSION

There is an increasing interest in achieving the SDGs 2030, so the study focused on the architectural goals of SDG 7, 9, and 13, namely: saving energy, developing the construction industry, and adapting to climate change, and considering the use of SMs as one of the effective solutions in this field to achieve these goals. On the other hand, there is also interest in applying BIM technology as an effective tool to reach the optimal choice of traditional building materials in the initial design stages as one of the solutions towards achieving the research goals. It was found that studies did not address the use of BIM in examining the environmental performance of smart materials. As a result of the analysis of previous case studies, a gap was found in the reciprocal relationship between BIM technology and smart materials that had not been examined by previous studies. There was an incentive to resort to visual programming through dynamo plugin to enhance the relationship between BIM and understanding the behavior of smart materials and evaluating their environmental performance.

This study presents the vital role of SMs in building components to achieve energy savings, developing construction sector, and adapting with climate changes towards SDGs. The following points can be concluded:

- It is possible to integrate SMs in building components, giving preference to the SDG 7, SDG 9, and SDG 13.
- SMs use in different components demonstrated significant potential for enhancing energy savings through various integration techniques, making it an effective and innovative material to be used in buildings.
- Given the ability of BIM technology to develop the building and construction industry sector and the ability of SMs to adapt to the climate changes. There is a need to develop BIM tools to enhance and accelerate the process of selecting these materials.

Table 5. Selected case studies analysis. Source: the authors

	Case studies	Material type	Materials building component						BIM dimensions				Towards SDGs			BIM software		Material database	
			Wall	Floor	Ceiling	Facade	Glazing	Structure	4D	5D	6D	7D	SDG 7	SDG 9	SDG 13	Revit	Autocade	Revit library	Excel
High performance materials	Sutter medical center in California	High performance concrete, steel and glazing																	
	Louvre Abu Dhabi																		
	Aviva stadium																		
	One island east skyscraper																		
	100 11 Avenue, New York City																		
	Helsinki Music Center, Helsinki																		
Smart materials	Tanjong Pagar Guoco Tower	Energy generating																	
	New United National Bank Headquarters																		
	Qatar national convention Centre																		
	DEWA headquarters | Dubai, UAE																		
	Courtyard by Marriott in Portland	Property exchange																	

Tropical **Dry** Desert Semi-arid **Temperature** Humid subtropical Oceanic climate Mediterranean climate **Continental** Hot summer-bumid continental warm summer-bumid continental **Polar**

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